Journal of Modern Education Review, ISSN 2155-7993, USA
November 2018, Volume 8, No. 11, pp. 818–831
Doi: 10.15341/jmer(2155-7993)/11.08.2018/002

http://www.academicstar.us

Can the Use of Elaboration in Junior Science Education Improve Academic Achievement among Chinese and Pakistani Students?

Law Lok Kan
(Delia Memorial School (Glee Path), HongKong, China)

Abstract: 40 Chinese and Pakistani S2 students from a local school were invited for this research. They were divided into elaborative interrogation group and rote memorization group for learning 10 hours science topics in 1st and 2nd term respectively. An immediate test and a surprise retest, which consist of factual knowledge part and higher order questions, were given to students. Relative to rote memorization, elaborative interrogation has a significant effect on retention of scientific knowledge on Pakistani in higher order questions.

Key words: science education, elaboration, Chinese and Pakistani students

1. Literature Review

1.1 Changes in Teaching and Learning Style in Science Education in Hong Kong

In the junior secondary education in Hong Kong, the instructional strategies by teachers are blamed to be teacher-centred. Teachers dominate the lessons and students are passively committed to a low level, rote learning. In the past junior form science education, the main teaching style involves mainly the spelling of vocabularies, underlining the text required by teachers and copying the model answers from teachers (Ho, 1996). Some teachers and students are not willing to adopt other forms of teaching because of the time cost and worry of poor academic result if the teaching mode is not exam-oriented (Kember, 2000).

However, most of the teachers and educators do not agree with the opinion that the traditional didactic memorization learning method can enhance students' learning in junior secondary schools (Oxford, 1990). Graham & Golan (1991) regard the commonly used memorization learning used as repeating and reciting. This kind of learning is surface learning, which is only useful in early development because it adds information to one's knowledge base (Kantrowitz & Wingert, 1991). Czuchry & Dansereau (1998) argue that rote memorization inhibits the retrieval route, making delayed retrieval more difficult, especially in complex tasks. In their research, students who are trained to use "linking" to connect and memorize ideas for a topic are able to recall more relevant information than students using rote memorization by reading after 48 hours. Perfetto, Bransford & Franks (1983) suggest the spontaneous activation of relevant information is restricted to occur because individuals are uninformed about the possible sources of information that are relevant for task completion. The absence of generation effect, a phenomenon in which individuals remember more words and pictures that they have to

Law Lok Kan, Master of Education (Educational Psychology) at the Chinese University of Hong Kong; Delia Memorial School (Glee Path) in Hong Kong; research areas/interests: educational psychology and teaching pedagogy. E-mail: lklaw@deliagroup.edu.hk, llkkevin@hotmail.com.

generate than that they simply read, may explain why rote memorization inhibits the retrieval route (Peynircioglu, 1989).

Isaacs & Carroll (1999) suggest students who rely heavily on rote memorization usually have poorer academic achievement in more sophisticated learning. In their study, students who are taught with traditional rote approach to learn mathematics with frequent drill and time tests make students nervous and undermine understanding. In contrast, students who are taught to de-emphasize rote memorization and use strategies-based approach which support facts and supply links to other mathematical concept like divisibility use common sense and support concept development. As a result, the mathematical achievement is higher for the strategies-based approach group. Willoughby, Waller, Wood & MacKinnon (1991) support the experimental data of Isaacs & Carroll (1999) in science text. In their study, students are given facts about animals' special attributes, for example, natural habitat, diet, special adaption and living environment. They are instructed to answer "why" questions for the facts (elaborative interrogation) and reading control group. Students' performance in elaborative interrogation group is better than the reading control group on immediate memory test and 1-month-delayed post test. If the students have rich knowledge about the content to-be-learnt, their performance in memory test and delayed test improve more.

1.2 The Necessity of Using Deep Approach in Learning

Researchers from different cultures always highlight the essentiality of deeper learning strategies, for example, elaboration to transfer previously learned knowledge to new situation (Morrison & Tang, 2002). Based on the latest understanding in learning, instructional strategies in science education nowadays is different. The use of investigative approach is highly recommended in current new secondary Hong Kong science curriculum to acquire knowledge, skill and attitude through various carefully planned tasks (Curriculum Development Council, 2002). Students are suggested to observe daily interesting phenomenon, designing and carrying experiments and interpreting results. Students build their own knowledge through scientific investigation. It can be achieved by analyzing inspirational information from textbooks, newspaper cutting and abstracts of science journals so as to gather knowledge and evidence to explain the rationale behind the daily phenomenon.

It is common to observe that teaching practices in science lessons in Hong Kong secondary school are combination of didactic and investigative approach. As scientific problems in investigative approach are usually ill-structured (Shin & McGee, 2003), they do not have one absolute right answer. It is important to develop students' skill to apply their domain knowledge meaningfully rather than simply memorizing chunk of concepts, the former of which involves deeper processing of knowledge because students need to examine different possibilities (Shekoyan & Etkina, 2007). For instance, there are a lot of context-rich, ill-structured problems in physics curriculum. Most of the questions are related to daily life (Shin, Jonassen & McGee, 2003). To solve problems, students need to construct the problem and design all alternative steps they can take. They need to verify the feasibility of their solutions by the construction of arguments, justification and domain knowledge. One common example is the physics problem concerning electricity and mechanics. In their research, students are asked to design an environmentally friendly flashlight which does not use batteries or power plug but squeezing the handle in and out. It is an open-ended problem towards the design of circuits and energy convertor. Students can have many ways to achieve the target. After examining the quality of their answers, novices to physics only focus on surface characteristics of the problem and give simple design without detailed considerations while expert students who adopt a more elaborative approach in learning can construct richer and more productive and

meaningful actions to the problem. The feasibility of making the products increases and the corresponding quality is better for expert students (Shekoyan & Etkina, 2007).

