

Fostering High School Students' Misconception about Boiling Concept Using Conceptual Change Laboratory (CCLab) Activity

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Abstract In this research, study of the effectiveness of conceptual change laboratory (CCLab) on fostering high school students' misconception about boiling concept has been done. The two students' misconception about boiling concept which was addressed in this study are: 1) Misconception-1 (MC-1), the water will only boil if it is heated and 2) Misconception-2 (MC-2), the water that is boiling must have a high temperature close to 100°C. The CCLab used in this research was the five-stage of lab activities oriented towards conceptual change developed by researchers. To support CCLab activities, student worksheets and the necessary laboratory equipment have been developed. A pre-experiment method with one group pretest-posttest design was used. The research subjects were 40 high school students consisting of 20 female students and 20 male students chosen by purposive sampling. Data were collected by two items conceptual test in the four tier test format concerning boiling concept, which has previously been validated and tested for its reliability. The results of this study show that the number of male students, whose misconceptions can be remediated is 85% for MC-1 and 90% for MC-2, while the number of female students, whose misconceptions can be remediated is 80% for MC-1 and 90% for MC-2. These results indicate that: first, the use of CCLab has a high effectiveness in remediating high school students' misconceptions about the concept of boiling; second, there is no gender bias from the use of CCLab in the process of remediating physics misconceptions.

Keywords Conceptual Change Lab, Misconception Remediation, Boiling Concept

1. Introduction

One of the fundamental problems that can obstruct the achievement of sound understanding of a physics concept is misconception. Students enter to the physics class with a variety of initial conceptions. Some of them do not have an initial conception but some have misconceptions. According to the literature, many things, including prior knowledge, daily life experiences, language, culture, teacher, textbooks, and instruction, are the source of the causes of misconceptions [1]. One source is the experiences in daily life. In daily life students often observe a physical phenomenon that involves many physical quantities that affect it, but because in reality sometimes the influence of a physical quantity on the phenomenon cannot be observed the students think that the physical quantities that affect to the phenomenon are only what they have observed. For example, because in daily life students observe and even practice that to boil water must go through a heating process, most of students have the thought that to boil water must always go through the heating process. And because the students also observe that a warm-up process is needed long enough for the water to boil, the students also think that the water that is boiling must have a high temperature.

Students' thoughts like this are identified when students are asked to take conception tests related to boiling concepts. The results of field observations found at least four forms of misconceptions that occur in high school students related to the concept of boiling, namely: 1) To

boil water must always go through a heating process, 2) The water is boiling so the temperature is certainly high, 3) For bubbles that appear in the water which is boiling, its contents is air, and 4) When the water is boiling, the process of convection in water is getting faster.

Misconceptions should not be allowed to remain in the minds of students, because of which student may become resistant to change with scientific ones and students may reject accepting new ideas [2], thus they are obstacles for students in learning and understanding some concepts in science. In physics one concept with another is usually interconnected. For example the concept of pressure is closely related to the concept of force, so if students have a misconception on the concept of force, then they will be difficult in understanding the concept of pressure in depth. Misconception is a situation that is difficult to be changed, because it is usually inherent in the minds of students and they are not aware that the conception they have is not in accordance with the scientific conception. Special approaches and strategies are needed to carry out misconception remediation that occurs in students. The approach that is often used is the conceptual change approach (CCA), while one of the strategies that is quite widely used is the cognitive conflict strategy. This approach and strategy was created based on constructivist theory. According to constructivist theory, students will construct conceptions related to a concept through two ways, namely the assimilation and the accommodation way [3]. Researchers who have used the CCA with cognitive conflict strategies in physics remedial teaching include: Baser [4], Kang et al. [5], and Madu & Orji [6]. Teaching specifically carried out with the aim of remediating the misconceptions that occur in students is known as remedial teaching.

