Using CCOText assisted by dynamic model and analogy to fostering students’ misconception about the concept of heat conduction

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Abstract. The aim of this study was to obtain an overview of the effect of using conceptual change oriented text (CCOText) assisted by dynamic models and analogy in the remedial teaching of the concept of heat conduction towards the remediation of misconceptions of high school students. CCOText consists of four text sections. In the third section of the text, which is the text part of the scientific explanation, the description is aided by dynamic model and analogy. The method used in this study is a pre-experiment with one group pretest-posttest design. The number of research subjects was 38 students consisting of 22 female and 16 male students, in one of the high schools in the Bandung district of West Java province. The subjects were selected by purposive sampling technique. Data were collected by conception test in the four tier test format related to the concept of heat conduction. The results showed that the use of CCOText in remedial teaching could be remediating 95% of high school students who had misconceptions on the concept of heat conduction. These results indicate that the use of CCOText assisted by Dynamic models and analogy has a high effectiveness in fostering students’ misconception about the concept of heat conduction.

1. Introduction

One mode of teaching that is often used for misconceptions-remediation oriented science teaching is conceptual Change Text or abbreviated as CCText [1,2,3]. Conceptual change texts (CCText) were firstly developed by Wang and Andre [4]. After that, many researchers developed and continued to use these methods, primarily Chambers and Andre [1]. With CCText it is aimed to remove students’ misconceptions or to rearrange their pre-knowledge. CCText is prepared to provide students to feel that their existing knowledge is insufficient in explanation of some topics. In conceptual change texts, firstly students are ensured to be aware of their misconceptions. After that, the reasons of these misconceptions are explained through examples and reasons. Students feel that their knowledge is insufficient in explaining new situations that they meet and conceptual change is ensured by showing them the concepts that are scientifically correct [5].

To give student understanding on the physical contents that contain microscopic or abstract phenomena phenomena required a teaching media that can visualize the phenomenon. One of the media that can be used is a dynamic microscopic model of microscopic physics phenomena [6]. In the
CCOText can also be enriched with other visual representation such as dynamic analogy. Hua & Hong [7] state that application of multimedia courseware in teaching physics makes abstract physical content more visual and intuitive.

One of the physical content that contains microscopic objects is the heat transfer content. One of the concepts covered in heat transfer content is the concept of heat conduction. Conduction is the transfer of heat through a conductor. Conductors are usually made of metal. In conductors, heat transferred in the form of energy of ions vibration which occupy the point of the crystal lattice of metal. This is a microscopic phenomenon that often makes difficult for students to understand it.

In this study, development and test of CCOText supported by dynamic model and analogy related to concept of heat conduction has been done. CCOText was designed based on students’ misconceptions by following six-steps Conceptual Change Model (CCM) synthesized by Stepans [8]. This article describes the results of CCOText development related to the concept of heat conduction and its implementation in the physical teaching of heat conduction concept in senior high school students.

2. Methods
The method used in this study is a pre-experiment with one group pretest-posttest design. The number of research subjects was 38 students consisting of 22 female and 16 male students, in one of the high schools in the Bandung district of West Java province. The subjects were selected by purposive sampling technique.

CHTFTTest item
Tier 1
When one end of the metal rod is heated, the other end will gradually become hot. This shows the heat transfer from the high temperature end to the low temperature end through the conductor. This heat transfer is referred to as conduction. In this conduction process heat is transferred in the form of...
A. Free electron kinetic energy that moves from a high temperature end to a low temperature end
B. Kinetic energy of the vibrations of positive ions which propagate from the high temperature end to the low temperature end
C. Kinetic energy of positive ions that move from the high temperature end to the low temperature end
D. Heat energy that moves from a high temperature end to a low temperature end

Tier 2
Are you sure of the truth of the answers you gave to Tier 1?
A. Sure  B. Not sure

Tier 3
The right explanation according to the answer choice you chose in Tier 1 is ...
A. In conductors there are lots of free electrons and can move freely, when the two ends of the conductor are different in temperature, the electrons move from high temperature to low temperature while moving kinetic energy.
B. Conductors are composed of positive ions which are bonded to each other regularly and free electrons around positive ions. These ions vibrate. When one end of the conductor rod is heated, the vibrations of positive ions at the end of the heat will be stronger which shows the greater kinetic energy of the ion. This vibrational kinetic energy is then propagated to the end of the rod where the temperature is lower.
C. The conductor is composed of positive ion bonds. When the two ends of the conductor are different, these positive ions move from the tip of the high-temperature conductor to the end of the low-temperature conductor while transferring kinetic energy.
D. Heat is energy that moves from a high temperature place to a low temperature place. When there is a temperature difference at the ends of the conductor due to heated feeding on the conductor will move heat energy.
E. ...................................................................................................................................................