1.3 Using Elaborative Interrogation to Learn Science

1.3.1 Elaborative Interrogation

Levin (2008) reviewed that a question strategy called elaborative interrogation is found to be effective in science education. Elaborative interrogation first appeared in late 1980s, which encourages students to produce verbal responses facilitating additional cognitive processing. It is implemented by periodically asking students why particular written or verbal statements or texts are true after reading. Researchers believe that students search their memories for relevant prior knowledge to prepare an impressive answer which is linked to the statements or texts.

There are 2 common types of elaboration. Comparative elaboration occurs when learners actively explain the relationship between 2 concepts in the text. Integrative elaboration occurs when the learners explain the relation between a concept in the text and concepts already in the learners' memory (Mayer, 1980).

Students are required to read a simple factual statement and to answer a "why" questions to clarify the relationship between the subjects and predicate (Pressley, McDaniel, Turnure, Wood & Ahmad, 1987). They facilitate the comprehension and retention of materials by asking students to generate explanations to response to "why" questions about information that is to be learned (Greene, Symons & Richards, 1996). This finding has been replicated in a wide range of students (Seifert, 1993).

Early elaborative interrogation research practiced by Donnelly & McDaniel (1993) and Seifert (1993) support elaborative interrogation improve understanding and recall of facts. In the research, students are divided into elaborative interrogation group (why questions added to the basic scientific text) and control group (no addition to the basic scientific text). For the elaborative group, why questions and blank spaces are printed under the appropriate scientific text for students to write responses to the question. The questions are designed to encourage students to go beyond the explicitly stated information which learners are not required to learn.

After reading the scientific texts, students are asked to perform a distractor task to read a short story and rate 63 statements on a scale of 1–5 for level of importance or conduct a verbalizer-visualizer imagery preference questionnaire. Following the distractor task, students are required to answer 4 multiple-choice questions. Half of the questions require students to direct retrieve the materials in scientific text, and half of the questions are inference-level questions that require students to speculate or go beyond the information given. 10 minutes are given to them to answer the questions. Then, students proceed to another piece of scientific text with other science concept. Distraction task and multiple questions are offered for participants until they read 12 scientific texts.

A surprise recall test is given to participants after they read and answer multiple-choice questions of all 12 scientific texts. Participants are offered with the first few words of each text to cue students the content to be recalled. The order of the text is corresponded to the original presentation order. A debrief is given to the participants to collect all necessary information related to the research.

The result of Donnelly & McDaniel's (1993) research on elaborative interrogation is encouraging. First, the performance on factual questions shows that students who answer why questions can effectively increase the level of factual learning from the scientific texts than the control group. Second, the elaborative interrogation group performs significantly better than the control group in the inference learning questions. However, in the surprise recall test, the performance of participants in elaborative group is similar to that of control groups.

There are other researches supporting that elaborative interrogation enhances understanding and recall of information. Seifert (1993) supports the research data of Donnelly & McDaniel's (1993). Young learners who generate why questions elaboration outperform the students in underline-only control group in learning target facts in the associative memory test. In addition, underline with elaboration group outperforms the underline-only control group in inference questions.

Woloshyn, Paivio and Pressley (1992) find similar result as aforementioned literature. Participants who use elaborative interrogation enhance learning for all science facts in the immediate recall test compared to the reading control group as learners are more aware of what they know. The gain from elaborative interrogation is also long-lasting. Relative to the reading control group, the performance of retention test of elaborative interrogation group 6 months after the study are significantly better in both cued and free recall.

Other studies on elaborative interrogation for texts about people (Pressley, McDaniel, Turnure, Wood & Ahmad, 1987); facts about Canadian provinces (Pressley, Symons, McDaniel, Snyder & Turnure, 1988); gender differences (Pressley et al., 1988), Canadian universities (Woloshyn, Willoughby, Wood & Pressley, 1990); facts about country (Woloshyn, Pressley & Schneider, 1992) consistently report the use of elaborative interrogation show greater effects on memory for target information over the reading control group.

Stein, Bransford, Franks, Owings, Vye and McGraw (1982) examine the type of elaborations produced by primary students with different academic success. Students are required to make the text easier by generating an elaboration at the end of text. Academically successful students are found to make a precise elaboration and have a better recall than average. Less successful students tend to make a less precise elaboration. After training, they can increase recall of text. Franks, Vye, Auble, Mezynski, Perfetto, Bransford, Stein and Little-field (1982) perform a similar research and have similar result to Stein et al. (1982) Once again, it is found that the use of elaborative interrogation enhance learning outcome and training poor readers to use elaborative interrogation can improve recall of information.

Researchers have proposed a knowledge-based, supportive explanation for the benefits of elaborative interrogation (Willoughby, Waller, Wood & MacKinnon, 1991).

