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Metacognitive Strategies on Classroom Participation and Student Achievement in Senior Secondary School Science Classrooms

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Abstract
Teachers constantly face the challenges of the most effective methods of instruction that could enhance academic achievement and match the diversity among students. This study therefore aimed at examining the effects of metacognitive strategies on classroom participation and student achievement in Senior Secondary School Science classrooms. One research question and hypothesis guided the study. The design for the study was a quasi-experimental design involving 3 intact groups namely two treatment groups:- Think –Pair-Share (TPS) strategy and the Metacognitive Questions (MQ) and a control group. The study lasted for 11 weeks. The sample comprised of 24, 22 and 21 subjects for control, TPS and MQ respectively. A researcher made achievement test in the topic-density was used to measure achievement in the 3 groups. The research question was answered using descriptive statistics as in mean and standard deviation while the hypothesis was tested using analysis of covariance (ANCOVA). Results revealed that the Metacognitive strategies were most effective in enhancing academic achievement followed by the TPS. The researcher recommends that Metacognitive strategies and questions be infused in the classroom so as to help students learn material more efficiently, retain information longer and generalize skills.

Key words: *Metacognition, metacognitive strategies, metacognitive knowledge, metacognitive questions, thinking skills, achievement, think-pair share*

Introduction

In the Science classroom, students are called upon to reflect on concrete examples and associate these with abstract theories. Metacognition refers to one's knowledge concerning one's own

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cognitive processes or anything related to them (Flaell as cited in Dantonio and Beisenherz, 2001). Quite simply, metacognition is thinking about thinking. Any process in which students examine the Method that they are using to retrieve, develop or expand information is deemed to be metacognitive in nature. Therefore, questions generated by the teacher would be considered metacognitive in nature if the questions invoke the process used to arrive at a response rather than soliciting a correct answer based on the student's memory of the material.

In a previous action research project that investigated participation, students first answered metacognitive questions in a journal, shared the information from their entry with a classmate, and then discussed the topic as a whole class (Stuever, 2005). The metacognitive questions forced students to examine their own process of thinking by writing their responses in a journal. The students then used the think-pair –share strategy thus giving the students the opportunity to discuss their answers with another student before volunteering to share their entry with the entire class.

Think–Pair Share –strategies engage students in thinking about their response first, and then allow students to discuss their ideas with a partner before sharing their ideas with the whole class. After posing a question over the current topic, the students could jot –down their answers to a question, turn to their neighbour and talk about their answers before sharing with the entire class. Not only is this strategy easy to put-into place, it forces student to use metacognition to examine their thinking, analyze their position, and explain their point of view to their classmates. Developing metacognitive questions about the topic at hand would be more labour intensive for the teacher. The teacher would have to change his/her mind-set and pose questions that truly require the teacher to analyze the existing links to other common experiences and material, determine which processes the student may possibly use, and formulate questions accordingly. Some of the questions that are posed during the course of the discussion can be meaningful and multifaceted, therefore requiring extended investigation and analysis. The use of either the think-pair-share strategy or metacognitive questions would be easy to put into practice in the science classroom even with the pressure to conform to current standards. Many different metacognitive practices are contained within the think-pair –share strategy. Students could write in a journal for the thinking component of the strategy, which would allow them to examine their knowledge. When they pair with a classmate, the students would be forced to discuss how they are thinking. By their sharing information with the entire class, students would be able to evaluate themselves while gathering information from other classmates. The teacher would also have the opportunity to evaluate the students' understanding based on the content of the discussions.

Another option is to have the students answer metacognitive questions for daily journal entries. Students would then discuss their entries as a whole.

The Problem

It has been observed by the researcher that many students, after learning about science concepts through activities that address the various intelligences and learning styles, still choose not to participate in classroom discussions. Instead a select few students answer teacher generated questions and develop their own questions on the topic while the rest of the students remain mute. Based on the lack of response from the majority of students, many times the teacher assumes that students that do not speak up have mastered the material but the results of an assessment over that topic frequently indicate something different. The theory backing up this study is the constructivist theory of Leasing. The theory backing up this study is the constructivist theory of learning. This theory encourage meaningful learning as opined by Windschitl(2002).Teachers elicit students ideas and experiences in relation to key topics, then fashion learning situations that helps students elaborate on structuring their current knowledge. Teachers encouraging students' reflective and autonomous thinking in connection with Metacognition may offer a solution. This research seeks to clarify if using the think-pair-share strategy or answering metacognitive questions in a journal and sharing their entries with the class will enhance the students' performance while learning the concept density. The study will also look at the influence the two metacognitive strategies have on student achievement.

