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Examining Low and Non-low Achievers' Motivation Towards Science Learning Under Inquiry-Based Instruction

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Abstract This study aimed to explore low and non-low achievers' motivation towards science learning among 8th graders in two public schools in central Taiwan under inquiry-based instruction. Mixed design research methods were adopted, and students were divided into experimental ($n = 56$) and control groups ($n = 45$). Six non-consecutive inquiry units (90–180 minutes each) were taught to the experimental group during one semester, while same topic units were instructed traditionally in the control group. A questionnaire measuring students' motivation towards science learning [MILS] was implemented as pre- and post-tests in both the experimental and control groups. Moreover, the teachers and 12 non-low achievers, and six low achievers from each group were interviewed four times in this semester. ANCOVA were used to analyze quantitative data in the questionnaire, and the interview data were coded. The results showed that statistically non-low achievers' achievement goals and perception of their learning environment in the experimental group significantly improved more than those in the control group. Practically, non-low achievers' expectancy and learning strategies and low achievers' confidence, value of science learning, achievement goals, learning strategies, and perception of learning environment in the

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experimental group were better than those in the control group. Low achievers still needed to use more learning strategies. Additionally, in the experimental group, hands-on activities and conceptual understanding motivated both achievers, various learning strategies motivated non-low achievers, and teachers and peers' assistance motivated low achievers. However, both achievers under intervention had more exam anxiety than those under traditional teaching due to their weak ability to calculate.

Keywords Low and non-low achievers · Inquiry-based instruction · Motivation · School science

Background

Previous studies have indicated a significant correlation between students' motivation towards learning and their academic achievements (Manolopoulou-Sergi, 2004; Schick & Phillipson, 2009; Sevinc, Ozmen, & Yigit, 2011). Students who have high learning motivation usually attain good academic achievement, and low achievers usually do not have enough motivation to learn (Linnenbrink & Pintrich, 2002). Researchers (Wu, Tuan, Hsieh & Chin, 2013) have surveyed low and non-low achievers' motivation towards learning science in school. It was found that low achievers perform significantly lower than non-low achievers in the aspects of expectations, values, and behavior. Studies have also mentioned that in science subjects, students' learning motivation decreases as their grade increases in school (Carreira, 2011; Tuan, Chin & Shieh, 2005). Therefore, it is necessary for science educators to find a way to effectively raise students' learning motivation, especially for low achievers.

Previous studies have proposed teaching strategies or models in order to improve students' learning motivation (Keller, 2010; Lavoie, 2008; Siegle & McCoach, 2005, 2007). For example, Keller (2010) proposed the Attention-Relevance-Confidence-Satisfaction (ARCS) model to enhance students' motivation to learn and developed corresponding teaching strategies and procedures. Inquiry-based instruction also has drawn considerable attention on this motivation issue (e.g. Marle, Decker, Taylor, Fitzpatrick, Khaliqi, Owens, & Henry, 2014; Moote, Williams, & Sproule, 2013; Rahayu, Chandrasegaran, Treagust, Kita, & Ibnu, 2011), and studies have indicated inquiry-based instruction could raise different aspects of students' motivation to learn science. However, few studies have discussed whether low achievers can also benefit from inquiry-based instruction (e.g. Chen, Wang, Lin, Lawrenz, & Hong, 2014; Kingir, Geban, & Gunel, 2012). It is needed to investigate the motivation of low and non-low achievers towards inquiry-based science learning in order to ensure that the inquiry-based instruction can bring its positive outcome to them. Therefore, in this study, we aimed to explore the following questions:

(i) What are the differences between low and non-low achievers' motivation towards science learning after inquiry-based instruction compared to those after receiving traditional instruction as shown in our questionnaire and interview data?
(ii) What factors result in low and non-low achievers' motivation towards science learning when they receive inquiry-based instruction as shown in our interview data?

