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CONCEPTUAL CHANGES IN SCIENTIFIC ARGUMENTATION THROUGH GUIDED GROUP SETTINGS

Lee Ling Heng, Johari Surif, Cher Hau Seng

INTRODUCTION

The main goal of scientific argumentation is to foster students' understanding of scientific concepts (von Aufschnaiters et al., 2008; Nussbaum, 2011; Sadler, 2004; Zohar and Nemet, 2002) and to eliminate alternative frameworks (Cross et al., 2008). The involvement of students in argumentative activities also enhances their scientific reasoning skills (Osborne et al., 2004).

In order to induce conceptual changes through collaboration, instructional intervention are usually conducted following the socio-cognitive conflict design (Amigues, 1988). This design is based on the idea whereby the pairing of students with different initial conceptions will lead to their cognitive conflict. As a result, they will then seek for equilibrium to accommodate their naive concepts as scientific concepts. According to Kendeou and Broek (2007), when students' existing concepts are activated and integrated with a scientific explanation, this will lead to an imbalance. The identification of this imbalance will trigger deeper information processing that causes conceptual changes. Mason (1996) stressed that conceptual change is likely to occur when students are asked to clarify, explain, and defend their own ideas. This is consistent with Schwarz et al. (2000), whom suggested that the knowledge construction tasks will be more effective if students engaged in peer argumentation.

According to Nussbaum and Sinatra (2003), while constructing a scientific argument, individuals need to consider both sides of the argument, explain aspects of the problem that are anomalous to their existing conceptions, and confront with the discrepancies between their points of views. These actions will allow students to engage in the process of deep thinking about the alternative concepts, and subsequently rebut the alternative frameworks and change their conception. Furthermore, by considering the three levels of scientific representation, students will form a better understanding of the concepts (Beall et al., 1994; Bucat and Mocerino, 2009; Johnstone, 1991), which assists the process of conceptual change. As stated by Bucat and Mocerino (2009), the sub microscopic level should be knitted into the observable macroscopic and symbolic levels of representation to enhance the understanding of chemistry concepts. However, are our students able to link all the three levels of representation in order to achieve conceptual change? Thus, this study examines conceptual changes in scientific argumentation through guided group settings.

METHODOLOGY

This descriptive study involved fourth form science students in the district of Pasir Gudang, Johor, Malaysia. Two instruments, the Open-ended Scientific Argumentation Test 1 and 2 (OSAT 1 & 2) were first developed based on the fourth form chemistry syllabus. Both instruments consisted of similar questions related to neutralization and the properties of acids and bases. In the instrument, information about the phenomenon being studied and diagrams were provided to assist students in answering the questions. After seven lessons of acids and bases, students were first asked to answer the OSAT 1 in the time allocated. The arguments constructed in the answers were assessed based on their accuracy and the three levels of representation in chemistry. If the argument consisted of alternative framework in any of the argumentation elements, that argument will be considered as non-scientific. On the other hand, any argument with the correct concepts and without any alternative framework will be classified as scientific argument. Thirty two (32) students who have constructed different arguments were then selected by using purposive sampling to go through a guided group argumentation. Guided by a researcher (McNeil et al., 2006), each group consisted of two students who mastered the scientific concepts and two students with alternative frameworks (Webb, 1985). According to Osborne et al. (2004), the characteristic of this combination is essential to create cognitive conflict among group members, which will trigger scientific argumentation. In groups, students were guided and encouraged to explain their arguments constructed, and to relate them to the three levels of representation. The argumentation processes were also recorded, transcribed and analyzed. Students were then asked to answer the OSAT 2 and the arguments constructed were re-assessed to compare the mastery of scientific argumentation before and after the guided group argumentation.

RESULTS AND DISCUSSION

Mastery of Scientific Argumentation

The findings show that almost all of the students involved have changed their existing alternative frameworks to the correct scientific concepts after following guided group argumentation. As shown in Figure 1, only 7.14% of arguments constructed by students have alternative frameworks. Besides, content analysis shows that these students experienced alternative frameworks at the sub microscopic level but provided appropriate scientific concepts at the macroscopic level. This indicates that scientific argumentation especially in guided group setting promotes conceptual change (Aydeniz et al., 2012; Nussbaum and Sinatra, 2003; Nussbaum, 2011).

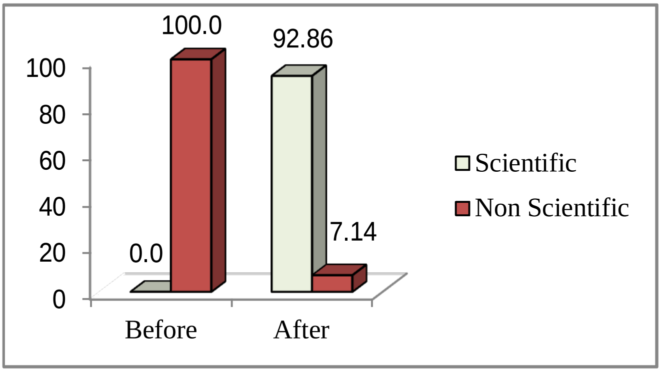

Figure 1 Comparison of students' mastery of scientific argumentation before and after guided group argumentation

Construction of Scientific Arguments at Macroscopic, Sub microscopic and Symbolic Level

Table 1 shows that all students involved in guided group argumentation could construct claim and evidence with correct scientific concepts. The element of reasoning constructed is mostly at macroscopic and sub microscopic level (57.15%). Furthermore, the arguments constructed did consist of the element rebuttal although the percentage is lower that other elements. The results suggest that guided group argumentation not only changed students' alternative frameworks to appropriate concepts, it also improved the quality of the arguments that are constructed (Aydeniz et al, 2012; Nussbaum, 2011). These findings corroborate with Cross et al. (2008) that involved in scientific argumentation help students to reflect on their existing ideas and eventually eliminate the alternative frameworks that exist. Content analysis also shows that the scientific arguments constructed were accurate in terms of the scientific concepts and complex in terms of the argumentation structure. Moreover, there are also arguments which showed the link between the three levels of representation. This suggests that students possessed deep and holistic scientific knowledge in the concepts being studied (Beall et al., 1994; Bucat and Mocerino, 2009).

