A Comparison Study on the Influence of Implementing Inquiry-Based Instruction on Science Learning Motivation and Interest

Pai-Lu Wu[1], Liou-Chiao Wu[2], Wen-Ling Shih[3], Ming-Lung Wu[4]

[1] Professor, Center for Teacher Education, Cheng-Shiu University, [2] Associate Professor, Center for Teacher Education, Fooyin University, [3] Assistant Professor, Department of Business Administration, Cheng-Shiu University, [4] Associate Professor, Education Teacher Center, National Kaohsiung Normal University, TAIWAN.

ABSTRACT

The purpose of this study was to explore the influence of implementing inquiry-based instruction on science-learning motivation and interest. The participants included students from three maritime vocational high schools located north, west, and south of Taiwan. One of the schools (School A) is an experimental school assigned by the National Science Council for High School Programs; the other two (Schools B and C) are extension experimental schools for the promotion of the High School Program. The number of student participants from each of the three schools depended on the number of classes offered in the program; 80 students from two classes were included from School A, 40 students from one class from School B, and 120 students from three classes from School C.

The results showed that after participating in the implementation of inquiry-based instruction, science learning motivation and interest were both increased. Among them, School A achieved the best learning effect. Significant variation was observed in terms of self-efficacy and performance goals with regard to learning motivation; considerable differences in learning interests were also seen with respect to attitude towards science, learning atmosphere, learning difficulties, and learning commitment.

Keywords: Inquiry-based instruction, science-learning motivation, vocational high schools

INTRODUCTION

Teaching science as inquiry is an important pedagogical approach frequently discussed among science teachers (Whitworth, Maeng & Bell, 2013). The learning activities of science exploration benefit students by establishing critical thinking skills and constructing individual knowledge structures (Schneider, Krajcik, Marx, & Soloway, 2002). By allowing the students to develop problem-solving strategies, the students develop the initiative to pursue, discover, and evaluate answers, a "transferable capability", with far-reaching consequences for future learning endeavors.

"Inquiry" implies an active learning process that allows students to answer research questions using data analysis and information exchange (Bell, Smetana & Binns, 2005). Inquiry-based instruction is, therefore, student-oriented. However, the instructor may direct students at key times during the learning process, as required for optimal exchange, e.g., beginners may need more instruction initially to exercise their inquiries more effectively (Zangori, Forbes & Biggers, 2012).

Numerous studies have investigated inquiry-based instruction, revealing a positive effect on teaching and learning (e.g., Avery & Meyer, 2012; Marshall & Horton, 2011; Powell-Moman & Brown-Schild, 2011; Walker, McGill, et al., 2008). Other studies have emphasized that the professional growth of teachers plays a significant role (Powell-Moman & Brown-Schild, 2011; Singer, Lotter, et al., 2011).

Pea (2012) showed that the school environment, categorized into human and sociocultural factors, influenced the implementation of inquiry-based instruction. The human environment includes motivated students, student initiative and motivation, peer support and cooperative learning environments, support from school mentors (e.g., the superintendent, principal, and teachers), and the involvement of colleges. The sociocultural environment includes reduced class sizes, manageable teaching load/courses, a reduced amount of content to teach, extended class time, increased planning time, team planning time with other teachers, tutoring and after-school support for students, policies that support science teaching, state and national guidelines, special programs and PD to address diversity, and community involvement. Thus, various factors influence the effectiveness of inquiry-based instruction, and the school must consider all of these to develop and implement inquiry-based instruction.

The National Science Council (2014) of the Republic of China proposed the High School Program in 2006 to help middle-level schools use newly developed technology to design a curriculum that adopts inquiry-based instruction. The purpose of the program is to encourage self-motivated problem-solving capabilities in the students, to inspire curiosity and motivation with regards to science, as well as to establish a teaching model that facilitates exploration initiative and an appreciation for thinking in students.

It is considered an honor for a researcher to be selected to take part in the High School Program at the maritime vocational high school in Southern Taiwan, for the implementation of inquiry-based instruction. The teaching assignment is usually for a period of 2 years, after which, the instructor promotes experimental instruction at two other extension schools (one in the north and the other in the west) over the course of the third year of teaching. The three schools included in this study have various school environmental contexts. To understand the difference between learning motivation and interest, a relevant comparison has to be made; thus, this was one of the motives of this study. An additional motivation of this study was to better understand how the different school environments influence inquiry-based instruction, in particular, the learning motivation and interest of the students.

