

Effect of Meta-Cognitive Instruction and Cooperative Learning Strategies on Students' Achievement in Science

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In this research work the researcher tried to introduce the higher level methods of teaching which are essential while teaching for proper concept development of students and to make them creative. This study is experimental in nature which consists of 2 experimental groups and 1 control group. The sample of 60 biology students was selected from the Faran Model High School, Jhang. The data was analyzed by paired sample t-test and one way analysis of variance. The results concluded that there was no noteworthy difference that existed between respondents of each groups based on randomization of data. Treatment given to first experimental group based on meta-cognitive learning performed comparatively better than peers in the rest of the groups. The results of paired sample t-statistics also declared that better performance was observed in the level of better learning based on meta-cognitive learning skills being part of daily life teaching and learning.

Keywords: *meta-cognitive instruction, meta-cognitive awareness, regulation of knowledge, cooperative learning strategies.*

Introduction

The simplest definition of meta-cognition is “cognition about cognition” or “thinking about thinking” (Flavell, Miller & Miller, 2002). Hence this concept is versatile and profound, so it has many more complex definitions (Dunlosky & Metcalf, 2009; Flavell, 1976). Fundamentally, this is actually a continuous process that is based on reflections and actions. The people who think meta-cognitively can alter their concepts and methods. The clearest

definition of meta-cognition focuses on the fact that it is a process or cycle and this is never ending process. The operations particularly related to processing of meta-cognitive thought, such as meta-cognitive regulation and control and does not come-up with expected behaviour of individuals that can be observed. Several processes connected internally with the meta-cognitive are not particularly measurable or observable all the time.

Meta-cognitive thinking includes students' ability to recognise gaps in their learning. In older students, meta-cognitive thinking may be viewed as a study strategy in which students evaluate their understanding of the material and identify parts of their learning that they need to continue for deeper comprehension. The accuracy of comprehension seems to be one of the most significant challenges for students to master. Dunlosky and Lipko (2007) concluded that when students can identify the material they already know and what material they still need to know, they can spend their study time more efficiently, studying only that material that is unlearned. This ability of students enables them to focus their study time on that material which is not clear to them. While students become overconfident when they suppose they comprehend with accuracy in their learning (Dabarera, et al., 2014; Dunlosky & Lipko, 2007).

It is said by Hartman (2001) that teaching the students with meta-cognitive strategies meant that the instructor will ponder about how his teaching will develop and enhance learner's meta-cognition. In the study of Bilgin, et. al. (2006) and Chang & Mao (2005), it was observed that cooperative learning (CL) strategies involve the learners in process of learning and tries to better their abilities of thinking critically, reasoning abilities, and skills of solving a problem of the learners. As studied by Stevens, R., & Slavin, R. (2002) for the accomplishment of CL, peer interaction plays a central role because it directly linked with the cognitive understanding. They focused on the fact that the students easily took part in learning processes with the help of group communications but there were some students who rejected to participate in traditional class settings.

The term meta-cognition deals with someone's own understanding regarding his own thinking processes or any aspect relevant to his thinking (Flavell, 1976). So basically, it can be said that meta-cognition is thinking about thinking. There are two main divisions of meta-cognition: Knowledge of cognition and regulation of cognition (Brown, 1987). The knowledge of cognition deals with the thinking activities, thinking abilities, and the conscious thought processes. Regulation of cognition deals with how students manage and monitor their thinking. All the activities that learners used to recover, redesign, or spread knowledge, seems to be meta-cognitive (Everson & Tobias, 1998).

It was noted by Chang and Mao (2005) that when CL strategies are used properly they facilitate the learners to go towards the higher level skills of the students instead of rote memorisation of concepts and texts etc.; the cognitive structure building methods results in

wide understanding of all learners in cooperative learning groups. Cooperative learning methods are not only useful for academic purposes but also in enhancing self-esteem, group relationships, and improved behaviour of students towards friends and school as well (Bilgin & Geban, 2006). The CL strategies also provide the facility to students to share one's concepts and answers with their group fellows. They could write their answers against that question, move towards his fellow or group fellow, and share his answer with the fellow and discuss it with all the class fellows as well. This strategy allows learners talk about their reasoning, break down their position, and clarify their perspective to their fellows. Through this discussion with the whole class, the learners become able to evaluate their performance by collecting information from the whole class. The instructor would likewise have the chance to assess the learners' understanding in view of the discussed material. The application of these methods i.e. meta-cognitive strategies and cooperative learning method would be simple in science classes even with the burden of syllabus, it's topic to be covered, and to obtain good marks on demand from parents.