Literature Review

Inquiry-Based Instruction

Inquiry-based instruction has played an important role in the curriculum reform of science education around the world. Bybee, Taylor, Gardner, Scotter, Powell, Westbrook, and Landes (2006) suggested that students should have the opportunities to explore related scientific concepts in order to enhance their conceptual understanding under inquiry-based instruction. Harris and Salinas (2009) argued that inquiry-based instruction can improve learners' understanding of concepts and scientific inquiry and cultivate their scientific attitude throughout the process. The National Research Council [NRC] (2007) pointed that learners should use different scientific methods during inquiry instruction. Basically, inquiry-based instruction contains the following procedures: proposing questions/problems and hypotheses, designing and carrying out experiments, analyzing data, proposing findings, communicating and discussing the findings, and making conclusions (NRC, 1996). Learners need to experience the procedures as many times as possible, and the instructor needs to help the learners to reflect upon the characteristics of the procedure so the learners can understand and engage in the inquiry activities (NRC, 2000). Moreover, the learners can understand the value of scientific inquiry through discussion and reflection during inquiry activities (NRC, 2012).

Colburn (2000) categorized inquiry-based instruction into three types: structured inquiry, guided inquiry, and open inquiry. Structured inquiry provides students the questions, procedures, and materials of inquiry, but no expected answers. Guided inquiry supplies students with the questions and materials of inquiry, but the procedures of inquiry need to be designed by students. As for open inquiry, students need to find the questions of inquiry, design the procedures, and prepare the materials. Banchi and Bell (2008) added confirmation inquiry based on the issue of whether the learners know the expected answers before conducting inquiry. Among the different types of inquiry, guided inquiry instruction has had the best effects on students' learning outcomes in the classroom (Bruder & Prescott, 2013). Therefore, we used guided inquiry instruction to teach the experimental group in this study.

Students' Motivation to Learn Science

Motivation can be defined as one's intention to engage in behavior (Elliot & Covington, 2001). Different theories of motivation have been developed in the field of education (Schunk, Pintrich, & Meece, 2008) and applied in the field of science education as well. For instance, some studies (Hushman & Marley, 2015; Wang & Tsai, 2016) have focused on students' self-efficacy in science learning, while others (Abraham & Barker, 2014; Nelson & DeBacker, 2008) have discussed students' achievement motivation. Researchers have tried to illustrate the motivation to learn science derived from different motivational constructs based on extant theories.

Several researchers defined the substance of learning motivation. For instance, Reeve (2009) indicated that learning motivation is consisted of internal and external components. The internal components are related to individual's personal needs, cognition, and emotion, while the external component related to factors outside of the individual, such as environment, society, or culture. While Pintrich, Smith, García, and McKeachie (1991) mentioned that value, expectancy, and affective components constitute learning motivation. Of these three components, value includes task value, intrinsic and extrinsic goal orientation. Expectancy is composed of individual's control beliefs and self-efficacy for learning and performance, while affective component means test anxiety. Moreover, Tuan et al. (2005) identified that among various motivation constructs, self-efficacy, active learning strategies, science learning value, performance goal, achievement goal, and learning environment stimulation are important for science learning.

Wu et al. (2013) integrated above theories of learning motivation (Pintrich et al., 1991; Reeve, 2009; Tuan et al., 2005) and formed a new theoretical framework. This framework contains seven constructs, which are self-efficacy, value of science learning, learning strategy, achievement goal, performance goal, learning environment, and exam anxiety. In this study, the constructs of the questionnaire used to measure students' learning motivation and interview protocol were developed based on this theoretical framework.

Inquiry-Based Instruction and Students' Motivation to Learn Science

Research has shown that inquiry-based instruction can benefit students' motivation towards science learning in secondary schools (Lee, Byeon, & Kwon, 2013; Pickens & Eick, 2009). Under inquiry-based instruction, students are empowered and encouraged to explore science, and the authenticity of the scientific experience can raise their motivation (Scogin, 2016). Many studies have discussed the influence of inquiry-based instruction on different constructs of motivation towards learning science. These studies found that inquiry-based instruction increases learners' interest in learning science (Rahayu et al., 2011), self-regulation of learning, career motivation (Moote et al., 2013), engagement in learning (Ibrahim, Aulls, & Shore, 2017; Wilhelm & Wilhelm, 2010), and stimulation from the learning environment (Morrison, Roth McDuffie, & French, 2015). However, few have illustrated the motivation to learn science using more comprehensive constructs in secondary school studies (e.g. Tuan et al., 2005; Wu et al., 2013).