RESEARCH DESIGN AND IMPLEMENTATION

Research Design

The research design for this study, in the form of a pretest and post-test experiment intended for a single group, is detailed in Fig. 1.

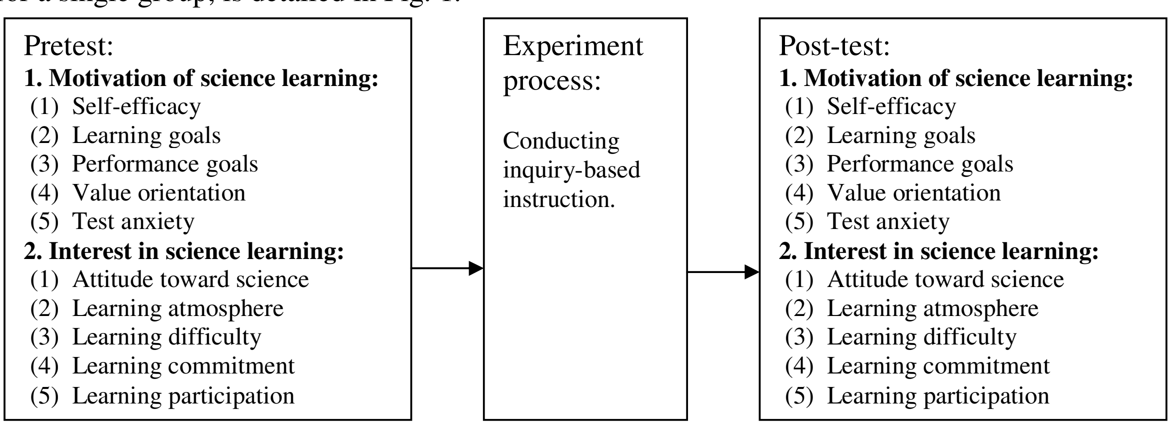

Figure 1. Research design of the study.

ISSN: 2186-845X ISSN: 2186-8441 Print
www.ajmse. leena-luna.co.jp

Participants

The teachers from the three schools participating in the study were all from the Department of Turbines. Because School A is a seed school, the teachers here must possess professional knowledge and are required to design the curriculum, as well as to share their teaching experiences with other teachers. After attending the inquiry-based instruction seminars, the teachers from Schools B and C asked for more teachers to participate in this inquiry-based instruction.

Eight teachers from School A formed a professional group that met three times monthly. At the group meetings held during the first year, one teacher would deliver a keynote speech, which was followed by two group activities lasting for a period of two hours. The effectiveness of the group meetings and the learning process involved were evaluated based on a self-made check index completed by the researcher, videotapes of the group during activities, a feedback list, a review of learning reports from the teachers, in-depth interviews, and observation. The professional learning group from School A continued its activities in the second year. Schools B and C established professional learning groups in the third year, lasting for 6 months, while carrying out inquiry-based instruction in the classroom. In total, 10 teachers participated in the study: two from School A (average age: 35 years), three from School B (average age: 33.3 years), and five from School C (average age: 39.8 years). All teachers in the study conducted inquiry-based instruction. School A had 80 students from two classes participate, School B was represented by 40 students from one class, and School C had 120 students from three classes participate. Purposive sampling was used for all students from the three schools listed above.

Description of Instruction

Eight teachers from School A were responsible for the research and development of lesson plans, teaching materials, and teaching aids during the first year. Two of the eight teachers from School A led the inquiry-based instruction in the second year; these teachers were in charge of promoting this instruction in Schools B and C in the third year. Three teachers from School B and five teachers from School C performed the inquiry-based instruction. In total, 10 teachers from the three schools implemented this experiment via 10 curriculums that focused on internship and project production. Students integrated and generalized the knowledge from the curriculum by observing, questioning, experimenting, defining the problem, questioning again and rethinking, verifying, explaining, and obtaining feedback.

