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INCULCATING CRITICAL THINKING IN CHEMISTRY LABORATORY

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ABSTRACT

Writing scientific paper in science laboratory serves the way to promote critical thinking since it helps students to improve their proficiency at writing in a professional style (Peter and John, 2009). Despite its importance, the influence of writing on critical thinking is less defined in science. Most of the researches have repeatedly called for more empirical investigations of writing in science, however only few provide such evidence (Rivard, 1994; Tsui, 1998; Daempfle, 2002; Klein, 2004). The objective of this study is to investigate the effect of writing essay in chemistry laboratory in promoting pre-university medical student's critical thinking skills. This study was implemented by evaluating participants' laboratory scientific reports based on The Holistic Critical Thinking Scoring Rubric (HCTSR), (Facione & Facione, 1994) by two experienced Chemistry teachers. The California Critical Thinking Skill Test (CCTST) was also used as a data collection to support the finding. Four experiments were selected and 100 pre-university medical students from one of medical private university colleges in Malaysia participated in the research. Results indicated that the writing group significantly ($p < 0.05$) improved their level of critical thinking skills whereas the nonwriting group did not. The CCTST scores of analysis skills were highly in the writing group but not the nonwriting group. The finding indicates that the assessments of science laboratory through scientific report provide an effective way to help students improved their critical thinking level.

KEYWORDS: scientific paper, critical thinking, pre-medical university students

INTRODUCTION

Emphasising of critical thinking criteria as one of the goals in educational institutions has become commonplace for the whole world. This is in line with the role of an educational institution as the suitable institution to teach critical thinking in developing the skills of problem solving and independent thinking (Lee, 1999). At higher education level, criteria of critical thinking is an important outcome in any discipline since it plays an applicable role for problem solving and decision making in any context, whether it is social, clinical, ethical, managerial, or political (Simpson, 2002).

Paul (1996) defines critical thinking as a “learning how to ask and answer questions of analysis, synthesis and evaluation”. This definition is supported by Brookfield (1987) who maintains that critical thinking involves two interrelated processes: ‘identifying and challenging assumptions, and imagining and exploring other’s’. Furthermore, other definition has been given by philosophers such as Pithers and Soden (2000) who stated that critical thinking encompasses a number of abilities such as identifying a problem and the assumptions on which it is based on focusing the problem, analysing, understanding and making use of inferences, inductive and deductive logic, and judging the validity and reliability of assumptions and sources of data (cited in Lai, 2011).

For medical students, critical thinking is used to relate basic concepts to real life situations during their pre-clinical courses. They eventually need to develop good clinical reasoning and decision making skills to provide safe and effective care to patients (Joie et. all, 2013). In recent years, the new medical curriculum strongly emphasises the importance of laboratory and practical classes (Azer et. all, 2013) in their education system as one of the strategies to produce quality practitioner. At pre-university level, this is the best phase to strongly expose the students’ laboratory strategies in fostering critical thinking among them. According to Hofstein and Walberg (1995), inquiry type laboratories are central to learning chemistry since students are involved in the process of conceiving problems and scientific questions, formulating hypotheses, designing experiments, gathering and analysing data, and drawing conclusions about scientific problems or phenomena. The most common assessment in practical science class is laboratory report (Mackenzie & Gardner, 2006), which assumes that students know how to identify evidence to support their claims, a skill necessary for scientific argumentation (Meena & Alison, 2013).

In line with the objectives and format of writing laboratory reports, some of instructors have a view that it is quite similar to scientific report. According to Beaufort (2007), writing a laboratory report typically follows the format of the standard scientific report. It treats genre merely as format

identified by heading and sections such as introduction, experimental, data and result, discussion, conclusion and reference. This means that writing for science laboratory report should extend beyond the traditional records of observations and formal reports. Students should write to explain, to sort out what they understand, to consider alternative and to respond to, to reformulate ideas in their own words, to speculate about possible explanations, and to puzzle over and interpret what others have thought and written (Vaughan and Brian 1996). It shows writing within disciplines is thought to require deeper analytical thinking (Langer & Applebee, 1987), which is closely aligned with critical thinking. Jean & Ralph (2004) stated that laboratory report have similarities to research articles (scientific writing) in undergraduate course in the experimental sciences. Based on this scientific writing format, students are required to elaborate, reprocess concepts and central ideas, hypothesise, interpret, synthesise and persuade and hence develop higher-order reasoning skills (Resnik & Klopfer, 1989 ; Sutton, 1992).

Dixon, Cassady, Cross, & Williams (2005) emphasise that writing is a vehicle through which students can express their critical thinking, and that writing seems to be an expression of critical thinking when students are trained to use critical thinking methods consistently in writing. Bean (2001) asserts that writing “requires analytical or argumentative thinking and is characterized by a controlling thesis or statement and a logical, hierarchical structure” (p. 17).

According to Applebee (1984), he has suggested that writing improves thinking because it requires and individual to make his or her ideas explicit and to evaluate and choose among tools necessary for effective discourse. Furthermore, Marzano (1991) suggested that writing used as a means to restructure knowledge improves higher-order thinking. Based in this context, writing may provide opportunity for students to think through arguments and use higher-order thinking skills to respond to complex problems (Marzano, 1991).

Therefore, writing essay approach in chemistry laboratory may help students’ to improve their writing skills specifically in writing laboratory report critically. This means that the laboratory report produced has to achieve certain critical thinking level which is crucial in fulfilling the objective of science learning. This study paves the way for scientific writing ability of pre-university medical students through essay writing treatment in chemistry laboratory. The objective is investigate the effect of writing essay in chemistry laboratory in promoting of pre-university medical student’s critical thinking skills.