Hence, after reviewing this literature, this study was conducted to investigate the effect of high order teaching strategies on science students' achievement. The focused objective of this study was to investigate the effects of meta-cognitive instruction and cooperative learning on science students' achievement at the secondary level. The null hypotheses used to gain the results of study were.

Ho1: There is no significant difference between the pre-test and post-test results of meta-cognitive instruction on science students' achievement.

Ho2: There is no significant difference between the pre-test and post-test results of CL strategies on science students' achievement.

Ho3: There is no significant difference between the pre-test and post-test results of control group on science students' achievement.

Research Methodology

The research was true experimental pre- and post-tests design with 2 experimental and one control group. In two experimental groups, the first group was meta-cognitive instruction and the second group for cooperative learning techniques. The sample consisted of three groups comprising 20 students in each group. The three groups first administered a science achievement test and a meta-cognitive awareness test (MAT) as pre-test and the results were compared to check the equivalence of groups. Then the students were taught through the above mentioned both teaching methods for 12 weeks as the experiment of the study. After completion of experiment time period all the groups were be post-tested to check the effect of the experiment and to compare the performance of students of all groups.

The experimental groups of the study were based on the following designs:



Meta-cognitive Instructions

IDEAL is an approach to Meta-cognition which means to Identify, Define, Explore, Act, and Look. This word is the short form for the strategies, which are utilised for proper and competent ways of solving and understanding the problem (Byrnes, 1996). From all the above mentioned meta-cognitive skills could be taught to pupils by the relevant instructor for effective thinking and problem solving.

Cooperative Learning Strategies

This is a type of pedagogy in which the instructor assigns diverse duties based on the material preferred for the study, which were arranged and constructed in a specific arrangement to achieve the objectives of the lesson for the group of 4-6 learners of the same age and achievement level. Communication of the group goal and tasks structure, monitoring of group work and testing of individual learning were made by the instructor.

Population

The population of this study was all the learners of 10th class enrolled in subject biology in girls' high schools of Pakistan and accessible population of this study was all the students of 10th class enrolled in subject biology in private high school of district Jhang.

Delimitations of the study

This research work is important in the local context because the studies carried out in the past deal with the population of male college students of arts subjects or teachers to prove the same process, but in this work at the female school students is very useful as well. In fact, it is a general concept that our teachers taught by giving lectures or book reading only. Hence this study is unique in providing new direction to teachers for achieving positive results of cooperative learning activities for better performance of learners. This study may also provide the insight to instructors and they can use the results of this study to develop positive attitude towards meta-cognitive and cooperative learning strategies.

Hence, due to time and resources constraints the following delimitations were found in this three groups pre-test, post-test research study. The delimitations were.

1. The students enrolled in the subject of biology.
2. Only 10th class female students.
3. The students of private school only.
4. Only the district Jhang.
- 5.

Sample and Sampling Method

The researcher selected samples by using random sampling technique and the sample for this study was all the biology students of 10th class section ‘A’ enrolled in Faran Girls High School, Satellite Town Jhang. The researcher selected the students of this school because they had a good strength of biology students and had minimum number of vacations in this school as compare to other schools. They had 69 girls in one class. The researcher took that class as the sample and divided the sample in three groups (20 girls in each group) on the base of randomisation of students. As the remaining 9 students were not interested to participate in the study so they were excluded from the experiment.

Instrument of the Study

The science achievement test was constructed by the researcher. The researcher had studied deeply the 10th class text book by PTB. The standard of all the items included in the test was measured by the difficulty level and item difficulty index formulas. All the items were chosen by keeping in view the blue-print used in school which covers all the parameters like knowledge, understanding, application and skill type questions.