Different Achievers in Inquiry-Based Instruction

Few studies have discussed the impact of inquiry-based instruction on different achievers' science learning in middle or secondary schools. Studies have discussed the effects on students' academic achievement tests. Kingir et al. (2012) found that the middle and low achievers in the experimental group performed significantly better than those in the control group on an achievement test. Marx et al. (2004) conducted a three-year longitudinal study and found that inquiry-based instruction benefited low achievers on achievement tests each year. They also found the effect size of the improvement grew year by year. Similar benefits were also presented in Chen, Huang, and Chou's (2016) study. Kulo and Bodzin (2013) declared that high, middle, and low achievers' scores increased significantly on content knowledge tests, with middle and low achievers having larger effect size than high achievers. Some studies have explored the effects on low achievers' views of science or the nature of science. Low achievers viewed science as more than just a subject and more authentic (Meyer & Crawford, 2015), and they had better understanding of the nature of science (Burgin, McConnell, & Flowers III, 2015) after experiencing inquiry-based instruction. The above studies focused on the cognitive aspects of science learning outcome, while other studies have focused on the affective aspect of learning outcome. Inquiry-based instruction can improve low achievers' interest and attitude towards science and technology, and their engagement in learning (Hayden, Ouyang, Scinski, Olszewski, & Bielefeldt, 2011). Also, studies have indicated that inquiry-based instruction increases low achievers' intentions to pursue science related careers (Burgin et al., 2015; Kanter & Konstantopoulos, 2010; Meyer & Crawford, 2015). Although some facets of low achievers' motivation were explored preliminarily, studies investigating different achievers' motivation under inquiry-based instruction are rare, and further research is necessary.

Methodology

This study adopted a mixed qualitative and quantitative design research method (Creswell, 2013). Data collection included administering one questionnaire and interviewing teachers and students. The questionnaire was administered in the beginning and at the end of the semester as a pre- and post-test in the experimental and control groups to measure students' motivation towards science learning. Based on the standards from the Ministry of Education in Taiwan, students with percentile rank value in class (according to their science scores last semester) lower than 25 were low achievers in city schools, while lower than 35 were low achievers in rural schools (Ministry of Education, 2012). We divided students' achievement levels into two cohorts: non-low achievers as one cohort and low achievers as the other cohort. The instructors, 12 non-low achievers and six low achievers were selected from experimental and control groups for interview. Criteria for selecting interviewees were based on our classroom observation and confirmed with classroom teachers. These students are articulated and willing to share their view point with researchers. All the interviews were conducted after every two inquiry units and at the end of the study.

Participants

This study was conducted on grade 8 students in two public junior high schools (one in metropolitan area, the other in rural area) in central Taiwan. One experimental class and one control class were selected and taught by the same instructor in each school, and students' science achievement in both classes was similar because students were randomly assigned into each class. Inquiry-based instruction was applied in the experimental class while traditional instruction was used in the control class. The instructor in school A had three years of experience teaching science and using inquiry teaching. The instructor in school B had taught science for three years as well but had just begun to use inquiry teaching in her class. Both instructors joined our research meeting held once every two weeks during the semester to further develop their knowledge and skills of inquiry instruction. In this study, we combine the experimental class in each school to form one experimental group ($n = 56$), and the control class in each school to form one control group ($n = 45$) for data analysis.

Inquiry-Based Instruction and Traditional Teaching

Guided inquiry-based instruction was adopted (Banchi & Bell, 2008), and the procedure was as follows. Firstly, the students in class were grouped with around 4 non-low achievers and 2 low achievers in each group. The instructor proposed a life question (e.g. how to increase the tone when playing a guitar) and introduced the basic principle behind the question (e.g. introduced the frequency of sound waves influences the tone of sound) to the students. After the introduction, the instructor provided materials to answer the question to each group and gave an exemplar of using these materials (e.g. instructor provided tissue box, rubber bands, and chop sticks and demonstrated how to make a simplified guitar), and each group needed to discuss and think about how to design the following experiments (e.g. decide what would be the independent variable). During the discussion, the instructor may provide some hints to students when any group made little or no progress (e.g. saying "you may need to decide what factor would influence the tone of sound first and this is the independent variable in your following experiment"). After all groups conducted their experiments, they were required to present their results in front of class (e.g. the thinner the string, the higher the tone of sound) and discuss the results with the instructor or other peers (e.g. if anything can explain the result). At the end of inquiry process, the instructor concluded the discussion and provided some complementary information (e.g. other life application regarding the tone of sound).

