Students’ Engagement in a Science Classroom: Does Cognitive Diversity Matter?

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Abstract: The purpose of the study was to investigate whether cognitive diversity would impact students’ engagement in small-group learning in a K-12 science classroom setting. A total of 45 seventh-grade students were recruited to participate in the study where two conditions were compared: homogeneous groups (all low-ability students) vs. heterogeneous groups (low-ability students with one high-ability student). Participating students were randomly assigned into six homogeneous groups (24 individuals in total) and five heterogeneous groups (21 individuals in total). The results revealed that the heterogeneous groups had significantly higher behavioral, emotional, social and cognitive engagement than the homogeneous groups.

Introduction
Advocates of cognitive diversity argue that learners with different levels of knowledge and skills could create a large shared group knowledge base or skill base. As a result, each group member could draw on that shared base, which resulted in fostered learning and performance. Also, in a heterogeneous group, high-ability learners need to restructure their knowledge in order to assist low-ability learners to learn and understand, a process which may benefit both parties (Webb, Nemer, & Zuniga, 2002). It is also possible that cognitive diversity is not as effective as expected in terms of impacting learning. Individuals with different levels of knowledge and skills may encounter conflicts and difficulty in communication, which negatively impacts group cohesion and member’s satisfaction (Curseu et al., 2007; van Knippenberg & Schippers, 2007). Therefore, the negative impacts of cognitive diversity within groups could attenuate the effectiveness of small-group learning (Curseu & Pluut, 2013). Therefore, it is necessary for researchers to examine how individuals are engaged in small-group learning. The purpose of the study was to investigate whether cognitive diversity would impact students’ engagement in small-group learning in a K-12 science classroom setting.

Method
Participants and design
A total of 45 junior high school students (24 females) were recruited to participate in the study. Their average age was 12.42 years old (standard deviation = .62 years old) with a range from 11 to 14 years old. All of them were seventh-grade students from a key junior high school in Shanghai, China, and were all enrolled in a science course as their electives. They did not receive any monetary or physical reward for participating in the study.

This study used a one-way between-subjects design with two conditions (homogeneous group vs. heterogeneous group). Participating students were randomly assigned into six homogeneous groups (24 individuals in total) and five heterogeneous groups (21 individuals in total). Each heterogeneous group only had one high-ability student and all students within a homogeneous group were low-ability students. Except that one heterogeneous groups had five individuals, all the remaining ten groups had four individuals each group.

Implementation and procedures
The study was implemented in a regular 90-minute face-to-face class session in a junior high school in Shanghai. Based on students’ performance in the prior course projects, the teacher selected the top five students in that class and identified them as five high-ability students. Each of these five students was randomly assigned to a seat in class when they came to the class. The rest of the students were then randomly assigned to the remaining seats in the classroom.

Measures and instruments
Behavioral, emotional and social engagement was assessed by three scales that were adapted from the previous research (Van Damme, De Fraine, Van Landeghem, Opdenakker, & Onghena, 2002). These items were implemented in a 7-point Likert scale, ranging from 1 “not true at all” to 7 “very true”. Negatively worded items
were reverse-scored such that higher scores reflect more positive attitude. Cognitive engagement was measured through group performance, which was assessed by two raters (a teacher and a researcher) on a 5-point Likert scale, ranging from 1 “Poor” to 5 “Excellent”.

**Results**
A series of one-way between-subjects ANOVA were conducted to evaluate the effects of groups’ cognitive diversity on individuals’ behavioral engagement, emotional engagement, social engagement and cognitive engagement. The results revealed:

- A significant effect of cognitive diversity on behavioral engagement, $F(1, 43) = 16.41, MSE = 1.11, p < .001$, partial $\eta^2 = .28$ (large effect), indicating that individuals in the heterogeneous groups ($M = 6.39, SD = .69$) had significantly higher scores on the behavioral engagement scale than those in the homogeneous groups ($M = 5.11, SD = 1.29$).

- A significant effect of cognitive diversity, $F(1, 43) = 6.86, MSE = 1.07, p = .01$, partial $\eta^2 = .14$ (large effect), indicating that individuals in the heterogeneous groups ($M = 5.84, SD = .79$) had significantly higher scores on the emotional engagement scale than those in the homogeneous groups ($M = 5.03, SD = 1.21$).

- A significant effect of cognitive diversity, $F(1, 43) = 5.13, MSE = 1.34, p = .02$, partial $\eta^2 = .13$ (large effect), indicating that individuals in the heterogeneous groups ($M = 6.46, SD = .82$) had significantly higher scores on the social engagement scale than those in the homogeneous groups ($M = 5.68, SD = 1.38$).

- A significant effect of cognitive diversity, $F(1, 9) = 16.85, MSE = .63, p = .003$, partial $\eta^2 = .65$ (large effect), indicating that heterogeneous groups ($M = 3.80, SD = .45$) had significantly better group performance (i.e., higher cognitive engagement) than homogeneous groups ($M = 1.83, SD = .98$).

**Discussion and conclusion**
Within a group of four to five individuals, the results of our study have revealed that even having one high-ability student can bring benefits to the group in terms of group performance and individual engagement. Not only were these students more interested, attentive, and socially engaged in the class activities, but also their groups were more successful to complete the learning task. One possible explanation for the positive results of cognitive diversity revealed in the current study is that low-ability students have the opportunity to learn from high-ability student by observing, asking, arguing and other forms of interaction. From their high-ability peer’s problem-solving and explanations, the rest of the group members become more and more interested by paying attention to their peers’ performance and have more and more interactions with each other, which finally leads to better group performance (i.e., cognitive engagement). Although groups with four to five individuals may encounter more cognitive conflicts than dyads and triads, the consequences of cognitive conflicts are not always bad.

Based on the results of the study, the educational implication is that, to increase students’ engagement, science teachers could provide them the opportunity to interact with their peers who are relatively more knowledgeable and skilled. Moreover, it may not be necessary to have a substantial number of high-ability students or learning-groups with small sizes. Relatively large groups with four to five individuals and with one high-ability individuals may be sufficient for a small group of students to learn science content.

**References**