Tier 4
Are you sure of the truth of the answers you gave to Tier 3?
A. Sure  B. Not sure

Figure 1. HCFTest item used in this study
The instrument used to collect data in this study consisted of conception tests in the Four Tier Test format about heat conduction or abbreviated as HCFTTest. HCFTTest item used in this study shows in figure 1. The categorization of conception states of high school students based on conception test results data with the four-tier test format was carried out using guidelines formulated by Gurel et al. [9]. The data analysis techniques used in this study include the calculation of the decrease in the quantity of students whose misconceptions after participating in the CCOText activity. Decreasing the quantity of students whose misconceptions between before and after the implementation of CCOText are calculated using equation (1)

\[
\Delta M(\%) = \frac{M_{ICT} - M_{FT}}{M_{ICT} - M_{ideal}} \times 100\%
\]

here \( \Delta M \) is a decrease in quantity of students whose misconception, \( M_{ICT} \) is the number of students who misconception at initial conceptual test, \( M_{FT} \) is the number of students who misconception at final conceptual test, and \( M_{ideal} \) is the ideal minimum of number of student whose misconception, that is zero (0). The criteria for determining the level of decrease in the quantity of students who have misconceptions between conceptual test-1 and conceptual test-2 are: High if \( 70\% \leq \Delta M \), Moderate if \( 30\% \leq \Delta M < 70\% \) and Low if \( \Delta M < 30\% \) [10].

In the part-1 of the CCOText, students’ pre-conception was diagnosed. In this section presented a picture of phenomena associated with the concept of heat conduction. Then the students are asked to express their conception about that presented phenomena. In addition, students are also asked to provide an explanation for their conceptions and the level of confidence in their concepts. At part-2 of the CCOText, a confrontation of conception takes place, students are asked to observe video about the heat conduction presented in CCOText. The student is asked to compare the conceptions he has had with the actual phenomenon that he has seen on the video, allowing for the occurrence of cognitive conflicts in their minds. At part-3 of the CCOText presented scientific explanation about heat conduction with explanation down to the microscopic level using various visual media such as virtual simulation, dynamic microscopic model and analogy. Interactively students asked to study the scientific explanation presented at CCOText until there is an accommodation process of new scientific conception to replace the old false conception. And at part-4 of the CCOText are presented reinforcement and enrichment of conception, students are required to observe and study other physical phenomena related to the heat conduction concepts shown in the video. After that they are faced with final conception tests related to the heat conduction concept to check the final conception that students have after following CCOText activity. The dynamic microscopic models used in CCOText are shown in Figure 2. Whereas dynamic analogy used in this study are shown in Figure 3.

**Figure 2.** Dynamic microscopic model used in CCOText
3. Result and Discussion

Table 1 shows the response of students to each tier of conception tests constructed in the four-tier test format at the initial conception tests (iCT) and final conception tests (fCT) related to concept of heat conduction.