Non-consecutive six units (aqueous solution, formation and propagation of sound, various sounds, images of lenses, specific heat, atoms, and molecules) were selected from the textbook, and we redesigned the lesson plans for the six units (90–180 minutes each) based on the procedure described in the last paragraph. The redesigned lesson plans were implemented in the experimental group in contrast to the traditional instruction in the control group (see next paragraph). The scientific concepts taught in the experimental group were the same as the ones taught in the control group. Moreover, the content of the experimental lesson plans was discussed with the two instructors in the research meeting to ensure it was practicable in class.

The traditional teaching in the control group was teacher-centered traditional instruction. Students in the class usually read textbooks, take notes, and doing problem solving exercises. In the traditional teaching, teacher highly emphasized exam-oriented problem solving ability, in order prepare students to accomplish all kinds of tests in school. Students will conduct lab activities but in receipt style experiment once or twice a semester.

Instruments

Motivation in Learning Science Questionnaire

The Motivation in Learning Science (MILS) Questionnaire was developed according to Wu et al.'s (2013) theoretical framework about learning motivation, as mentioned earlier in literature review. This questionnaire was used for measuring junior high school students' motivation to learn science using a Likert's construct (0–5). With one more construct than theoretical framework contains, there are eight constructs, namely Self-efficacy [SE] (seven items), Value of Science Learning [VSL] (seven items), Performance Goal [PG] (seven items), Achievement Goal [AG] (five items), Exam Anxiety [EA] (six items), Passive Learning Strategy [PLS] (six items), Learning Strategy [LS] (nine items), and Learning Environment Stimulation [LES] (nine items) in this questionnaire. The one more construct PLS is the negative items of LS, so basically, they both measure students' learning strategies. Besides PLS, EAs are deemed as the other negative motivators (Pintrich et al., 1991). The Cronbach's α for each construct ranges from 0.81 to 0.91, and for the entire questionnaire is 0.94. Furthermore, this questionnaire was shown to have good content validity, criterion validity, and construct validity.

Interview Protocol

The interview protocol was developed according to the eight constructs of the MILS Questionnaire in order to further investigate students' motivation towards learning science. The protocol for students explored students' perspectives of the eight constructs of motivation in the end of semester or after specific study unit, for instance, by asking students about the importance of the curriculum and their confidence in their learning. On the other hand, the interview protocol for the instructor asked his/her observations of students' motivation and the motivational difference among different achievers in the end of semester or after specific study unit.

Data Analysis

Independent samples *t* test was conducted in pre-test to compare the score of each motivational construct between the experimental and control group on low and non-low achievers, and there was no significant difference on the multiple comparisons. Since we collected pre- and post-test data, ANCOVA analysis of each motivational construct was conducted and the pre-test score of each construct was the covariate. The analysis allowed us to identify if the intervention had significant motivational benefits when comparing to the traditional teaching.

Furthermore, students' interview data were transcribed and coded using Nvivo software by six researchers. The six researchers coded two students' interview transcripts based on the eight constructs of MILS theoretical framework, and concepts related to those constructs were identified as codes (e.g. I felt successful because I understood a concept). Afterward, the six researchers compared and discussed their codes and the texts that their codes corresponded to. The final codes reached 0.88 inter-rater reliability (the number of codes agreed by the six researchers divided by the number of all final codes). Based on the final codes, any researchers began to code other transcripts. Last, the frequency of codes mentioned by the interviewed non-low/low achievers from experimental/control groups in each unit and at the end of semester the interview was calculated by Nvivo.