Elaborative interrogation activates relevant prior knowledge and connects the new facts with the prior knowledge (Lee, Lin, Tsou & Lin, 2009). Students are required to search information and elaborate their findings (Schmidt, Van der Molen, Te Winkel & Wijnen, 2009). When learners explain their ideas, they can be stimulated to reconstruct the gap between the prior knowledge and new information because of their active involvement in the subject-matter and deep processing (Nussbaum, 2008). Inference learning is enhanced because of the increase in understanding. Hence, the effect of elaborative interrogation is the greatest when students have better background knowledge of the text to be read.

The benefits of elaborative interrogation can be further explained by attention theory and assimilation theory. Attention theory states that elaboration is able to draw learners' attention to information emphasized in the questions and increase the encoding and performance (Mayer, 1980). Elaboration techniques are found to activate the meaningful set of past experience as assimilative context in accordance to assimilation theory. After the occurrence of this process, there is a superior transfer performance, especially for problems which requires to process information in a new way. Elaboration will raise students' general level of interest which increases test performance because of the increased encoded materials (Dansereau, 1978). The knowledge activated by elaborative interrogation is idiosyncratic for individual learner, which makes elaborative interrogation useful in learning. The effect of elaborative interrogation depends on the nature of the questions also. Elaborations which

precisely clarify the significance of factual relationships make facts become more sensible and more memorable (Stein & Bransford, 1979).

The presence of learning diversity is a great challenge in junior secondary science class. The aforementioned literatures suggest the use of elaboration, compared to rote memorization reading group, enhances the understanding (inference learning) and retention of scientific knowledge. Even poor academic achievers can enhance the recall of information after teachers equipping them with the technique of elaborative interrogation. The current research can provide insight whether the use of elaborative interrogation in Hong Kong can achieve the same advantages as previous studies and narrows the academic difference of students in science by introducing a better study method for poor students.

1.4 The Increasing Number of Pakistani Studying in Hong Kong

According to the 2011 Population Census conducted by Census and Statistics Department, the number of ethnic minorities increases in the past 10 years significantly. Southeast Asians account for the 81% of the ethnic minorities. Most of them are Indonesian, Filipino, Indian, Pakistani and Nepali. Children of Southeast Asians usually study in primary and secondary schools in Hong Kong. Education Bureau regards them as “Non-Chinese Speaking” (NCS) students. There are about 6300 NCS studying in the secondary schools, which accounts for 3% of total number of students in Hong Kong and the number has increased by twice compared with 2006.

Guan Z. Y. (2014) has mentioned that Education Bureau invites school with relatively more NCS to study to become designated schools. The purpose of designated school is supporting NCS with the aid of more resources by the practice of school-based curriculum. In some of the designated schools, Pakistani is the major population group among their admitted students.

In the research of Hau (2008), the academic achievement of NCS in mathematics has fallen behind than their Chinese counterpart and they do not hand in their homework on time. It is reported that NCS are inattentive, avoid learning and very shy in class. It is believed NCS can definitely improve much faster if more support is given to them.

2. Purpose of the Present Research

The aforementioned literature indicates the necessity of using elaboration to enhance students’ deep understanding and retrieval of knowledge towards science to fulfill investigative approach of learning in the current science curriculum.

However, the literature involving the participants from other Asian cities and does not relate to Hong Kong situation. In this research, subjects are invited from local designated school which admits Chinese and Pakistani students. The purposes of the research are to provide latest information on approach of learning and their conceptions of learning science in Hong Kong local school and investigate whether deep approach of learning like elaboration, relative to surface approach of learning like rote memorization, enhances learning and retention of scientific knowledge of Chinese and especially Pakistani students studying in Hong Kong.

There is 1 hypothesis in this research.

1) I hypothesize relative to rote memorization, elaborative interrogation enhances the understanding and retention of newly learnt scientific knowledge for all Chinese and Pakistani as the aforementioned literature.

3. Method

3.1 Subjects

40 secondary school students (20 Chinese and 20 Pakistani) from a local designated school are enrolled in the research project. Their age is within 13–15. All of them are fresh to the materials they learn in the research because it is the first time for the subjects to study secondary 2 in Hong Kong and they all have 3 hours of science lesson per week. From the information collected from their family, parents of the subjects have similar socio-economic status ($10000–13000 income per month) and educational background (secondary level).

3.2 Materials

3.2.1 Science Teaching Materials

The science topics included in the research are “energy” and “cells and human reproduction”. In accordance to the Curriculum Development Council (2002), students are required to observe and explain the phenomenon. The cause-and-effect relationship between different parts of structure should be clearly identified and apply the knowledge to new situation with rationale learnt in lessons.

In the topic “energy”, students need to describe and explain the importance and safety of controlled energy conversion, especially the process of generating electricity and renewable energy resources. While in the topic “cells and human reproduction”, students are required to identify the system and how they facilitate the process of reproduction. The pros & cons of different birth control methods are discussed in the topic.

The science materials used are adapted from news article for students to extend what they have learnt in real life situation. Students have received 2 sets of notes for each topic in the research. The first set of notes contains all necessary factual knowledge which is the learning objectives for the topics. Students are required to fill in the blank in the notes. The second set of notes is issued to students when a section in the first set of notes is finished. Second set of notes contain extra information for the science topics discussed. Students can explore further through discussing and investigating the materials.