Research Instruments: Questionnaire on Motivation for and Interest in Science Learning

The questionnaire used in this study to determine motivation for and interest in science learning was modified from the "Learning Motivation Scale for Elementary School Nature and Life Technology Courses" and the "Questionnaire on Learning Interest for Elementary School Science Courses" edited by Wu (2007), known for its excellent validity and effectiveness. The modified questionnaire adopted a five-point Likert scale; the higher the score, the higher the students' motivation and interest. For motivation for science learning, the questionnaire took into account self-efficacy, learning goals, performance goals, value orientation, and test anxiety. With regard to interest in science learning, the questionnaire included questions related to attitude towards science, learning atmosphere, learning difficulty, learning commitment, and learning participation.

School Environmental Context

The purpose of this study was to evaluate the effectiveness of the High School Program assigned by the National Science Council, emphasizing inquiry-based instruction for training students how to find, explore, and solve problems. School A, the experimental school, was responsible for integrating science into the vocational high schools; this responsibility included integration of emerging technologies with the International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers (STCW) and the application of green energy technologies to establish environmentally friendly protocols.

In setting up its curriculum example, School A focused on a maritime curriculum to elevate the professional growth of teachers and enhance the learning experience for students. After 2 years of hard work, outstanding results were achieved. Sixteen projects were produced and awarded the Best Actuating Unit Prize of 2012 Student's Contest of Handmade Ship Models. The students participated in SSH (Super Science High School) in Japan and achieved outstanding performance.

Schools B and C, extension vocational campuses of School A, are located north and west of Taiwan, respectively. School B is in the city and School C near the ocean. Both schools are maritime vocational high schools with an extended history. The teachers at School B and School C were very passionate about teaching and dedicated to creating enhanced learning experiences for their students.

Data Analysis

The data collected for this study were analyzed using SPSS software. The statistical analysis included descriptive statistics, calculations of the mean (*M*) and standard deviation (*SD*), and the Student's *t*-test.

RESEARCH RESULTS

Motivation For Science Learning

Table 1 shows the pretest and post-test Likert scores for the three vocational schools (Schools A, B, and C) regarding the motivation of the student to learn science. For School A, the self-efficacy, learning goals, performance goals, and value orientation pretest scores were 3.68, 4.03, 3.29, and 4.27, respectively; the corresponding post-test scores for School A were 4.17, 4.25, 3.76, and 4.33, respectively. Note that the post-test scores for these four categories were higher than the pretest scores. In contrast, the pretest score for test anxiety (a negative layer category) was 3.41, compared with the post-test score of 3.33. Thus, test anxiety decreased after conducting inquiry-based instruction.

For School B, the self-efficacy, learning goals, performance goals, and value orientation pretest scores were 3.20, 3.42, 3.11, and 3.58, respectively, with post-test scores of 3.44, 3.60, 3.36, and 3.71, respectively. Similar to School A, the post-test scores were higher than the pretest scores across the four areas tested. In this case, the pretest and post-test scores for test anxiety were 2.87 and 2.78, respectively, again showing a decrease in test anxiety levels following inquiry-based science instruction.

School C revealed self-efficacy, learning goals, performance goals, and value orientation pretest scores of 3.70, 3.78, 3.29, and 2.70, respectively, with post-test scores of 3.79, 3.82, 3.43, and 3.14, respectively. Similar to Schools A and B, the post-test scores were higher than the pretest scores. The pretest and post-test scores for test anxiety were 2.63 and 2.61, indicating a slight reduction in test anxiety.

To better understand the significance of various layers of science learning motivation with inquiry-based instruction, the Student's *t*-test was performed between sampling pairs after

Leena and Luna International, Oyama, Japan.
(株) リナアンドルナインターナショナル, 小山市、日本.
ISSN: 2186-845X ISSN: 2186-8441 Print
www.ajmse. leena-luna.co.jp

students completed the “Power Operation” course in the science curriculum (Table 1). Note that $p < 0.05$ indicated significance.

For School A, a significant difference was noted between students’ pretest and post-test scores for self-efficacy and performance goals ($t = -3.72$, $p < 0.01$ and $t = -2.98$, $p < 0.01$, respectively). However, this was not the case for learning goals and value orientation ($t = -1.39$, $p > 0.05$ and $t = -0.51$, $p > 0.05$, respectively) or for the anxiety scores ($t = -0.50$, $p > 0.05$).

