The Effects of Integrating Information Literacy into Inquiry Learning: A Longitudinal Study

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Abstract. The purpose of this study was to examine the effects of four-year integrated information literacy instruction on elementary students' comprehension of subject contents through inquiry learning. Moderating factors of students' academic achievements was another focus of this study. The subjects were 72 students who have participated in this study since they entered an elementary school. This elementary school adopted the information literacy instruction and integrated it into various subject matters via the framework of inquiry learning, such as Super 3 and Big6 models. A total of seven inquiry learning projects have been implemented from grade one through grade four. The results show that inquiry-based integrated information literacy instruction could help students from grade one through grade four grasp and apply the new concepts of subject contents. Regardless of academic achievements, if students would like to devote their efforts to inquiry processes, their conceptual understanding of subject contents improved effectively.

Keywords: Information literacy, inquiry-based learning, comprehension, academic achievement, longitudinal study.

1 Introduction

Information literacy is the abilities to recognize, locate, evaluate, use and create effectively the need information [1]. Many studies find that information literacy instruction should be integrated across the contexts of school curriculum, through inquiry-based learning [2-3]. Inquiry-based learning results better knowledge application and reasoning skills, but performs less well in basic or factual knowledge acquisition than traditional curriculum [4-5]. Studies also find that students of different academic achievements may perform differently in integrated information literacy instruction [6-8]. However, the above mentioned studies most are conducted in a short term; few investigate the effects of information literacy instruction in a longer period of time.

The purpose of this study is to investigate the effects of four-year integrated information literacy instruction on elementary students' comprehension of subject contents through inquiry-based learning. The moderating factor of students' academic

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achievements is another focus of this study. Specific problems related to the purpose are as follows:

- How do students comprehend subject matters in the four-year integrated information literacy instruction?
- Do students of different academic achievements comprehend subject matters differently in the four-year integrated information literacy instruction?
- How does the comprehension learning trend differ among students of different academic achievements in the four-year integrated information literacy instruction?

2 Literature Review

2.1 Information Literacy Instruction

Information literacy instruction is a valuable and essential part of the school's program. It emphasizes both problem solving processes and multiple literacies of library, media, and computer [1-2]. Information literacy instruction has been shown to be more effective when taught as an inquiry process combined with classroom subject contents [2-3], [6].

Many researchers indicate that information literacy should be taught systematically from elementary school level [1-2]. Callison [9] even suggests for more quantitative data and rigorous experimental research methodology as strategies for convincing school administrators of the benefits of information literacy instruction on student learning. However, the majority of previous studies in information literacy have been sporadic and in a short term; few studies systematically develop and evaluate the overall effectiveness of information literacy instruction on student learning.

2.2 Inquiry-Based Learning

The teaching of information literacy can be enhanced by the use of inquiry-based learning. The main purpose of inquiry-based learning is to teach students how, rather than what, to learn; it requires students to take active responsibility for their own learning and to apply concepts in a new situation [10].

Instruction based on inquiry is most advocated in science education by the National Research Council. It is believed that inquiry learning promotes a deeper understanding of the subject matter through the process of questioning, seeking evidence, developing explanations, evaluating the explanations, and communicating conclusions. In recent years, inquiry-based learning has also gained attention in social science instruction. Soares and Wood [11] advocate that every citizen should become problem solvers who collect, evaluate and apply data critically, in order to solve problems faced in today's democratic society.

Eisenberg and Berkowitz [12] develop an inquiry-based Big6 model for integrating information literacy into subject matters [13]. Afterwards, Eisenberg and Robinson construct the Super3 model, which includes three stages of Plan, Do and Review for young learners to start thinking in terms of process. Several studies confirm that

the Big6 and Super3 models could improve students' learning in information literacy and subject contents [2], [14].

2.3 Comprehension

Comprehension emphasizes transferring conceptual understanding in a new context through cognitive processes of interpreting, exemplifying, inferring, and comparing [15]. A number of meta-analysis has focused on the effects of inquiry-based learning on cognitive learning. Schroeder et al. [16] analyze 61 U.S. studies dealing with science teaching strategies and student achievement published from 1980 to 2004. They find that the effect size of inquiry learning strategy on student cognitive achievement is 0.65, which is judged to be significant. That is, inquiry-based science learning exhibits a positive influence on student achievement.

With respect to comprehension of student achievement, Wilson, Taylor, Kowalski and Carlson [17] randomly assign 58 students aged 14-16 years old to inquiry-based learning group or traditional learning group. The results show that students in the inquiry-based group outperform the traditional group in scientific knowledge, reasoning, and scientific explanations. A qualitative research by Chen [2] investigates third-grade students' performance on an integrated information literacy instruction in science curriculum. It shows that students' science learning on both memory and comprehension improved through inquiry learning.