The constructed tool for meta-cognitive awareness developed by Schraw and Dennison (1994) was utilised in this study. It was comprised of fifty-two statements. It was utilised as the Meta-cognitive Awareness Tool (MAT) by many researchers in meta-cognition study (Lippmann, 2005). The statements assisted to recognise the existence of meta-cognitive behaviour among learners (Lippmann, 2005).

Experiment Procedure

The three classes each comprised of 45 minutes, were handled by their previous school teachers who were teaching them before this study. The study was comprised of 3 various groups: a control group (CG), a cooperative learning group (CL), and a meta-cognitive instructions group (MI). The CG was taught the routine before study and the students answered cognitive questions relevant to the material they were delivered in the class. The instructors were given to the learners to discuss the things taught in the whole class if they want to do so. The CL group was following the same method utilised by the CG with one change. After teaching the lesson, each learner in the CL group was asked to read from their book of biology. Each learner of CL group was bound with another classmate as the pair to argue the topic with one another before discussing the topic with all students in the class and giving answers relevant to the book questions. The remaining third group used the same method utilised by the CG with one change. After teaching the material the learners of MI group used reading the text book using the various meta-cognitive instructional strategies.

Methods of Data Analysis

That's why the researcher used IBM SPSS Statistics v.23 for analysis of quantitative data. The obtained data was analysed by using descriptive statistics, analysis of variances, one-way Analysis of Variance (ANOVA) to find out differences between mean scores of control and treatment groups while responding for post-test scores by taking pre-test scores as the covariate variable. The researcher also used paired sample t-test to compare both pre-test and post-test scores between variables of investigation such as the effect of meta-cognitive instruction, cooperative learning instruction and simple lecture method.

Table 1. *Pretest-posttest paired sample t-statistics for meta-cognitive group based on Biology test*

Groups	N	Mean	SD	Std. Error Mean
Pre-test	20	29.00	5.572	1.246
Post-test	20	36.30	5.768	1.290

Paired Sample t-statistics						
Groups	Paired Differences			t-value	df	Sig*
	M	SD	Std. Error Mean			
Pre-test-Post-test	-7.300	3.600	.805	-9.069	19	.001*

*p < 0.05 (2-tailed)

As shown in above Table No. 1, a paired samples t statistics was applied to compare pre-test and post-test scores of the meta-cognitive group participants. It was found that there was a significant difference between responses given by respondents in the biology test conducted in both the pre-test (M=29, SD=5.572) and post-test scores (M=36.30, SD=5.768) where $t(19) = -9.069$, $p=0.001$. The results of the above paired-samples' t-test suggest that treatment given to the meta-cognitive group participants truly helped them to perform better than the way they responded in the pre-test. It further suggests that if the respondents are given a chance to learn using meta-cognitive based learning strategies it leaves positive effects on the level of students learning.

Table 2. *Pre-test-post-test paired sample t-statistics for the Cooperative Group based on a Biology test*

Paired Sample Descriptive Statistics						
Groups	N	Mean	SD	Std. Error Mean		
Pre-test	19	31.21	3.630	.833		
Post-test	19	40.63	3.933	.902		
Paired Sample t-statistics						
Groups	Paired Differences			t-value	df	Sig*
	M	SD	Std. Error Mean			
Pretest-Posttest	-9.421	5.124	1.176	-8.014	18	.001*

*p < 0.05 (2-tailed)

As shown in the above Table No. 2, a paired samples' t statistics was applied to compare pre-test and post-test scores of cooperative group participants. It was found that there was significant difference between responses given by respondents in the biology test conducted between both pre-test (M=31.21, SD=3.630) and post-test scores (M=40.63, SD=3.933) where $t(18) = -8.014$, $p=0.001$ which is less than assumed level of alpha i.e. 0.05. The results of the above paired-samples' t-test reflect that treatment was given to cooperative group participants based on cooperative learning strategies, therefore, respondents performed better than the way they performed in the pre-test.

