The Effects of Integrating Information Literacy into Science Instruction on Seventh-Grade Students’ Problem-Solving and Academic Achievement

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Abstract-- The purpose of this research was to investigate the effects of integrating information literacy into science instruction on students’ problem solving and science learning. In this quasi-experimental study, two 7th-grade classrooms from a public junior-high school were randomly assigned into the experimental group and control group. The former accepted an inquiry-based science curriculum infused information literacy using the Big6 model, while the latter accepted the traditional lecture-oriented instruction. The instructional unit in both groups was taught by the same teacher and lasted around five weeks. Three tests were administered before and after the instruction to test students’ problem-solving, memory and comprehension. Results from the analysis of covariance showed that the experimental group significantly outperformed their counterparts on problem-solving and comprehension learning, while not on the memory.

Keywords: information literacy; inquiry learning; Big6 model; problem-solving; science

I. INTRODUCTION

Information literacy is crucial for successful survival in today’s knowledge society [1]. Many studies suggest that the teaching of information literacy should be integrated into the regular curriculum using inquiry-based learning [2][3][4]. Iley[5], MacDonell [6] even advocate teachers giving young learners the opportunities to solve problems in order to improve their information literacy, and lay the foundation for more complex problem-solving situations in their lives. However, the results are not consistent with related studies which investigate the effects of inquiry-based and problem-solving learning on students’ deep thinking and factual knowledge acquisition [7][8][9].

Thus, the Big6 model is used as the framework for this study to examine the effectiveness of an inquiry-based approach in guiding students through problem solving and improving lower- and higher-order learning of subject matters. The Big6 model, created by Eisenberg and Berkowitz, is selected mainly because there are only six steps in this model, and it is easy for children and teenagers to remember and relate to [10]. However, there is only a limited amount of research into what constitutes an effective Big6 model, and few empirical studies of this model’s effects on problem solving and subject content learning [11][12]. This study would like to investigate this issue by conducting an experiment in two junior-high classrooms, which accept a science curriculum infused information literacy using the Big6 model, and the conventional teaching instruction, respectively. Students’ problem-solving skills, factual knowledge learning and concept understanding are the focuses for this study.

II. LITERATURE REVIEW

A. Integrating information literacy into instruction

Since the concept of information literacy was introduced in 1970s, it has been promoted by
numerous countries around the world. United Nations Educational, Scientific and Cultural Organization even suggests every nation should develop information literacy initiatives in the four key domains of education, health, business, as well as citizenship, so that their citizens can perform competitively and productively in a 21st century global information society [13]. In other words, information literacy is considered as the important basis for lifelong learning in the age of knowledge-based economy. Furthermore, the American Association of School Librarians (AASL) has developed new learning standards, entitled Standards for the 21-Century Learners, which expand the definition of information literacy to multiple literacies, including digital, visual, textual, and technological, which are crucial for all learners to be successful in the present society [1]. However, how can we teach our children to be information literates? In which ways the information literacy can be integrated into the school curriculum?

Information literacy is the abilities to recognize, locate, evaluate, use and create effectively the needed information [14][1]. Since these abilities are not equal to disconnected skills (such as computer skills), many studies suggested that information literacy is most effectively taught as an integral part of content learning, because the existing learning situations can provide meaningful environments for students practicing the above abilities [2][3][4][15]. In other words, the course-integrated instruction can improve students’ information literacy by delivering instruction at their point of needs and recognize the real needs to link information literacy to the contexts of an assignment or a subject area.

Furthermore, there is a large body of studies on information literacy finding that information literacy instruction should be integrated across all content areas through inquiry-based or problem-solving learning [4][10][16][17][18][19][20]. Inquiry learning is not a method of doing activities merely; rather, it is an approach to the chosen themes in which the posing of real questions and using a variety of sources of information are positively encouraged by teachers. During inquiry, students work alone or in groups to actively discover, explore, quest, understand, synthesize, and create new deep understanding, while teachers play two key roles that are very different from the instructor role in the conventional teaching situation. Teachers in inquiry learning are facilitators, who motivate students to develop the higher level thinking, and resource specialists, who provide the needed resources for students.