During this time, the remedial teaching of physics is usually carried out in classroom learning mode. However, due to limited time for learning activities in this class, remedial teaching is rarely held by the teacher. Actually in the physics learning curriculum, there is one learning session provided, which is the laboratory session. Until now, laboratory sessions are often used by teachers to conduct practicum activities oriented to the verification of physical content that has been informed at class sessions. To optimize the function of laboratory session and to overcome the problem of limited time for remedial teaching, this session can be filled with laboratory activities oriented to the remediation of misconceptions or conception reconstruction. Of course its implementation requires a design of laboratory activities that are oriented to conceptual change. To meet these needs, our research team has developed a conceptual change oriented to laboratory model called the conceptual change laboratory model (CCLab model). According to Surtiana, the advantage of the mode of laboratory activities is that students can be

facilitated to construct and change their conceptions through in-depth exploration activities by themselves. So the view of constructivism can be truly applied [7].

The purpose of this study is to test the effectiveness of the use of CCLab model in facilitating the remediation of two misconceptions that occur in high school students related to the concept of boiling which are: misconception-1 (MC-1), the water will only boil if it is heated and misconception-2 (MC-2), the water that is boiling must have a high temperature close to 100oC. Gender is one of the aspects reviewed in this research. This article reports the process and results obtained from the research activities that have been carried out.

2. Materials and Methods

The research method used in this study is the pre-experiment method. While the research adopts one group pretest-posttest designs. The research subjects were 40 high school students consisting of 20 female students and 20 male students, in one of the high schools in the West Bandung district of West Java province and were chosen by purposive sampling. Lab activities are carried out cooperatively in small groups. The CCLab model used in this research was the five-stage of lab activities oriented towards conceptual change, as shown in Figure 1.

Data were collected by two items conceptual test in the four tier test format concerning boiling concept (BCFTTest), which has previously been validated and tested for its reliability. Based on the results of expert judgment, the instruments used in this study have construct and content validity. While based on the results of the reliability analysis using the test-retest method, the instrument has a reliability coefficient of 0.78 which indicates that the conception test instrument used in this study has a high reliability. Figure 2 shows the sample of BCFTTest items used in this study.

Table 1 shows the guidelines used to determine student conception categories before and after participating in CCLab model based on conception test data in the Four Tier test format [8]. The quantity of students who achieved conception reconstruction after participating in CCLab activities was analyzed using techniques similar to those used by Surtiana et al [7][9].

Another goal of this research is to find out about the effect of gender on the achievement of conception reconstruction in the implementation of the CCLab model on the boiling concept. The research hypothesis proposed is "HA: There are differences in the number of male and female students who reach the conception reconstruction related to the boiling concept as the effect of applying the CCLab model".