Similar to School A, a significant difference was noted between students’ pretest and post-test scores for self-efficacy and performance goals ($t = -2.57$, $p < 0.05$ and $t = -2.22$, $p < 0.05$, respectively); however, learning goals and value orientation categories indicated no significant difference ($t = -1.85$, $p > 0.05$ and $t = -1.48$, $p > 0.05$, respectively). Likewise, students’ pretest and post-test scores for “test anxiety” indicated no significant difference ($t = -0.93$, $p > 0.05$).

For School C, similar to Schools A and B, a significant difference was indicated between students’ pretest and post-test scores for value orientation ($t = -3.51$, $p < 0.01$) but not for self-efficacy ($t = -0.46$, $p > 0.05$), learning goals ($t = -0.26$, $p > 0.05$), or performance goals ($t = -0.64$, $p > 0.05$). Likewise, students’ pretest and post-test scores for “test anxiety” revealed no significance ($t = -0.13$, $p > 0.05$).

Table 1. Student’s *t*-test analysis of the significant difference between students’ pretest and post-test scores on Vocational Students’ Motivation for Science Learning.

Motivation for science learning	*Schools*	*Pretest*		*Post-test*		*t-value*
		M	*SD*	*M*	*SD*	
Self-efficacy	A	3.68	0.58	4.17	0.54	−3.72**
	B	3.20	0.47	3.44	0.50	−2.57*
	C	3.70	0.65	3.79	0.58	−0.46
Learning goals	A	4.03	0.56	4.25	0.56	−1.39
	B	3.42	0.50	3.60	0.52	−1.85
	C	3.78	0.53	3.82	0.50	−0.26
Performance goals	A	3.29	0.33	3.76	0.67	−2.98**
	B	3.11	0.61	3.36	0.39	−2.22*
	C	3.29	0.711	3.43	0.68	−0.64
Value orientation	A	4.27	0.49	4.33	0.54	−0.51
	B	3.58	0.51	3.71	0.59	−1.48
	C	2.70	0.48	3.14	0.36	−3.51**
Test anxiety	A	3.41	0.47	3.33	0.57	0.50
	B	2.87	0.57	2.78	0.59	0.93
	C	2.63	0.79	2.61	0.69	0.13

N is the number; *M* is the mean; *SD* is the standard deviation.
N for School A = 20; *N* for School B = 30; *N* for School C = 18.
* $p < 0.05$; ** $p < 0.01$.

Interest In Science Learning

Table 2 the significant difference between pretest and post-test scores among the three vocational schools, with regards to students' interest in learning science. For School A, the pretest scores for "attitude towards science", "learning atmosphere", "learning commitment", and "learning participation" were 2.69, 3.20, 3.34, and 3.59, respectively; the corresponding post-test scores were 3.89, 4.05, 3.94, and 3.76, respectively. Similar to the results for motivation for science learning, the post-test scores were higher than the pretest scores across the four categories listed. The pretest and post-test scores for "learning difficulty" (a negative dimension) were 3.22 and 2.28, revealing a decrease in perceived "learning difficulty" after inquiry-based instruction.

Similar to School A, School B's pretest and post-test scores for "attitude towards science", "learning atmosphere", "learning commitment", and "learning participation" were 3.22, 3.38, 3.21, and 3.19, respectively and 3.48, 3.43, 3.27, and 3.34, respectively, indicating higher post-test scores in these areas. A slight decrease was observed between pretest and post-test scores for "learning difficulty", 3.10 compared with 3.09, respectively, indicating a slight improvement after conducting inquiry-based instruction.

For School C, the pretest and post-test scores for "attitude towards science", "learning atmosphere", "learning commitment", and "learning participation" were 3.13, 3.34, 3.33, and 3.20, respectively, and 3.39, 3.46, 3.34, and 3.24, respectively. The post-test scores were higher than the pretest scores for all four categories, similar to the results obtained for Schools A and B. The pretest score for "learning difficulty" was 3.22 and the post-test score was 3.14, indicating a decrease in perceived "learning difficulty" after receiving inquiry-based instruction.