Table 1 Comparison of students' mastery of argumentation elements before and after guided group argumentation

Element	Before			After		
	Scientific (%)	Non Scientific (%)	No answer (%)	Scientific (%)	Non Scientific (%)	No answer (%)
Claim	56.25	43.75	0.00	100.00	0.00	0.00
Evidence	50.00	50.00	0.00	100.00	0.00	0.00
Reasoning:						
Macro only	0.00	71.88	6.25	7.14	0.00	0.00
Sub micro only	0.00	0.00		3.57	0.00	
Macro and sub micro	12.5	9.37		57.15	7.14	
Macro, sub micro and symbol	0.00	0.00		25.00	0.00	
Rebuttal:						
Alternatif claim	12.50	3.12	84.38	60.71	0.00	39.29
Alternatif evidence	18.75	0.00	81.25	53.57	0.00	46.43
Alternatif reasoning:						
Macro only	3.12	18.75	78.13	14.29	0.00	28.57
Submicroonly	0.00	0.00		21.43	0.00	
Macro and sub micro	0.00	0.00		32.14	0.00	
Macro, sub micro and symbol	0.00	0.00		3.57	0.00	

Based on Table 1, more than half of the arguments constructed did include the element rebuttal. Thus, the arguments presented are considered complex and with high quality since rebuttal is seen as a quality indicator (Erduran, 2007; Osborne et al., 2004; von Aufschnaiter et al., 2008). However, a few students constructed simple arguments with mostly macroscopic level, but sub microscopic level with alternative frameworks, and without the element rebuttal. These results align with the findings by Dindar and Geban (2011) which reported that alternative frameworks are difficult to eliminate. Thus, it is clear that scientific argumentation could promote conceptual change which is driven by the efforts of students to construct evidence, reasoning and rebuttal at the macroscopic, sub microscopic and symbolic levels. Hence, it requires in-depth explanation of the thinking process that occurs in students' scientific argumentation scheme.

Conceptual Change in Scientific Argumentation Scheme

Figure 2 shows the conceptual change in scientific argumentation scheme of students involved in guided group argumentation.

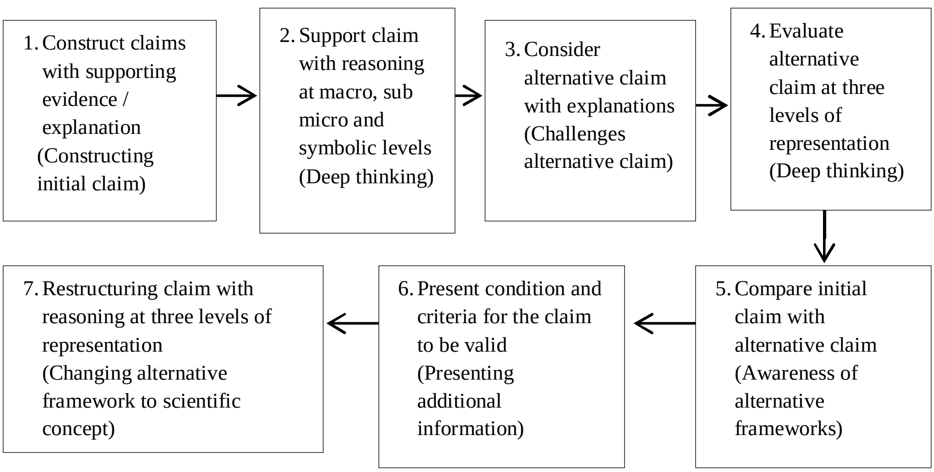

Figure 2 Conceptual change in scientific argumentation scheme

Based on Figure 2, students involved in comparing and evaluating the two alternative concepts at the macroscopic, sub microscopic and symbolic levels which led to cognitive conflicts. Through the process of deep thinking, students aware of their alternative frameworks and replaced it with appropriate scientific concepts. This conceptual change enables students to understand the scientific concepts completely and subsequently enhance their mastery of related concepts. These findings are in line with several studies which reported that argumentation in group setting can be used as a tool for conceptual change (Asterhan et al., 2009; Aydeniz et al., 2012; Nussbaum, 2011; von Aufschnaiters et al., 2008) and to eliminate alternative frameworks (Cross et al., 2008).

CONCLUSION

This study showed that conceptual changes occur when students construct scientific arguments that link between the macroscopic, sub microscopic, and symbolic levels of representations. While constructing arguments in a group setting, students tended to elaborate their pre-existing ideas in a social context, thus providing opportunities to their peers to evaluate the rationality and accuracy of the ideas, as well as to provide feedback (Aydeniz et al., 2012). The study also showed that the process of deep thinking about the two alternative concepts at the three levels of representation helped with conceptual changes. It was observed that students tend to restructure and accommodate these conceptions to discover and accept the alternative conception, if it is intelligible, plausible and fruitful (Posner et al., 1982). Hence, the teaching and learning of science need to focus on group argumentation and incorporate the linkage between the macroscopic, sub microscopic, and symbolic representations (Tsai, 1999; Wu, 2003) to promote meaningful learning and to ensure students' understanding of scientific concepts (Jaber and BouJaoude, 2012).

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