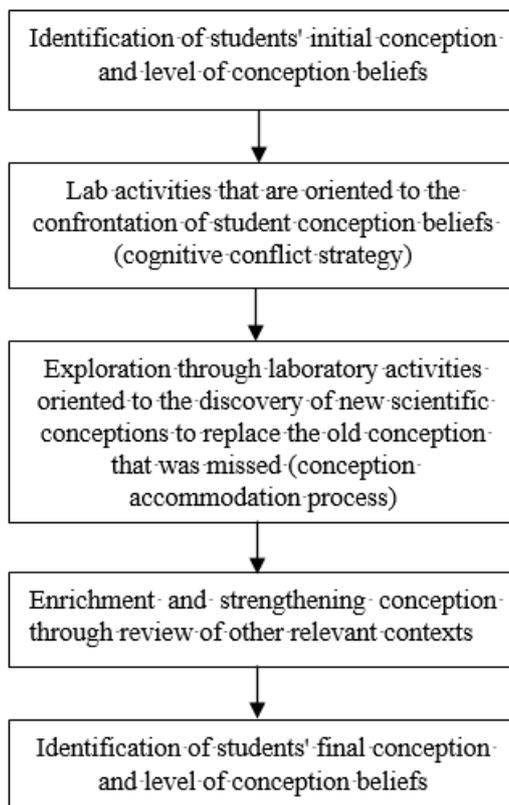


Figure 1. Stages of CCLab model

No.2.
Tier 1
 In daily life, you must have seen boiling water. Do you think the water will boil if the temperature
 A. Can be at temperatures below 100°C, or 100°C or above 100°C
 B. Only if the temperature is 100°C or more
Tier 2
 Are you sure about the answer you gave in Tier 1?
 A. Sure
 B. Not Sure
Tier 3
 The right explanation according to your choice in Tier 1 is
 A. To release water molecules from their bonds when boiling requires a high energy equivalent to a water temperature of 100°C or more
 B. To convert water to gas when boiling, it requires high energy which is equivalent to the temperature of water of 100°C or more
 C. The energy given to water when boiling is used to release bonds of water molecules and fight environmental stresses. If the environmental pressure is high then a large amount of energy is needed whereas if the environmental pressure is low then the energy required is relatively small to release the bonds of water molecules, so that the water can boil at room temperature to temperatures above 100°C
 D. The energy given to water when boiling is used to release bonds of water molecules and resist gravity. Because Earth's gravity is large enough, the energy needed is large enough which is identical to temperatures of 100°C or more
 E.
Tier 4
 Are you sure about the answer you gave in Tier 3?
 A. Sure
 B. Not Sure

Figure 2. Sample of BCFT Test items used in this study

3. Finding and Discussion

By using the categorization guidelines for students' conceptions as shown in Table 1, it can be determined what state of conceptions students have before and after participating in CCLab model.

By using the categorization guidelines for students' conceptions as shown in Table 2, it can be determined what state of conceptions students have before and after participating in CCLab activities.

Having knowing the condition of the students' conceptions before and after the CCLab model, a pattern of the conceptual change that occurred from before to after the CCLab model can be obtained. With the pattern of conceptual changes achieved by students, the effectiveness of implementation of CCLab model remediating the misconceptions of high school students can be determined. Figure 3 shows the pattern of conceptual change of female (F) and male (M) students in MC-1 before and after

participating in CCLab model. While Figure 4 shows the pattern of conceptual change of female (F) and male (M) students in MC-2 before and after participating in CCLab model.

In Figure 3 it appears that 80% of female students and 85% of male students change their conception from a mistaken one to a scientific one. Whereas in In Figure 4 it appears that 90% of female students and 90% of male students change their conception from a mistaken one to a scientific one. These changes show that CCLab model can facilitate the revision or reconstruction of students' conceptions from erroneous conceptions to scientific concepts related to MC-1 and MC-2.

Figure 5 shows a bar chart of the number of female and male students who have misconceptions related to MC-1 and MC-2 before and after CCLab model. In the figure, it appears that there was a significant decrease in the number of female and male students who have misconceptions from before to after CCLab model.

Table 1. Students' conception categories based on conception test results data

Tier 1	Tier 2	Tier 3	Tier 4	Conception Category
True (T)	Sure (S)	True (T)	Sure (S)	Scientific Conception (SC)
True (T)	Sure (S)	True (T)	Not Sure (NS)	No Conception (NC)
True (T)	Not Sure (NS)	True (T)	Sure (S)	No Conception (NC)
True (T)	Not Sure (NS)	True (T)	Not Sure (NS)	No Conception (NC)
True (T)	Sure (S)	False (F)	Sure (S)	Misconception (MC)
True (T)	Sure (S)	False (F)	Not Sure (NS)	No Conception (NC)
True (T)	Not Sure (NS)	False (F)	Sure (S)	No Conception (NC)
True (T)	Not Sure (NS)	False (F)	Not Sure (NS)	No Conception (NC)
False (F)	Sure (S)	True (T)	Sure (S)	Misconception (MC)
False (F)	Sure (S)	True (T)	Not Sure (NS)	No Conception (NC)
False (F)	Not Sure (NS)	True (T)	Sure (S)	No Conception (NC)
False (F)	Not Sure (NS)	True (T)	Not Sure (NS)	No Conception (NC)
False (F)	Sure (S)	False (F)	Sure (S)	Misconception (MC)
False (F)	Sure (S)	False (F)	Not Sure (NS)	No Conception (NC)
False (F)	Not Sure (NS)	False (F)	Sure (S)	No Conception (NC)
False (F)	Not Sure (NS)	False (F)	Not Sure (NS)	No Conception (NC)