Findings

Table 1 shows the result of ANCOVA of each construct in experimental and control groups on low and non-low achievers in MILS Questionnaire. Non-low achievers'

Table 1 ANCOVA of each construct in experimental and control groups on different achievers in MILS Questionnaire

	Non-low achiever						Low achiever					
	Exp ($n = 39$)		Cont ($n = 34$)				Exp ($n = 17$)		Cont ($n = 12$)			
	M[a]	SD	M[a]	SD	F	η^2	M[a]	SD	M[a]	SD	F	η^2
SE	3.62	0.94	3.61	0.93	.02	.00	2.94	1.11	2.96	1.14	.04	.00
PLS	2.43	1.06	2.69	1.12	.50	.01	1.87	1.56	2.21	1.87	1.37	.05
LS	3.15	1.00	2.98	1.06	1.04	.01	2.55	1.31	2.78	1.62	.02	.00
VSL	2.87	1.19	2.96	1.25	2.45	.03	3.14	1.87	2.69	2.19	2.63	.10
PG	2.84	1.25	2.77	1.31	.04	.00	2.56	1.25	2.61	1.50	.06	.00
AG	3.62	1.25	3.25	1.37	4.24*	.06	3.20	1.81	2.93	2.37	.48	.02
LES	3.24	1.00	3.16	1.06	4.16*	.06	2.93	1.75	2.59	2.25	.95	.04
EA	3.73	1.12	3.27	1.25	2.85	.04	3.21	1.69	2.92	2.25	1.25	.05

SE Self-efficacy, *PLS* Passive Learning Strategy, *LS* Learning Strategy, *VSL* Value of Science Learning, *PG* Performance Goal, *AG* Achievement Goal, *LES* Learning Environment Stimulation, *EA* Exam Anxiety, *M*[a] adjusted post mean, *$p < 0.05$

adjusted post-mean in the experimental group outperformed than those in the control group on AG ($F = 4.24$, $p < 0.05$, $\eta^2 = 0.06$) and LES ($F = 4.16$, $p < 0.05$, $\eta^2 = 0.06$) with medium effect size (Cohen, 1988). Although there were no statistical difference on other constructs, non-low achievers in the experimental group scored higher than those in the control group on the constructs LS ($\eta^2 = 0.01$) and EA ($\eta^2 = 0.04$) with low effect size. However, non-low achievers in the experimental group scored lower than the ones in the control group on the constructs PLS ($\eta^2 = 0.01$) and VSL ($\eta^2 = 0.03$) with low effect size. Low achievers' scores in the experimental group were more than those in the control group on VSL with medium effect size ($\eta^2 = 0.10$), and on AG ($\eta^2 = 0.02$), LES ($\eta^2 = 0.04$), and EA ($\eta^2 = 0.05$) with low effect size, while low achievers in the experimental group obtained less score than the ones in the control group on PLS with low effect size ($\eta^2 = 0.05$).

In short, non-low achievers under inquiry-based teaching showed significantly better achievement goals and perception of learning environment. Despite of no statistically significant difference on other constructs' comparison, inquiry-based instruction still improved non-low achievers' learning strategies in practical compared to traditional instruction in effect size. It also practically improved low achievers' value of science learning, achievement goals, and perception of learning environment, and they became less passive in learning in contrast to those in the control group. However, practically non-low achievers recognized less value of science learning in the experimental group than those in the control group, and both achievers in the experimental group had higher exam anxiety compared to the counterparts in the control group.

Table 2 presents the different frequently appearing interview codes (i.e. the codes were mentioned by at least half interviewed non-low/low achievers from experimental/control groups in each unit and at the end of semester interview). Non-low achievers expected hands-on activities (see code "Expect hands-on" in aqueous solution and

Table 2 Different frequently appearing codes for different achievers' interview transcripts between the experimental and control group

