An Exploratory Study of Eighth Graders' Engagement in Science Learning

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ABSTRACT

The purpose of this research was to use the questionnaire and engagement in science learning questionnaire to explore the states of junior high learners' engagement in science learning. Seven hundred and sixty (760) eighth graders in junior high schools in south Taiwan were selected by stratified random sampling. Findings revealed that: (1) the emotional engagement scale rate of male students was significantly higher than female students; (2) On both cognitive and behavioral engagement scales, high-achievement students are significantly higher than average-achievement students and average-achievement students are significantly higher than low-achievement students. On the emotional engagement scale, high-achievement students are significantly higher than average-achievement and low-achievement students; (3) On behavioral, emotional and cognitive engagement scales, high-preference students are significantly higher than average-preference students and average-preference students are significantly higher than low-preference students.

Key words: Achievement, behavioral engagement, cognitive engagement, emotional engagement, engagement in science learning.

INTRODUCTION

In traditional science teaching, the goal of the teacher is mainly focused on conveying science knowledge and definitions. Consequently, students find science classes tough and boring and do not know how to apply what they learn (Lunetta, 1998; Patrick and Yoon, 2004). These kinds of teacher-centered activities are not able to provide opportunities for students to take an active role in learning, therefore, students' motivation and engagement decline. Students' achievement is influenced by their engagement (Finn, 1993; Sirin and Jackson, 2001). Skinner and Belmont (1993) found most students who are involved in classroom activities participate persistently and experienced positive feelings in class. High-engagement students put more effort into learning, spend more time studying, take assignments to heart, comprehend what they learn in class and apply what they learn in daily life. On the contrary, low-engagement students are reluctant to take part in learning and lack comprehensive knowledge of academic work (Newmann et al, 1992).

Engagement refers to students' participation and involvement in learning activities and relates to the domains of behavior, emotion and cognition (Fredricks et al, 2004; Ryan and Patrick, 2001). Fredricks et al. (2004) classified students' engagement in class into behavioral, emotional and cognitive engagement. Newmann et al. (1992) pointed out that engagement means that students learn and become proficient in their studies based on their own psychological investment and efforts. Kuh (2003, 2009) stated that engagement is revealed by behavior and cognition in the procedure of learning in accordance with the indexes of the time and energy students spend on certain tasks. By interacting with others, engagement makes task activities meaningful. Engagement has always been viewed as an authentic indicator to predict the learning achievement of students (Capie and Tobin, 1981; Tobin and Capie, 1982). Some researches indicated that students' engagement in class helps them extend cognitive development (Greenwood et al, 2002; Lee and Anderson,
Others indicated that students’ engagement time has a positive correlation with their achievement (Capie and Tobin, 1981). Therefore, students’ engagement has been regarded as a key construct to understanding and predicting their achievement in schooling.

Appleton et al. (2008) examined the relevant research done on engagement and found that the majority of research has investigated behavioral and emotional engagement. Cognitive engagement has been added to the definition of engagement during the past decade. For example, Fredericks et al. (2004) investigated engagement in terms of the three dimensions, behavioral, emotional and cognitive engagement. Fredericks et al. (2011) reviewed and categorized various scales from elementary to senior high students. They defined these scales according to the aforementioned three dimensions. Thus, our study is based on the definition of engagement given by Fredericks et al. (2004), which includes the three dimensions of behavioral, emotional and cognitive engagement.

Fredricks et al. (2004) defined the three aspects of engagement as follows:

(1) Behavioral engagement: This includes the following:

- **Positive conduct:** Obeying the rules at school and in class without misbehaviors such as skipping school, cheating, damaging academic and public equipment and making trouble.
- **Involvement in learning and academic tasks:** Referring to the relevant behaviors in learning such as effort, persistency, concentration, attention, asking questions, class discussion, attendance rate, dropout rate and active participation etc.
- **Participation in school-related activities:** This includes athletics and school governance.

To sum up the definitions aforementioned, behavioral engagement consists of relevant activities in the curricula and outside the classroom such as positive classroom behaviors, assignments, attendance rate, effort, persistency and attention, etc.

(2) Emotional engagement: This includes the following:

- **Students’ affective reactions in the classroom:** This includes students’ affective reactions toward relevant people and things in learning, such as interests, boredom, happiness, sadness and anxiety etc.
- **Emotional reactions to the school and the teacher:** Including feelings toward school, liking or disliking school, teacher, or tasks etc.
- **Identification with school:** Consisting of belonging (a feeling of being important to the school) and value (an appreciation of success in school-related outcomes).

To summarize the descriptions earlier mentioned, emotional engagement can be viewed as a series of interactions among individuals, peers and instructors, along with the content of curricula and schools. It affects students’ feelings and preferences toward taking part in activities in and outside the classroom, including positive and passive emotional reactions (such as interests, boredom, happiness, sadness and anxiety, etc) toward classes, studies and teachers.