3.2.2 Science Test Materials

The science test is designed according to the teaching aims for each topic. 50% of the paper involves recalling of factual knowledge and 50% involves the elaborative and problem solving part. The question types of the paper involve multiple choice questions, completion (fill in the blank) and short answer questions. The types of questions are carefully designed to students with specific learning objectives (Nitko, 1996). Multiple choice questions and completion are useful in objectively assessing students’ performance of lower-order thinking skills like recall and comprehension of information. Short answer questions are useful in assessing higher ability of students in applying principles and interpretation of data in problem solving questions. 2 parts of the science test carry the same portion of score.

4. Procedures

40 subjects were divided into 2 groups. Because of the limited resources, a group of 17 students with 9 Chinese and 8 Pakistani students and a group of 23 students with 11 Chinese and 12 Pakistani students were formed. In the 1st term, scientific topic “energy” was introduced. One group was taught by traditional didactic method and another group was taught by the method of elaborative interrogation. 2.5 hours are used each week to introduce the topic to the students and it was finished in 4 weeks for both groups.

In lessons using traditional didactic method, conventional teaching was adopted. Teaching was teacher-centred and was consisted of whole class lecture, tutorials and laboratory works. The traditional didactic method emphasizes on reproduction (rote memorization) rather than meaning (understanding) (Nandi, Chan, Chan, Chan, & Chan, 2000). Teachers filled in the blank and let students copy the answers in all sets of notes without elaboration.

In the elaborative group, teacher elaborated on the notes when they went through the materials in class. In the second set of notes, teacher ask students why statements in notes were correct or not and asked them for opinions in the discussion problems. No answers were provided directly to the students. Teachers elaborate and raise examples when students asked questions about the topic concerned.

A science test was given to students after the completion of the topic. 1 month after the test, a surprise science test was given to the students. The surprised test is exactly the same as the science test.

In the 2nd term, topic "cells and human reproduction" was introduced and teaching methods for the 2 groups is reversed. Elaborative group in the 1st term received traditional didactic method in the 2nd term and vice versa. The length and format of teaching and test remained the same as the 1st term for both groups.

5. Result

5.1 The Effect of Elaboration and Rote Memorization on Different Question Types in Test and Surprise Retest

A 2×2×2×2×2 repeated measured ANOVA is conducted to compare the effect of treatment (elaboration and rote memorization) and race (Chinese and Pakistani) on the marks of factual knowledge and higher order questions (question type) in test and surprise retest (section). As the order of treatment should not have significant effect on treatment, this factor is not taken into account.

There is a significant interaction effect on Treatment, question type, section, group and race (alpha < .05).

Table 1 The Interaction Effect of Elaboration and Rote Memorization on Different Question Types in Test and Surprise Retest

Source	Section		Type III sum of squares	df	Mean Square	F	Sig.
Treatment * Question Type * Section * Group * Race	Linear	Linear Linear	328.573	1	328.573	5.839	.022*
Error (Treatment*Question Type*Section)	Linear	Linear Linear	1800.796	32	56.275		

* indicates alpha < .05

Interaction effect on treatment, question type, section and group of Chinese and Pakistani

The interaction effect of treatment, question type, section and group is analyzed separately according to races. There is a significant interaction of treatment* section* group in Chinese while there us a significant interaction of question type*section in Pakistani.

Interaction effect on treatment, a section and group of Chinese and Pakistani

Chinese

There is a significant interaction of treatment* section* group in Chinese.

Table 2 Interaction Effect on Treatment, a Section of Chinese

Treatment * Section * Group	Linear	Linear	413.736	1	413.736	7.683	.015*
Error(Treatment*Section)	Linear	Linear	753.957	14	53.854		

* indicates alpha < .05

As the order of treatment should not have significant effect on treatment, this factor is not taken into account for further analysis.

The cell means of interaction effect on treatment and section of Chinese is indicated in table 3. Chinese students show a decline in performance in both test and retest in both elaborative interrogation and rote memorization. Elaborative interrogation, relative to rote memorization, has no significant effect on understanding and retention of science knowledge in Chinese.

Table 3 Mean and Standard Deviation of Test and Retest Result of Students under Elaborative Interrogation and Rote Memorization of Chinese

Treatment * Section (Chinese)

Treatment	Section	Mean	Std. Error
Laborative interrogation	Test	67.450	.933
	Retest	70.750	1.088
Rote memorization	Test	64.050	1.173
	Retest	66.350	.930

Table 4 Paired T-test of Test and Retest Result of Students under Elaborative Interrogation and Rote Memorization of Chinese

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Elaborative interrogation Test – Rote memorization Test	3.400	17.04298	3.81093	-4.57636	11.37636	.892	19	.383
Pair 2	Elaborative interrogation ReTest - Rote memorization ReTest	4.400	14.58334	3.26093	-2.42521	11.22521	1.349	19	.193

Furthermore, a paired T-test is conducted to compare the effect of treatment (elaboration and rote memorization) on the marks of factual knowledge and higher order questions in test and surprise retest of Chinese. Chinese show an increase in performance in both test and retest in both treatments. However, the effect is insignificant.