METHODOLOGY

A pre-test and post-test experimental design with an experimental group and a control group was employed to determine whether critical

thinking performance in the writing group differ significantly from the nonwriting group. The study was carried out with 100 students who were enrolled to Foundation in Science (FIS) program at one of medical private universities in Malaysia. The mean age of the participants is 19. The participants of this study were learners leading to medical and pharmacy programmes and have taken compulsory Chemistry Lab courses that cover practical and written laboratory reports. They were randomly assigned to experimental (N=50) and control group (N=50) in each.

In the writing treatment, students were given thought essay questions before beginning the laboratory session. This question was related with what students have done in the laboratory. Students in nonwriting group was described to conduct experiment as a normal practice where at the end of the session, students sit for short quiz.

This study was implemented by evaluating participants' laboratory scientific reports based on The Holistic Critical Thinking Scoring Rubric (HCTSR), (Facione & Facione,1994) by two experienced Chemistry teachers. According to Ruminski (2006), Facione and Facione (1994) model is adaptable to assess several scenarios for management decision such as an advanced reporting class which has covered the reporting of data. The California Critical Thinking Skill Test

(CCTST) was used also as a data collection to support the finding.

FINDING AND DISCUSSION

The objective of this study was to investigate the effect of writing essay in chemistry laboratory in promoting of pre-university medical student's critical thinking skills. Analysis of paired-sample t-test was used to compare the differences in the statistics. **Table 1** illustrates the comparison of pre-test and post-test scores of students of nonwriting group and writing group. Compared the mean scores in the two groups, the writing group's score was lower than the control group's score in the pre-test, while the score of the post-test was higher than the post-test in the nonwriting group's. There was a significant differences found in the score ($p < 0.05$).

Table 2 shows the score on the CCTST for both of groups. Based on the analysis, the overall means score in the writing group was 218.56 ± 18.55 and the score in the nonwriting group was 211.980 ± 19.37 . There were no statistically significant differences in the two groups. However, the mean score of analysis skill (77.50 ± 8.22) in the writing group is highly significant compared with the mean score (74.00 ± 7.49) of nonwriting group ($p < 0.05$). The other two subscales Evaluation and Explanation have no statistically significant difference in the two groups.

Table 1 t-test results concerning the comparison of pre and post test scores of nonwriting group vs. writing group

Pair	Group	N	Mean	SD	t	Sig. (2-tailed)
Pair 1	Pre-test (writing group's)	50	1.96	0.57	1.769	0.083
	Pre-test (nonwriting group's)	50	1.98	0.57		
Pair 2	Post-test (writing group's)	50	3.02	0.38	-9.720	0.000*
	Post-test (nonwriting group's)	50	2.00	0.57		

Table 2 Comparison on CCTST in the writing group and nonwriting group

	Writing group (N = 50)	Nonwriting group (N = 50)	t-test for equality of Means	
	X ± sd	X ± sd	t	P
Analysis	77.50 ± 8.22	74.00 ± 7.49	-2.054	0.045*
Evaluation	69.84 ± 6.64	68.52 ± 6.47	-1.040	0.303
Explanation	71.22 ± 9.15	69.46 ± 9.48	-0.875	0.386
Total scores	218.56 ± 18.55	211.980 ± 19.37	-1.613	0.113

Collectively, the results of this study indicated that students who experienced writing in chemistry laboratory significantly improved their critical thinking level. It also indicated that the process of writing helps students develop improved analysis skill in laboratory. The same finding was previously obtained by Quitadamo and Kurtz (2007), in a related study that investigated the effect

of writing on critical thinking performance. According to Langer and Applebee (1987); Ackerman (1993); Holliday (1994); Rivard (1994), writing strategy in learning process is effective because students must conceptually organized and structure their thoughts as well as their awareness of thinking processes. In this study, completing the writing of essays on the experiment carried out

really helps students to organize their thinking process. In writing exercise, students begin to shape their thoughts at the point of construction and continually analyse, review and clarify meaning through the processes of drafting and revision, they necessarily engage and apply analysis skill (Klein, 1999; Hand and Prain, 2002).

The lack of significant change in the level of critical thinking in nonwriting group indicated that the normal practice lab instruction used in the chemistry laboratory did not help students to improve the level of critical thinking. Students do not appear to be able to respond critically in their writing to the information that they are exposed to and to move on to create new ideas and new perspectives. Most of the student did laboratory report with less evidence, fails to identify strong reason and fails to identify relevant arguments (pro and con). Students tend to write what they have learned in theoretical class rather than what they are conducting in laboratory. This is because students know (or they think they know) the expected outcomes of the experiment, students tend to chalk up any deviation from the expected outcome as the “experimental error” with little thoughtful explanation. (Peter and John, 2009).

CONCLUSION

This study was implemented on the basis of The Holistic Critical Thinking Scoring Rubric (HCTSR), (Facione & Facione, 1990) while the CCTST instruments as a supported finding. It shows that pre university medical students are more critical in chemistry laboratory essay writing compared with nonwriting approach. The findings of the present study imply that more work needs to be done towards upgrading the writing treatment on scientific writing ability among pre-university medical students. Essay writing treatment in laboratory are useful which actively engage students in the investigation of information during the experimental session and the application of knowledge will promote students’ critical thinking.

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