Group	Non-low Achiever		Low Achiever	
	Exp ($n = 12$)	Cont ($n = 12$)	Exp ($n = 6$)	Cont ($n = 6$)
Aqueous solution	Concentration in class—medium level (6) Difficulty—calculation (7) Expect hands-on (6) Importance in learning—future study/career (6) Try various learning strategies (7)	Concentration in class—high level (8) Feel successful—answering difficult exam questions (6)	Confidence in learning—medium level (3) Difficulty—calculation (4) Curriculum fun (4) Hands-on helps understanding (3)	Confidence in learning—low level (3) Difficulty—calculation (4)
Various sound	Feel successful—understanding concepts (8) Curriculum fun due to life application (6) Difficulty—calculation (6) Expect hands-on (7)	Feel successful—reaching goals in exams (6) Confidence in learning—high level (9)	Curriculum fun (4) Difficulty—calculation (3)	Curriculum fun—medium level (4) Difficulty—calculation (3)
Specific heat	Confidence in learning—medium level (6) Try various learning strategies (7)	Confidence in learning—high level (7)	Curriculum fun (3) Difficulty—calculation (3) Feel successful—hands on (4) Ask peers to solve difficulties (4) Concentration in class—high level (3) Expect hands-on (4) Hands-on helps understanding (3)	Curriculum fun—none (4) Difficulty—calculation (3) Feel successful—understanding concepts (3)
End of semester	Difficulty—calculation (8) Try various learning strategies (9)	Difficulty—conceptual understanding (6)	Confidence in learning—medium level (6) Curriculum fun—medium level (3) Difficulty—calculation (5) Ask teachers to solve difficulties (3)	Confidence in learning—low level (3) Curriculum fun—none (3) Difficulty—calculation (5)

The number in the brackets means the number of interviewees mentioning the codes in the control group felt less successful in their learning various sound units), and they tried various learning strategies to facilitate their learning besides reading books or taking notes (see code "Try various learning strategies" in unit aqueous solution, specific heat, and end of semester interview). The following excerpts were representative of all excerpts of each code:

(Non-low achievers in the experimental group)

R: Do you have any opinions about the curriculum?

S_{HME1}: I expect more hands-on activities because they impress me and help my learning.

R: Do you have any suggestions to your teacher?

S_{HME2}: I hope we can have hands-on activities in every science class and they can help me memorize and learn concepts.

R: Did you use any learning strategies to help you understand more quickly?

S_{HME3}: I made tables to classify such as what dissolves in water and what not.

R: Did you review the content taught in class?

S_{HME4}: Yes, I read books and also searched the related information on the Internet.

R: Did you have other learning strategies other than taking notes?

S_{HME5}: If the content taught was related to my personal experience, I connected them together, and I remembered the content.

The excerpts demonstrated above corresponded to the questionnaire finding that non-low achievers in the experimental group had significantly better perception of learning environment in contrast to the ones in the control group. The learning environment provided non-low achievers with the opportunities to conduct hands-on activities, which they thought was friendly for their conceptual understanding. Consequently, they had more expectation to this course. They were not satisfied just learning with reading books or taking notes in class and tried more learning strategies even researching on the Internet.

Nevertheless, non-low achievers in the experimental group had problems on calculation (see code "Difficulty—calculation" in unit aqueous solution, various sound, and end of semester interview), which could be the reason that questionnaire finding shows they had higher exam anxiety compared to those in the control group:

R: Did you feel anxious about the exams in this unit?

S_{HME6}: Yes. I was afraid of seeing questions that I was not able to answer. I was afraid that I was not able to calculate.

R: Did you feel nervous when you took exams?

S_{HME7}: Actually I was quite nervous because of the calculation. It was difficult.

(The teacher in school B)

T_B: For middle achievers in the experimental group, science could be difficult for them to understand because of the mathematics part …but they still wanted to learn.

Non-low achievers under inquiry-based instruction seemed they had less difficulties on conceptual understanding compared to those in the control group (see code "Difficulty—conceptual understanding" in end of semester interview), and they felt successful when they understood concepts (see code "Feel successful—understanding concepts" in unit various sound), which may explain their performing well significantly on the achievement goals in MILS:

R: At what moment did you feel most successful in this unit?

S_{HME8}: When I could distinguish how many waves from the hands-on activities in class. Because I found distinguishing it a little bit hard.

(Non-low achievers in the control group)

R: What difficulties happened to you most often this semester?

S_{HMC1}: I did not understand the questions and concepts the teacher talked about in class. It was quite boring because it was just memorizing the formula.

Hands-on activities helped non-low achievers understand concepts the teachers intended to teach. Again, the learning environment in the experimental group significantly facilitated their conceptual understanding, which also significantly strengthened their motivation of achievement goals. Due to too much memorization and lack of conceptual understanding, non-low achievers in the control group felt less successful in their learning.