Table 3. *Pre-test-post-test paired sample t-statistics for Control Group based on Biology test*

Paired Sample Descriptive Statistics						
Groups	N	Mean	SD	Std. Error Mean		
Pre-test	21	28.24	6.115	1.334		
Post-test	21	29.76	7.536	1.644		
Paired Sample t-statistics						
Groups	Paired Differences			t-value	df	Sig
	M	SD	Std. Error Mean			
Pretest-Posttest	-1.524	5.437	1.186	-1.284	20	.214**

**p > 0.05 (2-tailed)

As shown in the above Table No. 3, a paired samples t statistics was applied to compare pre-test and post-test scores of control group participants. It was found that there was a non-significant difference between responses given by respondents in the biology test conducted between both pre-test (M=28.24, SD=6.115) and post-test scores (M=29.76, SD=7.536) where $t(20) = -1.284$, $p=0.214$ (2-tailed) which is greater than assumed level of alpha i.e.

0.05. The results of above paired-samples' t-test highlight that no treatment was given to the control group participants based on meta-cognitive learning or cooperative learning strategies; therefore, respondents performed in almost same way as they performed for pre-test data.

Table 4. ANOVA Pretest-Scores - Biology Test

Source	df	SS	MS	F	Sig.
Between Groups	2	93.766	46.883	1.697	.192**
Within Groups	57	1574.967	27.631		
Total	59	1668.733			

**p > 0.05

In the above Table No. 4, the results of one way analysis of variance (ANOVA) revealed that there was an insignificant difference, in pre-test, between responses of the three groups such as Meta-cognitive, Cooperative and Control based on a Biology test conducted where, $F(2, 57) = 1.697$, $p = .192$. The calculated value p is greater than assumed level of alpha which was 0.05.

Table 5. Bonferroni Multiple Comparison for Pre-Test Scores - Biology Test

Groups	Mean Difference	Std. Error	Sig.	95% Confidence Interval	
				Lower Bound	Upper Bound
Meta-cognitive-Cooperative	-2.211	1.684	.584**	-6.36	1.94
Meta-cognitive-Control	.762	1.642	1.001**	-3.29	4.81
Cooperative-Control	2.972	1.664	.238**	-1.13	7.08

**p > 0.05

Moreover, post hoc analysis was also performed for pair-wise comparison between any of the two groups separately with the help of the Bonferroni test which further inferred that there were non-significant differences between all the groups such as Meta-cognitive-Cooperative, Meta-cognitive-Control and Cooperative-Control groups.

Table 6. Analysis of variance based on post-test scores for Biology test

Source	Df	SS	MS	F	Sig.
Between Groups	2	1203.753	601.876	16.764	.001*
Within Groups	57	2046.431	35.902		
Total	59	3250.183			

*p < 0.05

In the above Table No. 6, the results of one way analysis of variance (ANOVA) showed that there was a significant difference, in the post-test results, between responses of all three groups such as Meta-cognitive, Cooperative and Control based on the Biology test conducted

where, $F(2, 57) = 16.764$, $p = .001$. The calculated value of p is less than assumed level of alpha which was 0.05.

Table 7. *Post hoc multiple comparison for post-test scores - Biology test*

Groups	Mean Difference	Std. Error	Sig.	95% Confidence Interval	
				Lower Bound	Upper Bound
Meta-cognitive-Cooperative	-4.332	1.920	.084	-9.07	.40
Meta-cognitive-Control	6.538*	1.872	.003	1.92	11.16
Cooperative-Control	10.870*	1.897	.001	6.19	15.55

*The mean difference is significant at the 0.05 level.

For a deeper understanding of the significant difference for Table 6, post hoc analysis was performed, for pair-wise comparison between any of two groups separately with the help of the Bonferroni test, which further inferred that there were significant differences between Meta-Cognitive-Control as well as Cooperative-Control groups. But there was no significant difference found between Meta-Cognitive-Cooperative groups. These results clearly indicate that treatment given to the participants of meta-cognitive group based on meta-cognitive learning out-performed while responding in the post-test in the biology test and showed comparatively better results as compared to their pre-test scores. Additionally, the results further indicate that treatment given to the participants of the cooperative group based on cooperative learning strategies, helped them to perform comparatively better than they performed in the biology test conducted as part of pre-test data. On the other hand, there was no noteworthy difference observed between meta-cognitive-cooperative learning groups, which indicates that the performance of participants of both groups was strengthened based on separate treatment given to both groups but still up-to a non-significant level.