Four experts in science education and two in measurement and evaluation validated the instrument for the study. The Kuder-Richardson formula 21 (K-R21) for essay test estimate of internal consistency of the Researcher Made Test (RMT) was calculated at 0.86.

A researcher – made achievement test was used to measure the academic achievement of the subjects. The items of the questionnaire were subjected to factor analysis to ensure that they are held together. One research question and hypothesis guided the study.

1 What are the distributions of the performance of the three groups of students in the researcher made test?
2 Ho1: No significant difference exists among the mean scores of the three groups.

Design and Procedure

This study uses a quasi-experimental design to compare the influence of think-pair-share strategies and metacognitive questions on participation in classroom discussions and achievement of secondary school science students. Three intact groups senior secondary one (SSS1) classes learned about density using a variety of lessons that incorporated models, teacher demonstrations, laboratories (Labs), reading and discussions. The three 38 minute classes were taught by the same teacher but the general cognitive test items (Researcher made) and the metacognitive questions were made by the researcher. The study consisted of three different treatments: a control group, think-pair-share (TPS) group, and a metacognitive questions (MQ) group. The control group started most classes with a journal entry, answering cognitive questions that were related to the material being taught. (Because of time constraints students did not have journal entries on lab days). Students were asked to share the information from their entries with the entire class if they so desired.

The TPS group followed the basic journal entry procedure used by the control group with one modification. Individual students in the TPS group answered the same cognitive questions as the control group, but then each TPS student was paired off with a classmate to discuss their respective journal entries one-on-one before sharing the information about the topic with the entire class. The MQ group followed the basic journal entry procedure used by the control group with one modification. Instead of answering cognitive questions, the MQ group answered metacognitive questions about the same topic, and then shared the information from their entries as a whole class. The metacognitive questions ask students to examine how they arrive at an answer versus the cognitive questions, which are based on content. The standard procedure of this classroom has been to use cognitive questions for the journal entries. An example of a cognitive question would be, "What is the density of this object?" compared to a metacognitive question, "What type of information do you need in order to find the density of this object?" The cognitive question focuses on the processes used to attain the correct answer. Daily cognitive questions were used for both the control group and the TPS group for the duration of the study. Daily metacognitive questions were used for the MQ group.

All three of the classes were taught about density using the same models, teacher demonstrations, labs, readings, and worksheets. The three treatment groups were taught the same science lessons on a daily basis. Only class discussions, which were generated by members of the individual classes, varied from class to class. All three treatment groups were given a pretest to gauge their understanding of the topic of density. No grade was given on the pretest. A similar test was given as a posttest to determine the mastery of the material presented. A grade was assigned on the posttest.

Three classes –second, third and fourth period / hour – were selected for this study. Morning classes were selected for the study so both students and the teacher would be fresh for the demands of the study. First period /hour classes had to be eliminated from the study because of time taken from that particular for morning announcements, leaving second, third and fourth periods/hours as for lab days. The tapes were reviewed in order to determine if misconceptions were uncovered and the quality of the discussions in the class could be evaluated. The tapes provided precise information regarding the conversations in the classroom to determine if more in–depth answers or questions were generated by the students of treatment groups.

A teacher-made pretest and posttest on density was given to all groups. Content over density is commonly taught in senior secondary school, level one (SSS I) Biology. The questions from the tests were distilled from a variety of science textbooks and worksheets. Most answers on both tests were worth one point each, but essay questions were awarded up to two points each.

Procedure

After informed consent was received, all three classes, the control group, the TPS group, and the MQ group, learned about density using a variety of lessons. These lessons included models, teacher demonstration labs, reading, worksheets, and discussions. For every activity that involved writing in their journals, each of the three classes followed a different procedure. Students in the control group (second hour) answered question in their journal and then discussed the questions as a class. Students in the TPS group (third hour) answered the same questions as the control group, but then paired off with classmates to discuss their answers, and then shared with the class. The students in the MQ group (fourth hour) answered metacognitive questions related to the same topic and then discussed their answers as a class.

Day 1: Students in all three classes were given a pretest over density.

Day 2 (Discussion 1): All students started the class with a journal entry. Students in the control group and the TPS group answered cognitive questions about how the spinning angel chimes work in their journals. After writing in their journals, the control group discussed their entries as whole class, while the TPS group paired off with a partner to discuss their answers before discussing their journal entries as a whole class.

The MQ group answered metacognitive questions in their journals, and then discussed them as a whole class. The procedure continued like this for the different days involved namely for days 3-11. After grading the review over density in class, the posttest was given to all classes.