Low achievers in the experimental group were more confident in their learning compared to the ones in the control group (see code "Confidence in learning" in unit aqueous solution and end of semester interview) because they had better conceptual understanding:

(Low achievers in the experimental group)

R: Were you confident to learn this unit?

S_{LE1}: About fifty percent confidence. I felt calculation was difficult, but the concepts were OK.

R: Is your confidence in learning in high, middle or low level after the semester?

S_{LE2}: It is in middle level. I can understand half concepts.

(Low achievers in the control group)

R: How was your confidence in learning science after this semester? One to ten.

S_{LC1}: It was three. I had low confidence in the beginning of semester, and I knew I could not learn it well. I did not expect too much and after the exam, I found the result did not change. I did not understand what my teacher taught in class.

Although low achievers under inquiry-based instruction still had calculation problem, they obtained better conceptual understanding than those in the control group. Thus, they were more confident in learning than the ones receiving traditional instruction.

Low achievers in the experimental and control groups both had calculation problems (see code "Difficulty—calculation" in all four interviews), which could cause their higher exam anxiety among all motivational constructs in MILS:

R: So you were easy to feel nervous when you took exams?

S_{LE3}: Yes, I did not know how to answer the questions and there was nothing in my brain.

R: What was difficult for you to learn?

S_{LE3}: It was difficult for me to learn calculation.

R: Did the exams make you feel anxious throughout the semester?

S_{LE4}: Yes, I was afraid I could not calculate the questions and got bad scores.

R: Why did you not have confidence to learn science?

S_{LC2}: I did not learn well in the former units and I had problem on calculation when answering exam questions

(The teacher in school A)

T_A: In this unit on specific heat, basically the concepts were OK, but it has some calculation related to the mixture of the heat, I feel it was scary for most students. For middle and low achievers, they had problems on calculation.

Low achievers receiving inquiry-based instruction found the curriculum more fun than the ones receiving traditional teaching (see code "Curriculum fun" in all four interviews), possibly explaining they improved their learning actions (less passive) in the experimental group in the questionnaire finding. They thought they achieved hands-on activities, which helped their understanding, and they expected more (see code "Hands-on helps understanding" and "Expect hands-on" in unit aqueous solution and specific heat). These were triangulated by the quantitative findings that low achievers had better achievement goals and perception of their learning environment, and they found more value of science learning than their counterparts in the control group:

T_A: In the experimental group, low achievers usually followed high achievers' steps. However I asked low achievers if they felt fun, they said yes and they felt they achieved something. They believed they could do hands on by themselves.

R: Why did you think the curriculum was no fun?

S_{LC3}: I needed to calculate questions …I expect to do more experiments.

R: Do you think this unit was interesting?

S_{LE5}: It was fun because I did hands-on work. It helped my understanding.

R: What did you learn through the hands-on activities?

S_{LE6}: It helped me understand oil and water …which one has larger specific heat.

In addition, low achievers in the experimental group liked to ask others' assistance when they confronted difficulties in learning compared to those in the control group (see code "Ask peers to solve difficulties" in unit specific heat and code "Ask teachers to solve difficulties" in end of semester interview). The learning environment had more communication and was friendlier for them to motivate their learning as the questionnaire findings indicate:

R: How did teacher help your learning?

S_{LE7}: She encouraged me and said she could help me and teach me if I had any problems in learning.

R: Do you think you built up friendly learning environment for students?

T_B: Yes, I tried to build up more interaction with them. I asked questions to them and they also asked questions to me. I responded to their questions.

Discussion

The inquiry-based instruction provided learners opportunities to propose questions/problems and hypotheses, design and carry out experiments, analyze data, propose findings, communicate and discuss the findings, and make conclusions (NRC, 1996). These various activities can meet low and non-low achievers' learning demands and increase their motivation towards learning compared to traditional instruction. Unlike traditional instruction, inquiry-based instruction provides both achievers with more autonomy, and they have more options to choose to engage in various activities. Therefore, they were motivated and increased their expectancy to science class through the friendly learning environment in the experimental group. They improved their learning strategies and became more engaged in the instruction, confirming previous studies (Ibrahim et al., 2017; Kulo & Bodzin, 2013).