Table 5 Mean and Standard Deviation of Test and Retest Result of Students under Elaborative Interrogation and Rote Memorization on Factual Knowledge Type of Question and Higher Order Question of Chinese

Paired Samples Statistics (Chinese)

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Elaborative interrogation- Test Factual Knowledge Question	35.1000	20	7.19576	1.60902
	Rote Memorization-Test Factual Knowledge Question	30.9000	20	8.70511	1.94652
Pair 2	Elaborative interrogation- Test Higher Order Question	32.3500	20	7.72061	1.72638
	Rote Memorization Test Higher Order Question	33.1500	20	7.31455	1.63558
Pair 3	Elaborative interrogation- Retest Factual Knowledge Question	42.2500	20	9.72179	2.17386
	Rote Memorization- Retest Factual Knowledge Question	40.2000	20	5.50215	1.23032
Pair 4	Elaborative interrogation- Retest Higher Order Question	28.5000	20	11.32998	2.53346
	Rote memorization- Retest Higher Order Question	26.1500	20	8.91642	1.99377

Table 6 Paired T-test of Test and Retest Result of Students under Elaborative Interrogation and Rote Memorization on Factual Knowledge Type of Question and Higher Order Question of Chinese

Paired Samples Test (Chinese)

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Elaborative interrogation Test Factual knowledge Question - Rote Memorization Test Factual knowledge Question	4.20000	12.26720	2.74303	-1.54123	9.94123	1.531	19	.142
Pair 2	Elaborative interrogation Test Higher Order Question - Rote Memorization Test Higher Order Question	-.80000	11.01960	2.46406	-5.95733	4.35733	-.325	19	.749
Pair 3	Elaborative interrogation Retest Factual Knowledge Question - Rote Memorization Retest Factual Knowledge Question	2.05000	12.42440	2.77818	-3.76480	7.86480	.738	19	.470
Pair 4	Elaborative interrogation Retest Higher Order Question - Rote memorization Retest Higher Order Question	2.35000	15.59445	3.48702	-4.94843	9.64843	.674	19	.508

Pakistani

Interaction effect of treatment*section is analyzed in Pakistani. A paired T-test is conducted to compare the effect of treatment (elaboration and rote memorization) on the marks of factual knowledge and higher order questions in test and surprise retest. The cell means of interaction effect on treatment and section of Pakistani is indicated in table. Pakistani shows a decrease in performance in test and retest in both treatment.

Table 7 Mean and Standard Deviation of Test and Retest Result of Students under Elaborative Interrogation and Rote Memorization of Pakistani

Treatment	Section	Mean	Std. Error
Elaborative interrogation	Test	54.350	2.199
	Retest	51.000	1.148
Rote memorization	Test	45.450	2.006
	Retest	40.700	.946

A paired T-test is conducted to compare the effect of treatment (elaboration and rote memorization) on the marks of factual knowledge and higher order questions in test and surprise retest of Pakistani.

Elaborative interrogation group, relative to rote memorization group, perform significant better (alpha < .05) in surprise retest. Elaborative interrogation, relative to rote memorization, facilitates the retention of science knowledge in Pakistani.

Table 8 Paired T-test of Test and Retest Result of Students under Elaborative Interrogation and Rote Memorization of Pakistani

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Elaborative interrogation Test – Rote memorization Test	8.900	32.41004	7.24710	-6.26836	24.06836	1.228	19	.234
Pair 2	Elaborative interrogation ReTest - Rote memorization ReTest	10.300	13.47551	3.01322	3.99327	16.60673	3.418	19	.003*

* indicates alpha < .05

Furthermore, a paired T-test is conducted to compare the effect of treatment (elaboration and rote memorization) on the marks of factual knowledge and higher order questions in test and surprise retest of Pakistani. Elaborative interrogation, relative to rote memorization, facilitates the retention of knowledge for higher order questions.

Table 9 Mean and Standard Deviation of Test and Retest Result of Students under Elaborative Interrogation and Rote Memorization on Factual Knowledge Type of Question and Higher Order Question of Pakistani

Paired Samples Statistics (Pakistani)

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Elaborative interrogation- test factual knowledge question	30.7000	20	12.59950	2.81733
	Rote memorization- test factual knowledge question	27.0000	20	10.83367	2.42248
Pair 2	Elaborative interrogation- test higher order question	23.6500	20	11.35677	2.53945
	Rote memorization- test higher order question	18.4500	20	6.90899	1.54490
Pair 3	Elaborative interrogation- retest factual knowledge question	26.5000	20	9.75759	2.18186
	Rote memorization- retest factual knowledge question	24.5500	20	7.38758	1.65191
Pair 4	Elaborative interrogation- retest higher order question	24.5000	20	9.48406	2.12070
	Rote memorization- retest higher order question	16.1500	20	9.12068	2.03945

Table 10 Paired T-test of Test and Retest Result of Students under Elaborative Interrogation and Rote Memorization on Factual Knowledge Type of Question and Higher Order Question of Pakistani

Paired Samples Test (Pakistani)

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. deviation	Std. Error Mean	95% confidence interval of the difference				
					Lower	Upper			
Pair 1	Elaborative interrogation- Test Factual knowledge question - rote memorization test factual knowledge question	3.70000	19.56931	4.37583	-5.45872	12.85872	.846	19	.408
Pair 2	Elaborative interrogation- test higher order question - rote memorization test higher order question	5.20000	15.39173	3.44169	-2.00355	12.40355	1.511	19	.147
Pair 3	Elaborative interrogation retest factual knowledge question - rote memorization retest factual knowledge question	1.95000	12.14160	2.71494	-3.73244	7.63244	.718	19	.481
Pair 4	Elaborative interrogation retest higher order question - rote memorization retest higher order question	8.35000	11.30568	2.52803	3.05878	13.64122	3.303	19	.004*

* indicates alpha < .05

6. Discussion

Hypothesis: relative to rote memorization, elaborative interrogation enhances the understanding and retention of newly learnt scientific knowledge for all Chinese and Pakistani as the aforementioned literature.