On the other hand, Chang and Mao [4] investigate the effects of an inquiry-based teaching in earth science and find that significant higher achievement scores only at the comprehensive test, not at the factual level. Wolf and Fraser [5] also compare the differences between inquiry and non-inquiry learning in scientific inquiry skills and scientific concepts. Both studies do not find significant differences.

Thus, it is not completely clear whether inquiry-based integrated information literacy instruction can improve students' comprehension of subject matters. More research should be conducted to explore this issue.

2.4 Students of Different Academic Achievements

Students of different academic achievements is another issue examined in the research on inquiry-based information literacy instruction. Cuevas, Lee, Hart and Deaktor [7] conduct the instructional intervention which incorporates science inquiry and information literacy for 25 third and fourth graders of diverse backgrounds. The results demonstrate that the intervention enhanced the inquiry ability of all students regardless of achievements. Particularly, low-achieving students make larger gains compared to the high-achieving students. However, a limitation to this study is the small sample size. Therefore, further research may need to verify the conclusions.

However, Chu [6] uses an inquiry project-based learning approach to examine the subject learning performance of fourth graders of different academic abilities. Surveys and interviews are conducted with students. Their perceived improvements in learning are not affected by the level of academic ability. Chu concludes that students benefit

from inquiry-learning regardless of their innate abilities. Both high achievers and lower-tier students improve their skills by participating in inquiry-driven projects.

In sum, for lack of thorough and conclusive empirical evidences concerning the effect of integrating information literacy into inquiry learning on students' subject learning, more research needs to be conducted to explore this issue.

3 Methodology

Researchers collaborated with classroom teachers and school librarians to develop the inquiry-based information literacy instruction and integrated it into various subject matters year by year. All participants received a pretest, the integrated instruction, and a posttest each semester since grade one. The tests were designed to test participants' comprehension of the instructional contents. This research was a longitudinal study.

3.1 Research Site and Participants

The study was conducted at Chiachia Elementary School (a pseudonym), which was in the urban southern part of Taiwan. Since 2005, this school has adopted the information literacy instruction and integrated it into various subject matters. The instruction was taught once a week from grade one to grade two, and twice from grade three through grade six. Each period was forty-minutes. The participants were 72 students, who have enrolled in this study since they were first graders entering the elementary school. According to their performance in five subject areas (Chinese, mathematics, life, science, and social studies) for the past four years, participants were divided into three groups of low, medium, and high-academic achievement students.

3.2 Instructional Contents

The information literacy instruction was integrated into subject matters via inquiry-learning frameworks of Super3 and Big6 models. A total of seven inquiry projects had been carried out in each semester since the second semester of first grade. The inquiry themes involved relevant units in subject matters, so that students could apply the information literacy skills in real situations. In other words, the integrated information literacy instruction provided students with meaningful learning contexts to inquire interesting problems. The details were listed in Table 1.

3.3 Instrument

Seven instruments were used as pretests and posttests to assess students' comprehension of subject contents in different projects. There were various types of questions in the instruments, such as multiple-choice, fill-in-the blank, essay, drawing, etc. The Cronbach α reliability coefficients of seven tests were from .710~.785. The discrimination coefficients of seven tests ranged from .217 to .600.

3.4 Data Collection and Analysis

Data sources for this study were scores from the instruments. Data were collected over 4 years from 7 inquiry projects and analyzed by SPSS 20. Paired sample *t* tests were conducted to measure students' improvements in comprehension between pretests and posttests. Since the item numbers were different among the seven instruments, the test scores all were transformed into standard T scores, and pair-wise comparisons (i.e. low-achieving group vs. medium-achieving group) were used to obtain the differences between them. Then effect sizes (*Cohen's d*) were calculated in order to determine the relative magnitudes of experimental treatments and to judge the practical meaningfulness of the results derived. At last, the effect size values were plotted out in a run chart which displayed four-year trend among students of different academic achievements. According to the effect size index in Cohen [18], effect size less than .20 is a trivial effect which has no practical significance, and effect sizes of .20, .50, and .80 are viewed as small, medium, and large effect sizes, respectively.

Table 1. Details about inquiry projects

Grade/Semester	*Super3/Big6*	*Theme*	*Subject*
G1/2nd S.	Super3	Investigation of Life on Campus	Life
G2/1st S	Super3	Our Community	Life
G2/2nd S	Super3	Folklore & Festival	Life
G3/1st S	Super3	My Plant Friend	Science
G3/2nd S	Big6	My Home Town	Social Studies
G4/1st S	Big6	Our Aquarium	Science
G4/2nd S	Big6	My Insect Friend	Science

4 Results

4.1 Students' Comprehension in the Inquiry-Based Learning Projects

The results of paired-sample *t* tests for seven pre-tests and post-tests in the inquiry-based projects are presented in Table 2. The obtained *t* values were all significant which meant all students improved in comprehending subject contents. Based on the effect size index in Cohen [18], there were 5 large and 2 medium values among 7 *Cohen's d* effect sizes. It meant that there existed non-ignorable significant improvements of comprehension in practice, especially for the "*My Plant Friend*" project in science subject and "*My Home Town*" in social studies of third grade (*Cohen's d* equal to 1.652 and 1.758, respectively). Thus, in four years, the integrated information literacy instruction had had a positive effect on students' ability to comprehend subject-matter contents associated with relevant inquiry topics. This finding confirms many researchers' claims that inquiry-based learning can help deep learning and concepts transferring [2], [10].