(3) Cognitive engagement: Referring to psychological investments in learning, a desire to go beyond the requirements, preferences toward challenging learning tasks, flexibility in problem solving, positive attitudes when facing failure, self-regulation and the application of strategy. Cognitive engagement is associated with students’ psychological investments and diligence in learning, as well as, comprehension or mastering of knowledge, skills, or abilities they learn in academic tasks. They are able to study proficiently and use valid learning tactics. These also include the academic involvement in students’ psychological aspects, consisting of self-regulation, learning goals, academic investments and being strategic, etc.

Lee and Anderson (1993) indicated that even when students were instructed by the same teachers and with the same materials in classes, they still attained different levels of task engagement and presented various experiences and distinct interpretations of learning tasks. These results are similar to the findings of Gallagher and Tobin (1987). Some students participated in class activities for most of the class period and answered the most of the teachers’ questions inquired. Students’ engagement was high and others students participated in the activities reluctantly or seldom participated.

Greenwood et al. (2002) pointed out students’ academic achievement might have reciprocal effects with engagement. Their findings showed that engagement is not significantly different among high, average and low-achieving students. However, low-achieving students showed obvious misbehavior. Horton and Utey concluded that learning engagement accelerates the distinctions of pedagogic situations and intervention. Engagement ought to be seen as the procedure of interacting authentically with students, in consideration of teachers and a good learning environment; such a view should exceed the scope of individual behaviors (Herrenkohl and Guerra, 1998).

Frenzel et al. (2007) pointed out that males exhibit higher enjoyment and lower anxiety and anger than females when learning mathematics. Wu and Lai (2011) found that the emotions of male and female 15-year-old teenagers are significantly different in the science learning classroom and male students’ emotions toward science learning are significantly higher than female students. Chang (2001) analyzed data rated to eighth graders in Taiwan who participated in TIMSS-REPEAT (TIMSS, 1999). He found that students with high preference toward science learning and taking jobs related to science had better achievement. Thus, gender and science preference could be variables.
which affect students' engagement in science learning.

However, among the previous studies science education, few studies investigated the areas of behavioral, emotional and cognitive engagement. Most studies on engagement have been dispersed in many fields of science education and conducted research only in terms of one or two of the three aspects (Pintrich, 2003; Zembylas, 2005). Zembylas (2005) stressed that emotion in science learning significantly impacts science learning situations as well as, the nature and success of students’ learning in science. In addition to cognition, which has been addressed in previous studies, most instructors need to consider the influences of motivation and emotion on promoting learners to change their prior (or mis-) conceptions. Pintrich (2003) pointed out that students engage in activities actively when they apply cognitive tactics or self-regulation to set up goals, to plan, monitor, manipulate and to modify their cognition, motivation and behavior. Under these circumstances, students acquire knowledge more and attain better performance. Ainley (2006) mentioned that adolescents tend to be unable to connect with what was learnt at school and lack motivation, affection and engagement in learning. Thus, though discussion of engagement often appears in studies, it is rarely the main factor under consideration. Rather, engagement is often used as a precedent indicator to assess performance in learning.

The purpose of this study was to use a questionnaire, engagement in science learning questionnaire, to explore and compare states of engagement in science learning to grasp the status quo of engagement in science learning for junior high learners and the differences between engagement in science learning according to gender, diverse levels of achievement, and various degrees of preference. The results will not only help instructors and learners to realize and examine the circumstances of engagement in science learning, but also provide teachers with pedagogic reflections. Hopefully, the findings of this study can also help teachers to promote students’ engagement in science learning, and enhance the achievement of students.

Based on the aforementioned discussion, the research questions are listed as follows. In terms of engagement in science learning:

- What is the difference between genders?
- What are the differences among students with diverse levels of achievement?
- What are the differences among students with various degrees of preference?

### METHODS

#### Samples

The population in this study was eighth graders in 100 junior high schools in Kaohsiung City, Taiwan. The studies were selected by stratified random sampling. Based on the number of classes, they were classified into three types of schools, small-sized (including 12 classes or less), medium-sized (including 13 to 36 classes), large-sized (including 37 classes and more). After calculating the totals and size ratio of each junior high school in Kaohsiung City, the number of sample schools in each of the three types was identified (Table 1). According to Table 1, the respondent schools were chosen randomly. The population was 760 students chosen from 26 classes by picking two classes of eighth graders in each respondent school by using a random method. After deleting incomplete questionnaires, 709 valid questionnaires remained. The ratio of valid questionnaires was 93.3%.