Previous studies have suggested the inquiry-based instruction benefits different achievers in their achievement tests in the secondary level (Kingir et al., 2012; Kulo & Bodzin, 2013; Marx et al., 2004). Our study provided evidence that the inquiry-based instruction increased different achievers' motivation towards science learning as well. Previous studies have also stated that inquiry-based instruction raises low achievers' interest, engagement, and career motivation (Burgin et al., 2015; Hayden et al., 2011; Kanter & Konstantopoulos, 2010; Meyer & Crawford, 2015). Besides theses aspects of motivation, our study found that inquiry-based instruction also strengthens low achievers' confidence to learn science, achievement goals and helps them recognize the value of science learning (i.e. the importance of their interest in science and the relation between science and life).

Low achievers in the experimental group had better confidence than those in the control group, as shown in students' interviews. Jen and Yong (2013) found a significant correlation between students' academic achievement and their confidence in science classes, implying low achievers in guided inquiry-based environment could perform better in their academic achievement than those receiving traditional teaching if they continue to learn in such environment.

Low achievers showed less passive learning behavior under inquiry-based instruction. Low achievers had a sense of belonging to their learning group and believed they could contribute to their ongoing task (Burgin et al., 2015), which could engage them in the inquiry process and make them more active in their learning behavior. Besides, the hands-on process made them feel fun and improved their understanding. This value was recognized by them, and their learning behavior was improved. If their teacher and peers further encourage and help them, their confidence in science learning can be raised.

Our findings show that hands-on experience and conceptual understanding motivate low and non-low achievers under inquiry-based instruction. Regarding hands-on experience, Fakayode, King, Yakubu, Mohammed, and Pollard (2011) found it motivated low achievers; however, their samples were adults. Our study indicates that the hands-on experience also motivated low achievers in the middle school level. For non-low achievers, not only conceptual understanding improved their motivation towards learning (Trifone, 2006), but also hands-on activities.

Various learning strategies motivated non-low achievers' science learning in the experimental group. Inquiry-based instruction established student-centered learning environment, and non-low achievers may hold constructivist epistemological beliefs in such environment. This belief may lead them to like and try various learning strategies when they learned science (Tsai, 1999). However, low achievers in inquiry teaching need to try to use more learning strategies because their construct "learning strategy" did not perform better than those in the control group.

Low and non-low achievers were frustrated by calculation as shown in the interview findings, possibly resulting in exam anxiety. Although they participated in the inquiry-based instruction, they still needed to take traditional exams, which emphasize calculation ability. They probably thought that what they learned from inquiry-based instruction did not help much in the traditional exams, and this perception may make them feel anxious about exams (Hong & Karstensson, 2002). In contrast to the control group, students in the experimental group had less opportunities to practice their calculation ability, possibly resulting that low and non-low achievers had higher exam anxiety than those in the control group. This perception may also reduce non-low achievers' value of science learning as presented in Table 1.

Conclusion and Suggestions

This study provided profiles of low and non-low achievers in regard to aspects of motivation towards science learning under inquiry-based instruction. We found that after implementing six units of inquiry-based instruction, non-low achievers improved their achievement goals and perception of their learning environment compared to their counterparts in the control group with statistical significance. Besides, non-low achievers benefited on their expectancy and learning strategies, and low achievers benefited on their confidence, value of science learning, achievement goals, learning strategies, and perception of learning environment, but these benefits did not show statistical significance in contrast to the ones in the control group. We suggest that longer intervention is needed in future studies to examine the benefits of inquiry-based instruction on different learners' motivation to science learning, especially for low achievers. In addition, hands-on activities and conceptual understanding can motivate all achievers. Various learning strategies can motivate non-low achievers' learning, and teachers and peers assistance can motivate low achievers' learning. For future inquiry-based teaching, we suggest that the instructors adjust their instruction to fit different achievers' learning needs. Finally, low and non-low achievers under intervention have higher exam anxiety in contrast to those receiving traditional teaching. Raising their ability to calculate could be a solution to reduce their exam anxiety.

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