4.2 Comprehension Differences in Students of Different Academic Achievements

For further understanding learning differences among students of different academic achievements, paired *t* tests for pretests and posttests on seven inquiry projects were conducted respectively. As shown in Table 3, among 21 *t* test results, most were significant except students of high academic achievement in "*Our Aquarium*" project (*t*= 1.80, *p*=.08). Based on Cohen's effect size index, regardless of low-, medium- and high-achieving students, the numbers of large effect size were more than the numbers of medium and small effect size (17, 3 and 1 respectively). The medium achievers progressed with the highest level of improvement (averaged *Cohen's d* = 1.290*).* The comprehension performances of high achievers reached great improvement with a value of 1.117 of averaged *Cohen's d.* Even for the low-achieving students, they also displayed a high level of progression (averaged *Cohen's d* = 1.116) after receiving the information literacy instruction. It implies that the instructional interventions could improve effectively students' comprehension learning, regardless of their academic achievements.

Table 2. Paired-sample *t* tests for seven inquiry-based projects (N=72)

Grade/	Pre-test		Post-test		t	p	Cohen's	Effect
Semester	M	SD	M	SD			d	Size
1/2	21.03	5.22	24.54	4.03	6.70	.00	0.788	M
2/1	29.79	8.90	37.60	7.74	7.03	.00	0.829	H
2/2	14.36	5.64	18.68	5.30	7.98	.00	0.940	H
3/1	8.64	4.05	17.24	5.22	14.02	.00	1.652	H
3/2	13.58	4.22	23.21	5.32	14.90	.00	1.758	H
4/1	34.89	13.07	43.36	13.29	5.69	.00	0.671	M
4/2	14.75	6.37	22.29	5.67	11.58	.00	1.364	H

$\alpha = .05$

4.3 Comprehension Learning Trend Analysis

From the previous results in section 4.2, we found that medium-achieving students displayed most progress, and the low achievers displayed equivalent progress with the high-achieving students. It is interesting to investigate how the lower achieving students progressed to reach to the comprehension ability levels of higher achievers. Thus, we further examined the trends of effect sizes across the four years by comparing the posttest scores between two groups, e.g. low vs. medium (L-M), medium vs. high (M-H), and low vs. high (L-H) (see Figure 1).

For the comparisons between the L-M, the posttest scores were not significantly different for Grade 1 (*t*=1.228, *p*=.226, *Cohen's d*=0.367), but were significantly different for Grade 2 (*t*=2.488, *p*=.017, *Cohen's d*=0.743), Grade 3 (*t*=3.015, *p*=.004, *Cohen's d*=0.902), and Grade 4 (*t*=2.634, *p*=.011, *Cohen's d*=0.787). For the M-H comparisons, there were not significantly different for Grade 1 (*t*=1.54, *p*=.130, *Cohen's d*=0.438) and for Grade 4 (*t*=0.490, *p*=.627, *Cohen's d*=0.144), but were

significantly different for Grade 2 (t=4.716, p<.001, *Cohen's d*=1.339) and Grade 3 (t=2.078, p=.043, *Cohen's d* =0.590). Finally, all the comparisons of comprehension learnings for the L-H were significantly different for Grade 1 (t=2.345, p=.026, *Cohen's d*=0.763), Grade 2 (t=7.341, p<.001, *Cohen's d*=2.275), Grade 3 (t=4.845, p<.001, *Cohen's d*= 1.502), and Grade 4 (t=2.426, p=.020, *Cohen's d*=0.752).