The Big6 model, developed by Eisenberg and Berkowitz [21], is one of the inquiry process models used by practitioners and researchers for integrating information literacy into curriculum [17][22]. This model provides a framework for students to learn how to complete a task or make a decision. The Big6 has six stages: Task Definition, Information Seeking Strategies, Location & Access, Use of Information, Synthesis and Evaluation. At the beginning of problem solving process, the scope of problem should be defined clearly and concept mapping is an effective tool in this phase. Later, students can broadly search for information from books, journals, films, internet, and even interviewing experts. After locating and accessing the needed information, students read them and extract the appropriate ideas. While using the information, strategies such as note-taking and summarizing are required. Students then synthesize all the information, draw conclusions about the problem and present their findings with proper media. Finally, students reflect on their performance by self-assessing the product and process. Students must recognize if the problem has been solved based on the stated criteria, and what they might do differently next time.

Although the Big6 model seems to be implemented easily for learners, few empirical studies so far have investigated its effects on students’ problem solving and learning in subject areas. And which subject content suitable for integrating information literacy by inquiry learning has not been examined entirely neither.

B. Science as inquiry

According to the National Science Education Standards [23], inquiry is an important teaching method in science. It involves various classroom activities, such as posing questions, making observations, examining books and other sources of information, analyzing data, and
communicating the results. Audet and Jordan [24] stressed that teachers should lead students to ask questions and make discoveries in search for new understanding of science. Hung [25] provided eighth graders with inquiry experiences and found that their abilities of formulating alternative hypotheses, designing experiments, etc. were better than the control group who designed the experiment based on the textbook only. In fact, the scientific inquiry is congruent to the concept of information literacy, because they both emphasize the reasoning and critical thinking. Therefore, we may integrate information literacy into science curriculum through inquiry-based strategy to improve students’ science learning.

National Research Council [23] underscored that student understanding of inquiry could not develop in isolation from science subject matter. In other words, scientific knowledge still remained important. Several meta-analyses showed that inquiry-based teaching produced positive results on cognitive achievement, process skills, higher order skills, and attitudes toward science [26][27][10]. Haury [28] reviewed many related studies and concluded that inquiry-oriented teaching could result in outcomes that included scientific literacy, familiarity with science processes, vocabulary knowledge, conceptual understanding, critical thinking, and positive attitudes toward science. Minner, Levy and Century [9] also emphasized that having students actively think about and participate in the investigation process increased their science conceptual learning.

However, Chang and Mao [8] investigated the effects of an inquiry-based teaching in earth science and found that significant higher achievement scores only at the comprehensive test, not at the factual level. National Research Council [23] also claimed that inquiry-based teaching may not be appropriate for the goal which was for students to memorize information. In addition, an inquiry-based study conducted by Brickman, Gormally, Armstrong, and Hallar [29] discovered greater improvements in inquiry students’ science literacy and research skills, but these students gained less self-confidence in scientific abilities compared to the traditional students. Furthermore, the roots of both inquiry-based and problem-based approaches can be traced back to the progressive movement, especially to John Dewey’s belief [30]. Their common characteristics included learner-centered, active learning, as well as real and ill-structured problems. In fact, similar research results of inquiry learning were also found in the problem-based learning studies (PBL). Reviewing problem-based learning research from the past 30 years, Hung, Jonassen and Liu [31] concluded that PBL curricula resulted better knowledge application and clinical reasoning skills, but performed less well in basic or factual knowledge acquisition than traditional curriculum. On the other hand, Strobel and Barneveld [32] used a qualitative meta-synthesis approach to compare the findings of the meta-analytical research on the effectiveness of PBL. They found that problem-based learning was superior when it came to long-term retention, skill development and satisfaction of students and teachers, while traditional approaches were more effective for short-term retention.