#### The measure instrument

This study used the instrument, engagement in science learning questionnaires (Hsieh et al., 2014) to evaluate the engagement of junior high students in science learning. The questionnaire contained three subscales, cognitive engagement, emotional engagement and behavioral engagement. Cognitive engagement refers to psychological investment in learning, the desire to go beyond the requirements, preference for challenging learning tasks, self-regulation and strategic manipulation. Emotional engagement includes students' affective reactions in the classroom, the emotional reactions to the school and the teacher as well as, identification with the school. Behavioral engagement indicated positive conduct, involvement in learning and academic tasks as well as, participation in school-related activities. The subscale of cognitive engagement had 7 items such as: “I can keep working on the difficult questions to find out the answers.” The subscale of emotional engagement had 8 items, including: “I am so enthusiastic in science learning.” The subscale of behavioral engagement had 8 items such as: “I can finish all the assignment by teachers.” The questionnaire had 23 items in total. The questionnaire was scored based on a Likert-type scale. Each respondent was asked to rate the items from 0 to 5 depending on their personal situations. The six rating options were strongly agree (5), agree (4), somewhat agree

<table>
<thead>
<tr>
<th>Variable</th>
<th>Small-sized</th>
<th>Medium-sized</th>
<th>Large-sized</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kaohsiung</td>
<td>25(3)</td>
<td>39(5)</td>
<td>36(5)</td>
<td>100(13)</td>
</tr>
</tbody>
</table>

Note: The numerals in the parentheses are the number of sampled respondents in the schools.
Table 2. ANOVA analysis of engagement in science learning between genders

<table>
<thead>
<tr>
<th>Different engagements</th>
<th>Male (N = 351)</th>
<th>Female (N = 358)</th>
<th>F value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>Cognitive engagement</td>
<td>22.43</td>
<td>8.41</td>
<td>21.99</td>
</tr>
<tr>
<td>Emotional engagement</td>
<td>22.20</td>
<td>9.99</td>
<td>20.70</td>
</tr>
<tr>
<td>Behavioral engagement</td>
<td>24.05</td>
<td>9.41</td>
<td>24.66</td>
</tr>
</tbody>
</table>

**p<0.01.

Table 3. ANOVA analysis of engagement in science learning among students with diverse levels of achievement

<table>
<thead>
<tr>
<th>Variable</th>
<th>H (N = 220)</th>
<th>A (N = 248)</th>
<th>L (N = 241)</th>
<th>F value</th>
<th>Scheffe post hoc</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>CE</td>
<td>26.27</td>
<td>6.58</td>
<td>21.85</td>
<td>7.06</td>
<td>18.86</td>
</tr>
<tr>
<td>EE</td>
<td>24.60</td>
<td>9.03</td>
<td>20.86</td>
<td>8.99</td>
<td>19.16</td>
</tr>
<tr>
<td>BE</td>
<td>28.81</td>
<td>7.35</td>
<td>23.80</td>
<td>7.70</td>
<td>20.88</td>
</tr>
</tbody>
</table>

Note: 1) H (High-achievement): students within the top 30% according to grades on mid-term exams. A (Average-achievement): students within the middle 40% range; L (Low-achievement): students within the lower 30%; 2) EE: emotional engagement; CE: cognitive engagement; BE: behavioral engagement; 3) **p<0.01.

(3), somewhat disagree (2), disagree (1), and strongly disagree (0). The Cronbach alpha for the Engagement in Science Learning Questionnaire was 0.97; for each scale, the Cronbach alpha ranged from 0.94 to 0.95.

**Data analysis**

Quantitative data on engagement in the science learning of eighth graders in Kaohsiung City was collected in this study. The collected data were analyzed by SPSS. According to the research design, the data were analyzed through descriptive statistics and ANOVA to examine the differences between genders (male/female), science achievement (high/average/low) and science preference (high/average/low) in terms of cognitive, emotional and behavioral engagement. If necessary, post hoc comparison was conducted.

**RESULTS AND DISCUSSION**

**The differences between genders**

To grasp the differences, the scores of the questionnaire, Engagement in Science Learning Questionnaire, were analyzed by means of ANOVA. The results are shown in Table 2. It shows that the average scores of the males were higher than those of the female in the dimensions of cognitive, emotional, and behavioral engagement. We see especially large difference in emotional engagement, up to level of significance (F=4.42, p<0.01). This points to significant differences between males and females in emotional engagement in science learning classrooms, and the emotional engagement of males was higher than that of females. Lo (2009)'s study on interest in science learning also pointed out that the emotional engagement of males was significantly higher than that of females. Another previous research Wu and Lai (2011) showed that emotions of male and female 15-year-old teenagers were significantly different in science learning classrooms and again, the males rated distinctly higher than did the females. The aforementioned study also mentioned that instructors had more interaction with males, gave more feedback and attached higher expectations (She, 1998). These factors might result in the distinctions between genders.