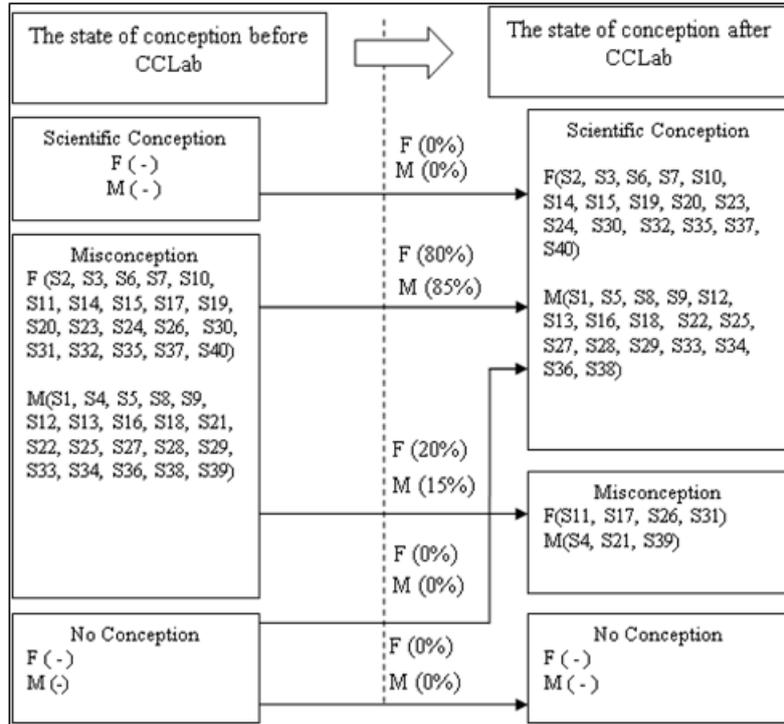


Figure 3. Pattern of conceptual change of female and male students in MC-1 before and after CCLab

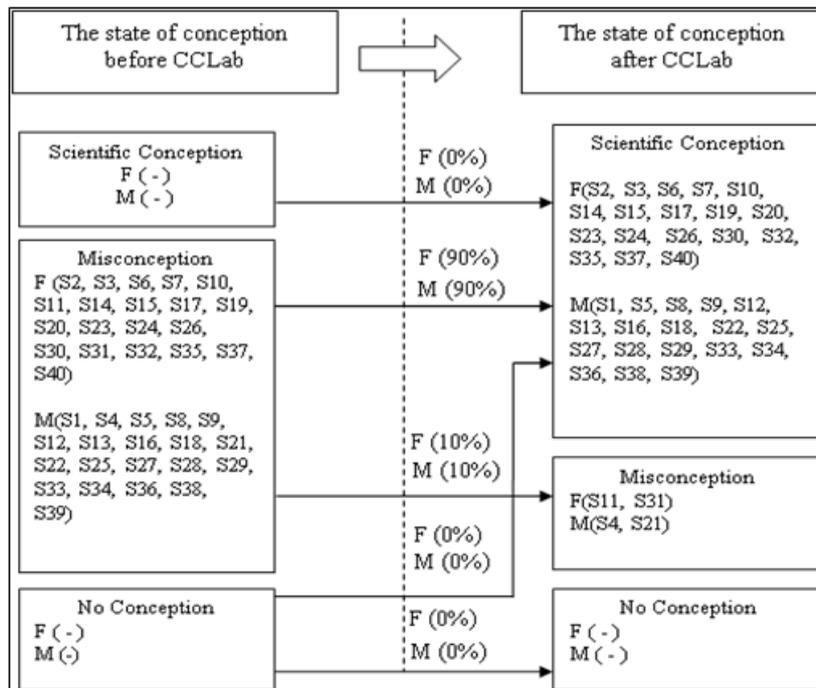


Figure 4. Pattern of conceptual change of female and male students in MC-2 before and after CCLab