C. Information problem-solving

Isaksen, Dorval and Treffinger [33] define problem solving as a process of closing the gap between what is and what is desired. However, information problem-solving (IPS), the Big6 model emphasizes, involves a set of information-based practices, which are define information problem, search information, scan information, process information, as well as organize and present information[34]. Students would understand that they must make effective choices in each step during the information problem-solving process. Thus, IPS is a central focus of information literacy instruction on the K-12 level [35].

However, IPS has been given little attention in school, and direct instruction about these skills is rarely provided in curricula. Many studies showed that children, teenagers and adults have trouble with solving information problems [36] [37]. These studies advocate that there is a need to find better methods to mediate IPS instruction.

Though the Big6 is an information problem-solving model, would students’ problem solving
skills be improved through the inquiry process using Big6 model? This is another issue this study would like to explore.

III. RESEARCH QUESTION

The purpose of this study was to investigate the effect of integrated information literacy in seventh-grade science curriculum on students’ problem-solving and science learning. Specific problems related to the purpose were as follows:

1. Does the integrated information literacy instruction have an effect on students’ problem-solving ability?
2. Does the integrated information literacy instruction have an effect on students’ ability to memorize the science content associated with the topic?
3. Does the integrated information literacy instruction have an effect on students’ ability to comprehend the scientific concepts associated with the topic?

IV. METHODS

A. Participants

Participants for the study consisted of two seventh-grade classrooms from a public junior-high school in a rural area of Taiwan. Each classroom had 30 students and gender was equally distributed. They all were average students.

B. Instructional Content

The instructional content for this study was the unit of Heredity, based on the seventh-grade science textbook. An inquiry-based science curriculum infused information literacy was delivered to the experimental group. It was designed according to the Big6 model. First, the science teacher motivated students to inquire the physical characteristics which could differentiate ourselves from others, so that each group of students could pose questions relating to the concept of heredity for inquiring. The teacher clearly stated the criteria for the task and provided examples with different levels of quality. This was the Task Definition stage based on the Big6 model. Then, in the stages of Information Seeking Strategies, Location & Access, and Use of Information, under the teacher’s guidance, students tried to find the answers to the questions through using books, magazines, as well as computers. Then, they put all of the information from the different sources into a report and presented to their peers. Finally, they reviewed their own performance during the process and wrote down their reflection in their journals. It was the Evaluation stage. However, if students could not find suitable answers to the questions, or read some information more interesting, they could always go back to the Task Definition stage to change their questions. In other words, the Big6 process was not linear or in a restrictive order. In the whole learning process, the teacher’s role was as a guide on the side-lines who encouraged students and provided support in report preparation and oral presentations.

On the other hand, the control group was exposed to the traditional method on the same instructional content used for the experimental group. The traditional method was teacher-centered and lecture oriented. The teacher provided the students with clear and detailed explanation, but did not ask students to raise questions, nor need to find answers through reading, viewing, and observing. The classroom activities mostly focused on memorizing the factual knowledge about heredity.

This unit in both experimental and control groups was taught by the same science teacher around five weeks, 3 periods of time per week. Each period of time was 45 minutes.

C. Research Instruments

1) The New Problem-Solving Test: It was designed, by Jan and Wu [38], to test students how to define a question, propose solutions, and avoid facing the same problems. Its reliability was .91 (Cronbach’s α = .91).

2) The Memory Test: There were 25 multiple-choice items, designed by the researcher, which measured students’ recall of the learned subject content. Its reliability was .853 (Cronbach’s α = .853).

3) The Comprehension Test: It was composed of 22 multiple questions, designed by the researcher, which required students to transfer their understanding of scientific concepts covered
D. Procedure

Two seventh-grade classrooms from a public junior-high school were selected and randomly assigned to the experimental group and control group. Then they received three pretests (problem-solving, memory and comprehension tests) to determine their problem-solving skills, and prior knowledge level in the instructional content. Next, the experimental group accepted an inquiry-based science curriculum infused information literacy using the Big6 model, while the control group accepted the traditional instruction. The instruction unit, taught by the same science teacher, lasted for five weeks, 3 fifty-minute class periods each week. Upon the completion of the instruction, both groups received three posttests (the same tests with different item orders).