For Chinese, relative to rote memorization, elaborative interrogation improves the retention of scientific knowledge as indicated by the better achievement in test (except higher order questions) and retest of students in the elaborative interrogation group, although the difference is insignificant. If the type of question is taken into consideration, students in elaborative interrogation group show a higher achievement in the test about factual knowledge and retest about factual knowledge and higher order questions relative to the rote memorization group. Interestingly, the elaborative interrogation group has a lower mean score of higher order question in test compared with the rote memorization group.

For Pakistani, a similar trend is observed. Relative to rote memorization, elaborative interrogation improves the understanding and retention of scientific knowledge as indicated by the better achievement in test and retest of students in the elaborative interrogation group. The achievement of Pakistani in the elaborative interrogation group in retest is significantly better than the control group (alpha <.05). If the type of questions is taken into consideration, Pakistani students in elaborative group perform significantly better than rote memorization group in higher order question (alpha < .05). Relative to rote memorization, elaborative interrogation facilitate the retention of knowledge, especially higher order questions for Pakistani.

It is observed that the effect of elaborative interrogation on understanding and retention of scientific knowledge is not significant for Chinese students. Although the effect of elaborative interrogation on understanding of Pakistani students is not significant, the use of elaborative interrogation can significantly facilitate the memorization of scientific knowledge of Pakistani students, especially for higher order question.

Other Differences between Chinese and Pakistani in Learning Junior Science Observed in the Present Research

Chinese students seem to be better science learners than Pakistani. It is because the score of Chinese students in factual knowledge and higher order question is significantly higher than Pakistani in test and retest in experimental and control group (alpha < .05). The difference in conception of learning science and their approach of learning may be one of the possible reasons for the difference between their academic achievements. The difference between cultures, family support and extent of adapting Hong Kong education system may cause the difference in efficiency in learning.

Factual knowledge is better retained than higher order questions in both treatments and both races. For Chinese students, the retest result of factual knowledge questions is significantly higher than that of test (alpha < .05) while the test result of higher order question is higher than that of factual knowledge question (alpha < .05). In addition, in retest, the result of factual knowledge type of questions is significantly higher than higher order questions (alpha < .05). For Pakistani students, test and retest result of factual knowledge type of questions is significantly better than higher order type of question (alpha < .05). This indicates both Chinese and Pakistani perform better in reproduction of answer rather than elaborating the ideas that they have learnt. This indicates that junior form students may not able to apply and manipulate the knowledge that they have acquired effectively.

7. Implication and Suggestion for Further Research

Support of NCS to integrate in HK education system is one of the targets of Education Bureau. Their academic result is generally poor than their Chinese counterparts. The use of unsuitable learning strategies in learning may be one of the reasons that they cannot acquire the knowledge well. The use of elaborative interrogation can facilitate their retention of scientific knowledge. Teachers can equip students with elaborative interrogation to help them understand and memorize the subject knowledge.

Further research can be practiced to investigate whether elaborative interrogation carries the same effect on other subjects like Geography, Life & Society. Students from schools with different bands can be invited for investigating the effect of elaborative interrogation on learning. Furthermore, the quality of work done by subjects in elaborative interrogation group is suggested to be recorded to evaluate the extent of subjects that equip and manipulate the skill of elaborative interrogation.

In the research of Alemán, de Gea, and Mondéjar (2011), relative to conventional classroom teaching, the use of competitive e-learning assignments raise the performance of students in the immediate follow-up test and 10-week follow-up test. In the era of IT teaching, further research on whether collaborative and elaborative e-learning lesson can promote the retention of knowledge can be carried out to give insight to educators.

8. Conclusion

Relative to rote memorization, elaborative interrogation improves retention of science knowledge of Pakistani, especially in higher-order questions.

References

Alemán J. L., de Gea J. M. and Mondéjar J. J. (2011). “Effects of competitive computer-assisted learning versus conventional teaching methods on the acquisition and retention of knowledge in medical surgical nursing students”, *Nurse Education Today*, pp. 866–871.

Berry D. C. (1983). “Metacognitive experience and transfer of logical reasoning”, *The Quarterly Journal of Experimental Psychology*, pp. 39–49.

Biggs J. B. (1985). “The role of metalearning in study processes”, *British Journal of Educational Psychology*, pp. 185–212.

Biggs J. B. (1991). “Approaches to learning in secondary and tertiary students in Hong Kong: Some comparative studies”, *Educational Research Journal*, pp. 27–39.