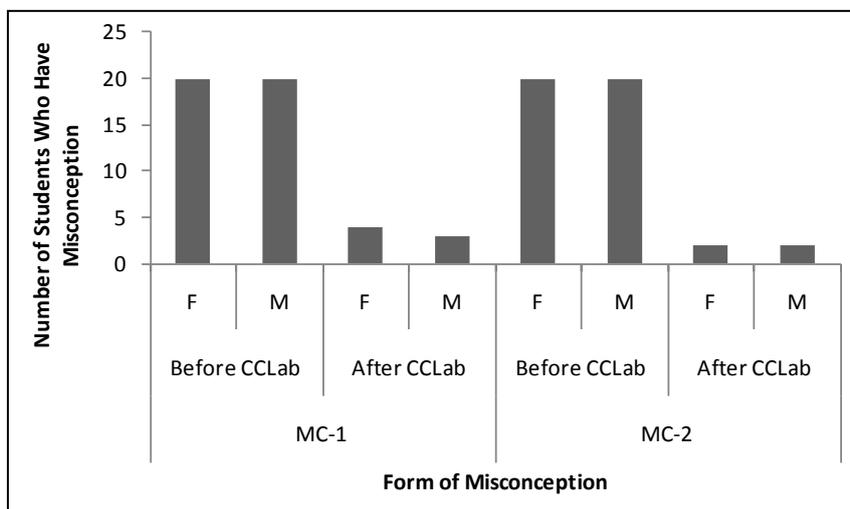


Figure 5. Bar chart of the number of female and male students in MC-1 and MC-2 before and after CCLab activities

Table 2. Quantity of female and male students who are misconceptions on the concept of boiling was remediated

Misconception	Number of students whose misconceptions before CCLab		Number of students whose misconceptions after CCLab		Decreasing the number of students who are misconceptions		Category of reduction	
	F	M	F	M	F	M	F	M
MC-1	20	20	4	3	0,80	0,85	High	High
MC-2	20	20	2	2	0,90	0,90	High	High

Table 2 shows the quantity of female and male students whose misconceptions was remediated during implementation of CCLab model related to the concept of boiling.

In Table 2, it appears that before CCLab model, the number of female and male students who had misconceptions related to MC is 20 each, and after CCLab model the number has drastically decreased to only 4 for female students and 3 for male students. Regarding MC-2, before CCLab model the number of female and male students who had misconceptions was also 20 students each, after CCLab model the number of students who had misconceptions related to MC-2 also dropped dramatically to 2 for female and male students. Based on data of the quantity of students whose misconceptions before and after CCLab model, a decrease can be calculated in the quantity of students whose misconceptions are related to the concept of boiling. The results show that: related to MC-1, the quantity of misconceptions of male students decreased by 0.80 and for female students the quantity decreased by 0.85. While related to MC-2, it can be calculated that the decrease in the quantity of misconceptions of female students were 0.9 and the decrease in the quantity of misconceptions of male students were 0.9 too. These results indicate that the implementation of the CCLab model has a high effectiveness in remediating the misconceptions that occur among high school students regarding the concept of boiling.

When we compare of male students to female students

whose misconceptions related to MC-1 and MC-2 can be remediated, the numbers are almost balanced. This indicates that there is no gender bias in the process of remediating misconceptions through CCLab model. This fact is supported by the results of different test numbers of male and female students who achieve remediation of misconceptions using the Mann-Whitney test at the level of confidence ($\alpha=0.05$) as shown in Table 3.

Table 3. Test the different numbers of male and female students who have achieved conception reconstruction

Misconception	Mann-Whitney U	Asymp. Sig.	Conclusion
MC-1	0.760	0.08	Not significantly different
MC-2	0.500	0.12	Not significantly different

In Table 3 it appears that for the two misconceptions that occurred in the boiling concept, the obtained value of Asymp. Sig. is greater than the level of confidence ($\alpha=0.05$). This shows that the proposed hypothesis is rejected, which means that for the two misconceptions, there is no difference in the number of male and female students who achieve remediation of the misconception. Statistical test results show that the CCLab model is suitable for remedial teaching activities for both male and female students.

4. Conclusions

Based on research data on the implementation of the CCLab model in remedial teaching related to the concepts of boiling, it can be concluded that the implementation of the CCLab model in remedial teaching about boiling concept has a high effectiveness in reducing the number of students who have misconceptions. There is no gender bias in the process of remediation of misconceptions through the use of the CCLab model.

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