The Student's *t*-test was performed between sample pairs of the five science-learning interest categories to determine whether or not a significant difference existed after students attended a "Power Operation" course. The test results are shown in Table 2.

For School A, significant differences between students' pretest and post-test scores were found for attitude towards science ($t = -6.39$, $p < 0.001$), learning atmosphere ($t = -6.36$, $p < 0.001$), learning commitment ($t = -4.51$, $p < 0.001$), and learning difficulty ($t = 5.68$, $p < 0.001$). However, a significant difference was not observed between students' pretest and post-test scores for learning participation ($t = -0.49$, $p > 0.05$).

The results of School B differed from those of School A. In this case, a significant difference between students' pretest and post-test scores was evident for attitude towards science ($t = -2.60$, $p < 0.05$); however, such was not seen in the other categories: learning atmosphere ($t = -0.56$, $p > 0.05$), learning difficulty ($t = 0.25$, $p > 0.05$), learning commitment ($t = -0.77$, $p > 0.05$), and learning participation ($t = -0.49$, $p > 0.05$).

For School C, significant differences could not be established between the students' pretest and posttest scores in any of the five categories: attitude towards science ($t = -1.51$, $p > 0.05$), learning atmosphere ($t = -0.70$, $p > 0.05$), learning difficulty ($t = 0.40$, $p > 0.05$), learning commitment ($t = -0.00$, $p > 0.05$), and learning participation ($t = -0.17$, $p > 0.05$).

Leena and Luna International, Oyama, Japan.
(株) リナアンドルナインターナショナル, 小山市、日本.
ISSN: 2186-845X ISSN: 2186-8441 Print
www.ajmse. leena-luna.co.jp

Table 2. Student's *t*-test analysis of the significant difference between students' pretest and post-test scores on Vocational Students' Interest in Science Learning.

Interest in science learning	*Schools*	*Pretest*		*Post-test*		*t value*
		M	*SD*	*M*	*SD*	
Attitude towards science	A	2.69	0.434	3.89	0.55	−6.39***
	B	3.22	0.54	3.48	0.58	−2.60*
	C	3.13	0.52	3.39	0.55	−1.51
Learning atmosphere	A	3.20	0.260	4.05	0.67	−6.36***
	B	3.38	0.46	3.43	0.45	−0.56
	C	3.34	0.78	3.46	0.62	−0.70
Learning difficulty	A	3.22	0.282	2.28	0.62	5.68***
	B	3.10	0.41	3.09	0.38	0.25
	C	3.22	0.69	3.14	0.77	0.40
Learning commitment	A	3.34	0.284	3.94	0.63	−4.51***
	B	3.21	0.34	3.27	0.42	−0.77
	C	3.33	0.46	3.34	0.94	0.00
Learning participation	A	3.59	1.27	3.76	0.58	−0.49
	B	3.19	0.46	3.34	0.45	−1.47
	C	3.20	0.52	3.24	0.76	−0.17

N is the number; *M* is the mean; *SD* is the standard deviation.
N for School A = 20; *N* for School B = 30; *N* for School C = 18.
* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

DISCUSSION

The purpose of this research was to examine the impact of inquiry-based instruction on science learning motivation and interest. The participants included students from three maritime vocational high schools located north, west, and south of Taiwan. The similarities and differences among the three schools are outlined below.

(1) Similarities

a. Inquiry-based instruction had a positive influence on students' learning motivation for all three schools. The average grades of the students increased. Significant variation was revealed between pretest and post-test scores for self-efficacy and performance goals for Schools A and B, and value orientation for School C.

b. A positive influence was evident between inquiry-based instruction and students' learning interest for all three schools. Again, the average grades rose. Significant variations were indicated in the comparison of pretest and post-test scores for attitude towards science, learning atmosphere, learning difficulty, and learning commitment for School A. For School B, significant variation was evident between pretest and post-test scores for attitude towards science.

(2) Differences

a. After implementing inquiry-based instruction, the effect on learning motivation was the same for Schools A and B; however, it had a varied impact on students at School C. Significant variations were observed in self-efficacy and performance goals in the pre-test and post-test scores for Schools A and B; however, this was not the case for School C. At School C, significant variation was indicated for value orientation.

b. Inquiry-based instruction seemed to have the greatest positive effect on the learning interest of the students at School A, followed by Schools B and C. Significant variations were revealed between the pre-test and post-test scores for attitude towards science, learning atmosphere, learning difficulty, and learning commitment at School A, and for attitude towards science at School B. No significant variations were found among the five categories for the learning interest of the students at School C. Consequently, School A had the best performance, followed by Schools B and C.