Conclusion and Discussion

The results of this study end with the conclusion that there was no noteworthy difference between respondents of each groups such as control, experimental 1 and experimental 2 based on randomisation of data. Later treatment was given to the first experimental group based on meta-cognitive learning, which helped the students of the same group to perform comparatively significantly better than peers in the rest of the groups such as the cooperative learning group as well as the control group. The results of paired sample t-statistics also help to come to this point that there was clearly development observed in the level of better learning based on meta-cognitive learning skills, being part of daily life teaching and learning. This not only made the teachers to think critically, it was also helpful for learners to perform better later in their professional career, which is more important for development of our generations. . The results of the paired sample t-statistics also helped to come to this point, that better performance was observed in the level of better learning based on meta-

cognitive learning skills being part of daily life teaching and learning. These skills are not only helpful for the teachers to think critically but also helpful for learners to perform better in their professional career which is more important for development of our generations.

It is observed from teachers' duties that they are trying to improve the students' achievement level using various instructional methods and utilising practical techniques to enhance the concept development process, but this is not the actual story. Our students are still suffering from the use of old and boring traditional styles of teaching on the basis of which proper concept development and creative thinking abilities are not possible to produce. In this study an attempt is made to provide a novel and unique learning situation to students to enhance the performance of students and introduce new styles of teaching techniques. Thus, the findings of this study highlight the effect of met-cognitive instruction and cooperative learning strategies on the achievement of science students. The findings are in line with Shamir, Metvarech, & Gida, 2009; Brown, 1987; Veeman, 2006; Hall, Danielewicz, & Ware, 2013; Bilgin & Geban, 2006; Meichenbaum, 2005; Rehman & Khan, 2011; and in contract to those who said that cooperative learning techniques are not effective (Soares & Wood, 2010; Little, Feng, VanTassel-Baska, Rogers, & Avery, 2007; Slavin, 1995; Mills & Durden, 1992; Yamarik, 2007; Johnson & Johnson, 1989).

Apart from the above discussion, results are evident to show that treatments given to different groups based on meta-cognitive learning and use of cooperative learning strategies during teaching at school, helped the students to perform comparatively better and significantly different as compared to students included in control group. These results were based on a biology test conducted twice before and after the study and it was clearly concluded that students of cooperative learning performed better than students of learning through meta-cognitive techniques and both groups were significantly different from control group where no treatment was given at all.

Meta-cognition is powerful forecaster of academic achievement and the capability of solving a problem (Theide et al., 2003). The learners who are capable to differentiate properly among different information they seek and the information they don't seek are accepted to think upon and memorise new knowledge and information (Everson & Tobias, 1998). When the learners believe that they can solve all the questions in the test then obviously they will end their studies. Their desire for change and will for improvement in instructors, originate from the need to motivate the learners who sounds are deprived, form the attention and interest in science subjects. The instructional methods can stimulate the learners and provide them the chances to seek and learn, comprehend and identify the concepts delivered in the class and in daily life (Kramarski.et.al., 2004). This results in the learners to be stronger in handling the new problem or situation. The instructors should permit the learners to undersea and by investigation and exploration by their own concepts with instructors only as the guides.



Recommendations

1. It is recommended that teachers should have to focus on their teaching style and primarily have to focus on the positive development of their students by adopting new and effective ways of teaching to make the teaching process more effective.
2. This study showed that cooperative and meta-cognitive learning styles are most effective in nature, especially when it is necessarily important for individual difference among students by giving them individual assignments as well as prepare them as a part of team.
3. It is further recommended that teachers are not only the key personality to improve the level of learning for students but for moral development of their children. It also necessary that parents have to show their participation to motivate students and encourage their children as well as the school administration to involve such activities as to let the doors open for new and effective learning of students.

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