Results

Table 1: Mean Performance scores for the three student groups on the Researcher-made Test

Group	N	Mean	Standard Deviation	Minimum Score	Maximum Score
Pre-test					
Control	24	44.69	5.16	30.00	54.00
Think = Pair –Share (TPS)	22	42.38	7.38	21.00	5800
Metacognitive Questions (MQ)	21	45.65	6.43	26.00	59.00
Post –test					
Control	23	45.95	7.10	30.00	55.00
TPS	22	57.24	5.67	50.00	65.00
MQ	21	61.80	4.62	55.00	69.00
TOTAL	133	48.78	9.78	21.00	69.00

Table 2: Analysis of Covariance (ANCOVA) for achievement scores of subjects

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	7485.491[a]	5	1497.098	39.671	.000
Intercept	303588.420	1	303588.420	8044.568	.000
TEST	7485.491	5	1497.098	39.671	.000
Error	4566.336	121	37.738		
Total	314241.000	127			
Corrected Total	12051.827	126			

a. R Squared = 621 (Adjusted R Squared =.605)

Discussion

Results of table 1 shows that mean post test scores of the three groups, Control (45.95), Think-Pair-Share (57.21) and Metacognitive Questions (61.80) varied more greatly than did the pre-test mean scores. Also the ANCOVA analysis for the three groups (table 2) showed a significant difference as the computed F value of 39.67 was significantly greater than the critical F value of 2.21. These findings corroborate with those of Marzano (2003) and Stuever (2005), where they found positive results for student achievement and increased participation when both strategies were combined. The cumulative effect of combining experimental inquiry with metacognitive questions worked together to stimulate more thoughtful, interactive responses from students. This finding agrees with the constructivist theory where teachers encourage students' reflective and autonomous thinking. Although the metacognitive questions groups showed a trend toward higher quality discussion, the amount of participation in all treatments showed mixed results.

Table 3: Multiple Comparisons using the Bonferroni correction for multiple comparisons (Wikipedia)

	(I) TEST	(J) TEST	Mean Difference (I-J)	Std. Error	Sig.
Bonferroni	posctrl	posMQ	-15.8455*	1.89797	.000
		posTPS	-11.2835*	1.87415	.000
	posMQ	posctrl	15.8455*	1.89797	.000
		prectrl	18.1043*	1.87822	.000
		preMQ	17.1500*	1.94264	.000
		preTPS	21.4190*	1.91937	.000
	posTPS	posctrl	11.2835*	1.87415	.000
		prectrl	13.5424*	1.85415	.000
		preMQ	12.5881*	1.91937	.000
		preTPS	16.8571*	1.89582	.000
	prectrl	posMQ	-18.1043*	1.87822	.000
		posTPS	-13.5424*	1.85415	.000
	preMQ	posMQ	-17.1500*	1.94264	.000
		posTPS	-12.5881*	1.91937	.000
	preTPS	posMQ	-214190*	1.91937	.000
		posTPS	-16.8571*	1.89582	.000

The mean difference is significant at the .05

The Post-hoc analysis using the Bonferonni correction indicated significant differences between Post-control and Post-MQ and Post TPS. Equally, Post-MQ and Post-control, Pre-control, Pre-MQ and Pre-TPS also differed. Table 3 illustrates also that Post-TPS differed significantly from Post- control, Pre-control, Pre-MQ and Pre-TPS. Pre-control differed significantly from Post-MQ and Post-TPS. Pre-MQ differed significantly from Post-MQ and Post-TPS while Pre-TPS differed significantly from Post-MQ and Post-TPS.

Note	Posctrl	–	Post Control
	Pos MQ	-	Post Metacognitive Questions
	Post TPS	-	Post Think -Pair -Share
	Prectrl	-	Pre-test control
	Pre MQ	-	Pre Metacognitive Questions
	Pre TPS	-	Pre Think – Pair-Share

Conclusion

Metacognition is a strong predictor of academic success and problem solving ability (Theide et al., 2003). Students who are able to effectively discriminate between information they have learned and information they have not learned are more likely to review and learn new information (Everson & Tobias, 1998). If students believe they know everything for the test, they will probably end their studying. Premature cessation of studying before learning is completed will most likely result in poor performance. The will of changing and the desire of innovation by teachers come from the necessity of 'motivating' students, who seem to have lost their interest in science. The metacognitive strategies are teaching strategies which can motivate students and give them the opportunity to learn, understand and recognize the information received in class and in their everyday life. This will make the students to be more and more independent in facing new situations. Teachers should allow the students to seek understanding by exploring and investigating on their own with teachers as facilitators.

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