Table 3. Paired-sample t tests for students of different academic achievements

G/S	A.A.	N	Pre-test		Post-test		t	p	Cohen's d	Effect Size
			M	SD	M	SD				
1/2	L	20	17.30	6.48	22.90	5.10	4.09	.00	0.914	H
	M	28	21.46	4.04	24.50	3.70	4.72	.00	0.893	H
	H	24	23.63	3.31	25.96	2.85	3.43	.00	0.699	M
2/1	L	20	24.75	8.61	34.65	7.26	4.27	.00	0.955	H
	M	28	29.68	8.64	36.50	7.28	3.77	.00	0.711	M
	H	24	34.13	7.34	41.33	7.46	4.17	.00	0.850	H
2/2	L	20	10.15	4.55	14.40	4.84	5.04	.00	1.128	H
	M	28	13.29	4.59	17.96	4.10	4.97	.00	0.938	H
	H	24	19.13	3.98	23.08	3.28	3.96	.00	0.806	H
3/1	L	20	7.60	3.75	14.55	4.21	5.81	.00	1.300	H
	M	28	7.79	3.56	16.11	5.10	8.07	.00	1.525	H
	H	24	10.50	4.31	20.79	4.24	11.39	.00	2.323	H
3/2	L	20	11.65	5.02	19.45	5.74	5.56	.00	1.244	H
	M	28	13.61	4.06	24.93	3.87	12.48	.00	2.358	H
	H	24	15.17	3.00	24.33	5.05	8.71	.00	1.777	H
4/1	L	20	28.15	10.81	37.40	17.61	3.07	.01	0.686	M
	M	28	33.75	11.33	45.32	9.76	4.94	.00	0.934	H
	H	24	41.83	13.73	46.04	11.57	1.80	.08	0.369	L
4/2	L	20	12.25	4.48	19.80	3.64	7.09	.00	1.585	H
	M	28	14.68	5.29	22.86	4.25	8.83	.00	1.669	H
	H	24	16.92	8.09	23.71	7.70	4.89	.00	0.997	H

α＝.05, G/S represents Grade/Semester. A.A. represents Academic Achievement.

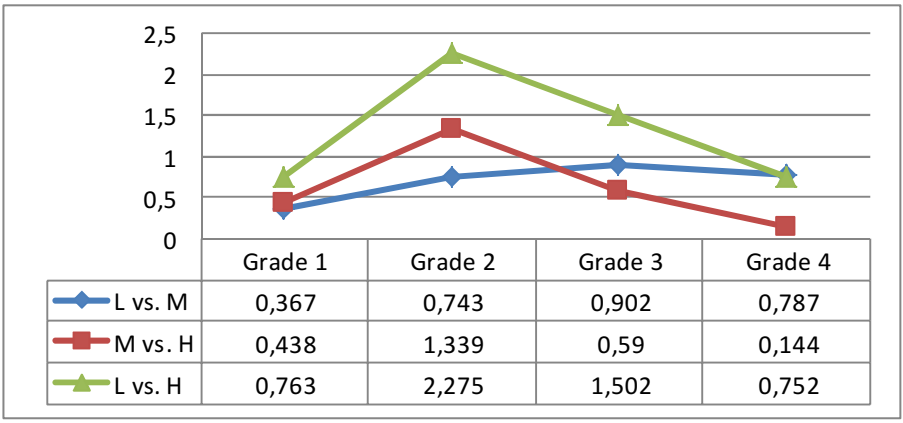

Fig. 1. Trends of effect sizes in group comparisons across grades

All the three trends of effect sizes seemed to increase in Grade 2 and then to decrease from Grade 3 to Grade 4. This means that the discrepancies of comprehension capability between lower and higher levels of academic-achieving students were first enlarged but shrunk later after integrating information literacy into the inquiry projects during the four years. In other words, the lower levels of academic-achieving students may be not familiar with comprehension learning in the information literacy instructions at the beginning, but they can progress and reach to the level of high academic-achieving students in one or two years later. The scenario of progressions on comprehension ability is specially manifested for the medium-achievers to reach to level of the high achievers. As for the low-achieving students, the instructional intervention helps them draw near the comprehension levels of their medium- and high-achieving peers; however, the effect sizes of L-M and L-H in grade 4 still are medium magnitude (*Cohen's d*=0.787 and 0.752, respectively), which have practical significance. Thus, it implies that low-achieving students may need more time to get familiar with inquiry-based learning strategy.

5 Discussion and Conclusions

In the four-year integrated information literacy instruction, students performed well in comprehending subject contents. Therefore, integrating information literacy into inquiry learning can help elementary students comprehend subjects' concepts and apply them in new situations. These findings are similar to the results found by previous researchers [2], [10]. That is, during inquiry, students actively engage in higher level thinking, i.e. posing real questions, comparing a variety of related information. In fact, in the four-year integrated information literacy instruction, the selection of inquiry topics and design of instructional activities were both completed via constant dialogues among researchers, classroom teachers and librarians. Thus, the integrated instruction matched the elements for building inquiry motivation proposed by Thomas, Crow and Franklin [19]. The elements included choice of topics, ties between course content and research topics, explicit goals and evaluation criteria, etc.

Regardless of their academic achievements, it was found that if students devote their efforts to inquiry processes, their conceptual understanding of subject contents improves effectively. Low-achieving students were still behind other levels of achievers in comprehension learning. These results confirm Hung's claim [20] that students of low-academic achievements might need more time to be familiar with inquiry-based learning strategy.

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