Our results indicated that inquiry-based instruction had a positive influence on students' learning motivation and interest. The study results are similar to those of Avery & Meyer (2012), Marshall & Horton (2011), Powell-Moman & Brown-Schild (2011), and Walker, McGill, Buikema & Stevens (2008). Additionally, the results from this study showed that inquiry-based instruction had various impacts on students' learning motivation and interest at different schools, and they verified the significance of the school environment context with regard to the implementation effect provided by Pea (2012). In this study, different environments profoundly influenced the effects of inquiry-based instruction in these three schools. For example, School A was an experimental school, where teachers were responsible for the success or failure of the High School Program. The 1-year operation of the professional learning group gave teachers the opportunity to fully understand this instruction; they achieved the best effect with program implementation. In contrast, School B, a city school, was an extension program of the experimental school (School A). At School B, only one class carried out the inquiry-based instruction; this instruction was applied in three curriculums within one semester, explaining the effect that was achieved. School C, located near the ocean, was also an extension of the experimental school. For School C, only one curriculum included inquiry-based instruction in three classes within one semester; consequently, the desired effect could not be achieved.

Leena and Luna International, Oyama, Japan.
(株) リナアンドルナインターナショナル, 小山市、日本.
ISSN: 2186-845X ISSN: 2186-8441 Print
www.ajmse. leena-luna.co.jp

REFERENCES

[1] Avery, L. M., & Meyer, D. Z. (2012). Teaching Science as Science Is Practiced Opportunities and Limits for Enhancing Preservice Elementary Teachers Self-Efficacy for Science and Science Teaching. *School Science and Mathematics, 112*(7), 395-409.

[2] Bell, R. L., Smetana, L., & Binns, I. (2005). Simplifying inquiry instruction: Assessing the inquiry level of classroom activities. *The Science Teacher, 72*(7), 30-33.

[3] Marshall, J. C., & Horton, R. M. (2011). The relationship of teacher-facilitated, inquiry-based instruction to student higher-order thinking. *School Science and Mathematics, 111*(3), 93-101.

[4] National Science Council, Taiwan. (2014). Retrieved March 10, 2014, from http://w1.ceels.org/highscope/web/modules/tinyd0/

[5] Pea, C. H. (2012). Inquiry-based Instruction: Does School Environmental Context *Matter? Science Educator, 21*(1), 37-43.

[6] Powell-Moman, A. D., & Brown-Schild, V. B. (2011). The Influence of a Two-Year Professional Development Institute on Teacher Self-Efficacy and Use of Inquiry-Based Instruction. *Science Educator, 20*(2), 47-53.

[7] Schneider, R. M., Krajcik, J. Marx, R. W., & Soloway E. (2002). Performance of students in project-based science classrooms on a national measure of science achievement. *Journal of Research in Science Teaching, 39*(5), 410-422.

[8] Singer, J., Lotter, C., Feller, R., & Gates, H. (2011). Exploring a Model of Situated Professional Development Impact on Classroom Practice. *Journal of Science Teacher Education, 22*, 203-227.

[9] Walker, C. L., McGill, M. T., Buikema, A. L., & Stevens A. M. (2008). Implementing Inquiry-Based Learning in Teaching Serial Dilutions. *Journal of College Science Teaching. 37*(6), 56-61.

[10] Whitworth, B. A., Maeng, J. L., & Bell, R. L. (2013). Differentiating inquiry. *Science Scope, 37*(2). 10-17.

[11] Wu Shih-Hsun (2007). *A study of the Han nationality students and the aboriginal students on their learning motives and learning interests in the science course*. Thesis, Graduate Institute of Mathematics and Science Education, National Pingtung University of Education, PingTung, Taiwan.

[12] Zangori, L., Forbes, C., & Biggers, M. (2012). This is inquiry ... right? Strategies for effectively adapting elementary science lessons. *Science and Children, 50*(1), 48-53.