**The differences among students with diverse levels of achievement**

To grasp the differences, the scores of the questionnaire, Engagement in Science Learning Questionnaire, were analyzed by means of ANOVA. The results are shown in Table 3. From the outcome of the analysis, students with diverse levels of achievement reached the levels of significance in the three dimensions, cognitive, emotional and behavioral engagement. These show differences among students with high, average and low achievement levels. By the use of Scheffe’s post hoc method high-achievement students were significantly higher than average-achievement students and average-achievement students were significantly higher than low-achievement students in cognitive and behavioral engagement in science learning classes. In the aspect of emotional engagement, high-achievement students were significantly higher than average-achievement and low-achievement students. The engagement of high-achievement students was better than that of others in cognitive, emotional, or behavioral engagement.
Pekrun (2006) mentioned that during learning, students' emotion greatly impact individual academic achievement; and vice versa. Fredricks et al. (2004) pointed out that engagement and academic achievement are positively correlated. When students attain higher academic achievement, they also have more confidence and value science learning more (Chen, 2006). Therefore, they develop positive engagement in science learning.

The differences among students with various degrees of science preference

To grasp the differences, the scores of the questionnaire, Engagement in Science Learning Questionnaire were analyzed by means of ANOVA. The results are shown in Table 4. In the three dimensions of cognitive, emotional, and behavioral engagement, the outcome of the analysis of students with various degrees of preference all reached the level of significance. These showed significant differences among students with high, average and low preferences toward science learning. By the use of Scheffe's post hoc method, high-preference students scored higher than average-preference students, and average-preference students had higher ratings than low-preference students in cognitive, emotional, and behavioral engagement in science learning classes. According to these findings, high-preference students rate higher than other students in cognitive, emotional and behavioral engagement. Chang (2001) analyzed the data of eighth graders in Taiwan who participated in TIMSS-REPEAT (TIMSS, 1999). He found that students with high preferences toward science learning and those taking jobs related to science attained better achievement. In this study, the differences among students with various degrees of preference were similar to those described in Lo's research (2009). The engagement of high-preference students was better than that of other students, cognitive, emotional, or behavioral engagement. Students' preferences influence individual learning engagement.

Conclusion

The differences of engagement in science learning according to gender, diverse levels of achievement, and various degrees of preference

The findings showed that the average scores of males were higher than those of females in the dimensions of cognitive, emotional and behavioral engagement. For the emotional dimension in particular, the differences reached the level of significance (p<0.01). This means that male students have significantly higher emotion engagement than female students in science class. This study also found that students with high-achievement and preference toward science learning had higher engagement in cognitive, emotional and behavioral dimensions compared to students with average-achievement and preference and low-achievement and preference.

This finding indicated that engagement is a crucial element for academic achievement. It could be used to predict students' academic performance in the short term, and the states of engagement and memory in the long term (Fredricks et al, 2004). Students can acquire more knowledge and attain better performance by using cognitive or self-regulation strategies to engage in activities actively (Pintrich, 2003).

Students with high engagement, who were instructed by the same teachers in the same class with the same materials, had better achievement and performance in learning. On the contrary, students with low engagement performed worse.

Suggestions for the instruction

To minimize gender differences, teachers need to increase the engagement of females, pay attention to female students’ affective reactions, encourage them to take up scientific activities, and give them more opportunities to get involved in learning while setting up the pedagogic goals and developing curricula.

Low-achievement students had three primary problems: aptitude, motivation and learning strategies. They found science learning activities to be complex and different from the assigned tasks. Because of the lack of the prerequisite knowledge and basic concepts in science, low-achievement students felt unable to complete assignments. If they did not use good strategies to learn effectively, their confidence, motivation and engagement were reduced.

After failing several times, they were reluctant to learn, and even gave up learning. Thus, when designing curricula, the instructor should take low-achievement students into consideration.

The solution is to increase hands-on activities, provide a friendly environment and promote the engagement of low-achievement students. Enhancing the engagement of low-achievement students is a fundamental method to solve problems in learning.

To inspire learners' curiosity, strengthening learning motivation and comprehension could improve cognitive, emotional, and behavioral engagement.

Therefore, the Engagement in Science Learning Questionnaire diagnoses the problems of engagement in science learning, and provides teachers with an instrument to estimate students' achievement. At the same time, it can also prevent the occurrence of low achievement for students.

We found significantly different engagement in science learning among students with various degrees of science preference. We suggest that instructors should provide more interaction with learners and design curricula in relation to the issues in daily life. This could inspire learners directly, enhance preference and boost learning engagement.
Suggestions for future research

This study targeted eighth graders in southern city in Taiwan. Future studies might collect samples from other cities to confirm the findings of this study. In addition, future research could use qualitative methods to explore why female students' emotional engagement is significantly lower than that of male students; and why high achievement and high learning preference students have higher cognitive, emotional and behavior engagement than do average and low achievement students. Finally, a case study is recommended to explore how students' engagement influences science learning.

REFERENCES