Biggs J. B. (1993). “What do inventories of students’ learning processes really measure? A theoretical review and clarification”, *British Journal of Educational Psychology*, pp. 1–17.

Biggs J. B. (1999). *Teaching for Quality Learning at University.* Buckingham: The Open University Press.

Bude L., Imbos T., Van der Wiel M., Broers N. and Berger M. (2009). “The effect of directive tutor guidance in problem-based learning of statistics on students’perceptions and achievement”, *Higher Education*, pp. 23–36.

Census and Statistics Department (2011). *2011 Population Census Thematic Report: Ethnic Minorities*, Hong Kong: HKSAR.

Curriculum Development Council (2002). *Syllabuses for Secondary Schools Science (Secondary 1–3)*, Hong Kong: Printing Department.

Czuchry M. and Dansereau D. F. (1998). “The generation and recall of personally relevant information”, *Journal of Experimental Education*, pp. 293–315.

Dansereau D. (1978). “The development of a learning strategies curriculum”, in: J. H. P. O'Neil, *Learning Strategies*, New York: Academic Press.

Dart B. and Boulton-Lewis G. (1998). *Teaching and Learning in Higher Education*, Camberwell: Australian Council for Educational Research.

De Grave W. S., Dolmans D. H. and Van der Vleuten C. P. (1999). "Profiles of effective tutors in problem-based learning: Scaffolding student learning", *Medical Education*, pp. 901–906.

Donnelly C. M. and McDaniel M. A. (1993). "Use of analogy in learning scientific concepts", *Journal of Experimental Psychology: Learning, Memory, and Cognition*, pp. 975–987.

Dunlosky J. (2013). "Strengthening the student toolbox: Study strategies to boost learning", *American Educator*, pp. 12–21.

Dunlosky J., Rawson K. A., Marsh E. J., Nathan M. J. and Willingham D. T. (2013). "Improving students' learning with effective learning techniques promising directions from cognitive and educational psychology", *Psychological Science in the Public Interest*, pp. 4–58.

Entwistle N. and Waterston S. (1988). "Approaches to studying and levels of processing in university students", *British Journal of Educational Psychology*, pp. 258–265.

Franks J., Vye N., Auble P., Mezynski K., Perfetto G. and Bransford J. et al. (1982). "Learning from explicit versus implicit texts", *Journal of Experimental Psychology: General*, pp. 414–482.

Graham S. and Golan S. (1991). "Motivational influences on cognition: Task involvement, ego involvement, and depth of information processing", *Journal of Educational Psychology*, pp. 187–194.

Greene C., Symons S. and Richards C. (1996). "Elaborative interrogation effects for children with learning disabilities: Isolated facts versus connected prose", *Contemporary Educational Psychology*, pp. 19–42.

Hau K. T. (2008). *Tracking the Adaptation and Development of non-Chinese Speaking Children (NCS) in Mainstream Schools*, Hong Kong: The Chinese University of Hong Kong.

Ho K. K. (1996). "Secondary school science education in Hong Kong: Prospect and retrospect", *New Horizons in Education*, pp. 53–57.

Isaacs C. and Carroll W. (1999). "Strategies for basic-facts instruction", *Teaching Children in Mathematics*, pp. 1–17.

Kantrowitz B. and Wingert P. (1991). "A dismal report card", *Newsweek*, pp. 64–68.

Lee G., Lin Y., Tsou K. S. and Lin C. (2009). "When a problem-based learning tutor decides to intervene", *Academic Medicine*, pp. 1406–1410.

Levin J. (2008). "The unmistakable professional promise of a young educational psychology research and scholar", *Educational Psychologist*, pp. 70–85.

Maehr M. L. and Pintrich P. R. (1991). "Preface", in: M. L. Maehr and P. R. Pintrich, *Advances in Motivation and Achievement*, Greemnwich: JAI Press, pp. 9–13.

Martin V. L. and Pressley M. (1991). "Elaborative-interrogation effects depend on the nature of the question", *Journal of Educational Psychology*, pp. 113–119.

Marton F., Watkins D. and Tang C. (1997). "Discontinuities and continuities in the experience of learning: An interview study of high-school students in Hong Kong", *Learning and Instruction*, pp. 21–48.

Mayer R. E. (1980). "Elaboration techniques that increase the meaningfulness of technical text: An experimental test of the learning strategy hypothesis", *Journal of Educational Psychology*, pp. 770–784.

Mayer R. E. and Gallini J. K. (1990). "When is an illustration worth ten thousand words?", *Journal of Educational Psychology*, pp. 715–726.

McDaniel M. A. and Donnelly C. M. (1996). "Learning with analogy and elaborative interrogation", *Journal of Educational Psychology* , pp. 508–519.

Morrison K. and Tang J. F. (2002). "Testing to destruction: A problem in a small state", *Assessment in Education: Principles, Policies, and Practice*, pp. 289–317.

Nandi P. L., Chan J. N., Chan C. P., Chan P. and Chan L. P. (2000). "Undergraduate medical education: comparison of problem-based learning and conventional teaching", *Hong Kong Medical Journal*, pp. 301–306.

Newble D. I. and Entwistle N. J. (1986). "Learning styles and approaches: Implications for medical education", *Medical Education*, pp. 162–178.

Nitko A. (1996). *Educational Assessment of Students*, Des Moines: Prentice-Hall Order Processing Center.