Table 1. The answers of students in each tier of heat conduction conception test

| Students (S) | Initial conception test | Students (S) | Final conception test |
|--------------|-------------------------|--------------|-----------------------|
|              | Tier1 | Tier2 | Tier3 | Tier4 |              | Tier1 | Tier2 | Tier3 | Tier4 |
| S            | T     | S     | T     | S     | S1, S2, S3, | S4, S5, S6, | S7, S8, S9, | S10, S11, | S12, S13, | S14, S15, | S16, S17, | S18, S19, | S20, S21, | S22, S24, | S25, S26, | S27, S29, | S30, S32, | S33, S34, | S35, S36 | S37, S38 |
| T            | S     | T     | S     | T     | S39, S40, | S41, S42, | S43, S44, | S45, S46, | S47, S48, | S49, S50, | S51, S52, | S53, S54, | S55, S56, | S57, S58, | S59, S60, | S61, S62, | S63, S64, | S65, S66, | S67, S68, | S69, S70, |
| U            | T     | S     | T     | S     | T81, S82, | S83, S84, | S85, S86, | S87, S88, | S89, S90, | S91, S92, | S93, S94, | S95, S96, | S97, S98, | S99, S100, | S101, S102, | S103, S104, | S105, S106, | S107, S108, | S109, S110, | S111, S112, |
| D            | S     | T     | S     | T     | T113, S114, | S115, S116, | S117, S118, | S119, S120, | S121, S122, | S123, S124, | S125, S126, | S127, S128, | S129, S130, | S131, S132, | S133, S134, | S135, S136, | S137, S138, | S139, S140, | S141, S142, |
| E            | T     | S     | T     | S     | T143, S144, | S145, S146, | S147, S148, | S149, S150, | S151, S152, | S153, S154, | S155, S156, | S157, S158, | S159, S160, | S161, S162, | S163, S164, | S165, S166, | S167, S168, | S169, S170, |
| N            | T     | S     | T     | S     | T171, S172, | S173, S174, | S175, S176, | S177, S178, | S179, S180, | S181, S182, | S183, S184, | S185, S186, | S187, S188, | S189, S190, | S191, S192, | S193, S194, | S195, S196, | S197, S198, |
|              | T     | S     | F     | S     | T199, S200, | S201, S202, | S203, S204, | S205, S206, | S207, S208, | S209, S210, | S211, S212, | S213, S214, | S215, S216, | S217, S218, | S219, S220, | S221, S222, | S223, S224, | S225, S226, |
|              | F     | T     | S     | F     | F227, S228, | S229, S230, | S231, S232, | S233, S234, | S235, S236, | S237, S238, | S239, S240, | S241, S242, | S243, S244, | S245, S246, | S247, S248, | S249, S250, | S251, S252, | S253, S254, |
|              | S     | F     | T     | F     | F255, S256, | S257, S258, | S259, S260, | S261, S262, | S263, S264, | S265, S266, | S267, S268, | S269, S270, | S271, S272, | S273, S274, | S275, S276, | S277, S278, | S279, S280, | S281, S282, |
|              | T     | NS    | F     | NS    | T283, S284, | S285, S286, | S287, S288, | S289, S290, | S291, S292, | S293, S294, | S295, S296, | S297, S298, | S299, S300, | S301, S302, | S303, S304, | S305, S306, | S307, S308, | S309, S310, |
|              | F     | NS    | T     | NS    | F311, S312, | S313, S314, | S315, S316, | S317, S318, | S319, S320, | S321, S322, | S323, S324, | S325, S326, | S327, S328, | S329, S330, | S331, S332, | S333, S334, | S335, S336, | S337, S338, |

SC = 0, MC = 20, NC = 18

SC = 35, MC = 1, NC = 2
Based on the answers of students in each tier, the number of students at each state of conception at the initial conception tests and final conception tests could be identified. Table 2 shows the quantity of students whose misconceptions was remediated during implementation of CCOText related to the concept of heat conduction.

**Table 2. Quantity of students who are misconceptions on the concept of heat conduction was remediated**

| Students’ misconception at the iCT | Students’ misconception at the fCT | Decreased quantity of students (%) | Category |
|-----------------------------------|-----------------------------------|-----------------------------------|----------|
| 20                                | 1                                 | 95                                | High     |

In Table 2, it appears that before CCOText activity, students who have misconceptions on the concept of heat conduction are quite large in number, namely 20 students. In Table 2, it is also shown that the quantity of students whose misconceptions has decreased dramatically after attending CCOText activity. There is only one person of students who are still misconceptions. Based on data of the quantity of students whose misconceptions at ICT and fCT, it can be calculated a decrease in the quantity of students whose misconceptions related to the concept of heat conduction (ΔM) using equation (1) which results in a decrease in quantity of students whose misconceptions was 95%. This shows that the use of CCOText supported by dynamic microscopic model and analogy has a high effectiveness in remediating misconceptions that occur in high school students related to the concept of heat conduction.

The results of this study are in line with the results obtained by some previous researchers, that the use of models both in the form of simulations and analogies can improve students' understanding of the content being studied to the level of deep and complete understanding. According to Sangar and Greenbowe [11] and Gobert et al [12], animation and simulations boost understanding subjects and especially case teaching abstract concept in subjects. Wibowo et al [13] state that explanation of this microscopic phenomenon needs to be supported by visual media that can model the invisible microscopic phenomena into a macroscopic phenomenon that can be observed by the eye.

4. Conclusion

Based on the research data it can be concluded that the use of CCOText supported by dynamic microscopic models and analogy has a high effectiveness in remediating the misconceptions that occur in high school students related to the concept of heat conduction. The effectiveness of CCOText in remediating misconceptions that occur in students shows the important role of dynamic microscopic model and analogy in supporting the process of accommodating conception in the minds of high school students.

5. References

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