E. Data Analysis

The data was analyzed using an analysis of covariance (ANCOVA) on posttest scores with the pretest as the covariate to determine any significant differences between the experimental group and the control group.

V. RESULTS

A. Analysis of Problem-Solving Results

Before further investigating the performance between two groups via analysis of covariance, it is necessary to conduct the relationship between the dependent variable and the covariate. The homogeneity of regression was tested and the result showed that the homogeneity between two groups was not significant (F=2.27, p>.05). Hence, the analysis of covariance could be conducted. Summary ANCOVA statistics were shown in Table II. As shown in Table II, the obtained F ratio was not significant (F=0.04, p>.05). The inquiry-based science curriculum infused information literacy cannot improve seventh-grader’s memory achievement than the traditional lecture-led method.

TABLE II. SUMMARY OF ANCOVA IN MEMORY TEST

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>Df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
<th>$\eta^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
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<td>1</td>
<td>0.07</td>
<td>.04</td>
<td>.00</td>
<td>.00</td>
</tr>
<tr>
<td>Error</td>
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<td>57</td>
<td>1.91</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$\alpha=.05$

B. Analysis of Subject Content Achievement Results

The homogeneity of regression was tested and the result showed that the homogeneity between two groups was not significant (F=2.468, p>.05). Hence, the analysis of covariance in comprehension test could be conducted. Summary ANCOVA statistics were shown in Table III. As shown in Table III, the obtained F ratio was significant (F=41.09, p<.05). The inquiry-based science curriculum infused information literacy can improve seventh-grader’s comprehension achievement than the traditional lecture-led method.

TABLE III. SUMMARY OF ANCOVA IN COMPREHENSION TEST

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>Df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
<th>$\eta^2$</th>
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</thead>
<tbody>
<tr>
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<td>99.01</td>
<td>41.09</td>
<td>.00</td>
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</tr>
<tr>
<td>Error</td>
<td>137.36</td>
<td>57</td>
<td>2.41</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$\alpha=.05$
VI. DISCUSSION

The data analyses of this study showed that the experimental group performed significantly better than their counterparts on the problem-solving and comprehension tests, but not on the memory test. In other words, the integrated information literacy curriculum using the Big6 model can help seventh-graders effectively solve information problems as well as gain a deep understanding of scientific concepts. As for student to memorize factual scientific information, the inquiry-based teaching only performs as equal as the teacher-led teaching. These results support previous research, such as [8][23][31][32].

Though the Big6 is an information problem-solving model, it also emphasizes critical thinking and reasoning during the inquiry, as problem solving process does. Thus, students’ problem solving skills was improved using the Big6 model, which may become one of the selected choices for mediating IPS instruction [37].

Through the Big6 model in this study, students in experimental group selected their interested topic for inquiry, such as gene, DNA, chromosome, and blood types. The teacher provided students with relevant materials, and encouraged them to compare, extract and synthesize the needed information. Thus the finding in comprehension learning of this study verified what many studies have stated that integrating information literacy into curriculum through inquiry-based strategies did help students develop higher-order thinking skills [31][32].

Compared to the lecture-based learning, the inquiry learning deemphasizes recall the factual knowledge. During the five-week instruction, students in the experimental group paid most of their attention to solve information problems, while the control group accepted lectures about the heredity topic. Thus, this study supported the assertion saying that the inquiry learning may not be the best choice for improving learners’ factual knowledge acquisition [8][31].

VII. CONCLUSION

From the results of this study, the integrated information literacy instruction in seventh-grade science curriculum using the Big6 model could improve students’ learning on problem-solving and comprehension levels, but not on factual information acquisition.

Based on the findings of this study, the following implications and recommendations are made for the future research:

1) Integrated information literacy science curriculum can improve students’ problem-solving and higher-order thinking skills.

2) Science teachers may design curricula with both inquiry- and lecture-based method using the Big6 model, so that students can acquire scientific concepts and factual knowledge.

3) Further empirical studies can be carried out on the relationship among age, subject contents, and inquiry learning.

REFERENCES


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