Nussbaum E. M. (2008). "Collaborative discourse, argumentation, and learning: Preface and literature review", *Contemporary Educational Psychology*, pp. 345–359.

O'Donnell A. M. (2006). "The role of peers and group learning", in: P. H. Alexander, *Handbook of Educational Psychology*, Mahwah, N. J.: Erlbaum, pp. 781-802.

Oxford R. L. (1990). "Styles, strategies, and aptitude: Connections for language learning", *Document Resume*, pp. 67–125.

Perfetto G. A., Bransford J. D. and Franks I. J. (1983). "Constraints on access in a problem solving context", *Memory & Cognition*, pp. 24–31.

Peynircioglu Z. F. (1989). "The generation effect with pictures and nonsense figures", *Acra Psychologica*, pp. 153–160.

Pressley M. and Harris K. R. (2006). "Cognitive strategy instruction: from basic research to classroom instruction", in: P. Alexander, and P. Winne, *Handbook of Educational Psychology*, San Diego: Academic Press, pp. 265–286.

Pressley M., McDaniel M. A., Turnure J. E., Wood E. and Ahmad M. (1987). "Generation and precision of elaboration: Effects on intentional and incidental learning", *Journal of Experimental Psychology: Learning, Memory, and Cognition*, pp. 291–300.

Pressley M., Symons S., McDaniel M., Snyder B. and Turnure J. (1988). "Elaborative interrogation facilitates acquistion of confusing facts", *Journal of Educational Psychology*, pp. 268–279.

Schmidt H. G., Van der Molen H. T., Te Winkel W. W. and Wijnen W. H. (2009). "Constructivist, problem-based learning does work: A meta-analysis of curricular comparisons involving a single medical school", *Educational Psychologist*, pp. 227–249.

Seifert T. L. (1992). "The effects of an elaboration strategy on memory", *Annual meeting of the American Educational Research Association*, San Francisco, pp. 1–32.

Seifert T. L. (1993). "Effects of elaborative interrogation with prose passages", *Journal of Educational Psychology*, pp. 642–651.

Shekoyan V. and Etkina E. (2007). "Introducing ill-structured problems in introductory physics recitations", *2007 Physics Education Research Conference*, pp. 192–195.

Shin N., Jonassen D. H. and McGee S. (2003). "Predictors of well-structured and ill-structured problem solving in an astronomy simulation", *Journal of Research in Science Teaching* , pp. 6–33.

Stein B. S. and Bransford J. D. (1979). "Constraints on effective elaboration: Effects of precision and subject generation", *Journal of Verbal Learning and Verbal Behavior*, pp. 769–777.

Stein B. S., Morris C. D. and Bransford J. D. (1978). "Constraints on effective pictorial and verbal elaboration", *Memory & Cognition*, pp. 281–290.

Stein B., Bransford J., Franks J., Owings R., Vye N. and McGraw W. (1982). "Differences in the precision of self-generated elaborations", *Journal of Experimental Psychology: General*, pp. 399–405.

Stockley D. (1995). *Elaborative Interrogation as a Learning Technique for Students with Learning Disabilities*.

The Curriculum Development Council. (1998). *Syllabuses For Secondary Schools*, Hong Kong: The Education Department.

Trigwell K. and Prosser M. (1991). "Relating learning approaches, perceptions of context and learning outcomes", *Higher Education*, pp. 251–266.

Van Blankenstein F. M., Dolmans D. H., Van der Vleuten C. P. and Schmidt H. G. (2013). "Elaboration during problem-based group discussion: Effects on recall for high and low ability students", *Advances in Health Sciences Education*, pp. 659–672.

Wentzel K. R. (1989). "Adolescent classroom goals, standards for performance, and academic achievement: An interactionist perspective", *Educational Psychology*, pp. 131–142.

Wilkerson L. (1994). "Identification of skills for the problem-based tutor: Student and faculty perspectives", *Instructional Science*, pp. 303–315.

Willoughby T., Waller T., Wood E. and MacKinnon G. (1991). "The effect of prior knowledge on an immediate and delayed associative learning task following elaborative interrogation", *Annual meeting of the American Educational Research Association*, Chicago.

Willoughby T., Wood E. and Khan M. (1994). "Isolating variables that impact on or detract from the effectiveness of elaboration strategies", *Journal of Educational Psychology*, pp. 279–289.

Woloshyn V., Paivio A. and Pressley M. (1992). "Using elaborative interrogation to help students overcome their inaccurate science beliefs", *Annual Meeting of the American Educational Psychology*, San Francisco, pp. 115–124.

Woloshyn V., Pressley M. and Schneider W. (1992). "Elaborative interrogation and prior knowledge effects on learning of facts", *Journal of Educational Psychology*, pp. 115–124.

Woloshyn V., Willoughby T., Wood E. and Pressley M. (1990). "Elaborative interrogation facilitates adult learning of factual paragraphs", *Journal of Educational Psychology*, pp. 512–523.

Wong B. Y. and Sawatsky D. (1984). "Sentence elaboration and retention of good, average and poor readers", *Learning Disabilities Quarterly*, pp. 229–236.

Yih-Tong Sun P. and Scott J. L. (2005). "An investigation of barriers to knowledge transfer", *Journal of knowledge management*, pp. 75–90.