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Effect of Concept Mapping On Students' Academic Achievement

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The study aimed to analyze effect of concept mapping, a constructivism based learning strategy, on academic performance of 7th grade students in the subject of general science. This quasi experimental research, based on 2x2 factorial research design, involved 167 students from two single sex schools. Major objectives of the study were to; (i) find out the effect of concept mapping as a learning strategy on the academic achievement of students (ii) study differential effect of concept mapping on academic achievement of male and female students (iii) to find out the interaction effect of concept mapping as a learning strategy and gender on students' academic achievement. Researcher's developed achievement test was used as pre test and post test. During the treatment of five months, experimental group was trained to develop concept maps for three weeks. Subsequently students developed concept maps of general science content individually, shared those in groups and were compared by teacher with scientifically accepted concept maps for possible correction and improvement. Data on gain achievement scores were analyzed through 2-way ANOVA. Results showed that the male and female students taught through concept mapping performed better than the students taught through traditional teaching method. However male students taught through concept mapping performed significantly better than the female students. It is therefore recommended that concept mapping should be used in elementary classes for teaching general science. Concepts maps may also be incorporated in the textbooks of science subjects at the school level.

Keywords: *Concept Mapping, Learning Strategy, Elementary Science Education, Constructivism, General Science, Gender*

Introduction

Learning is a purposeful, conscious and complex process (Adey & Shayer, 1994). An important feature of learning is that it involves a complex interactive system including environmental, social, motivational, emotional and cognitive factors (Baron & Byrne, 2003; Huffman, 2004; Joyce, Weil & Calhoun, 2004).

Various teaching-learning strategies have been developed to accelerate learning process of students. Learning strategies evolve from the learning theories defining the role of teacher, students and the contents. In Pakistan, at present, mostly behavioural practices are in vogue in schools where students are passive and classroom environment is mostly teacher dominated (Iqbal, 2011). The National Curriculum 2006 stresses for the paradigm shift from the behaviourism to constructivism to enhance conceptual learning in science and development of attitude towards learning of science (Govt. of Pakistan, 2006). This curriculum demands such teaching-learning strategies that may involve students in their own knowledge construction, placing them as centre of learning activity and teacher as a facilitator. Concept mapping is one of the teaching-learning strategies under constructivism having its orientation in David Ausubel's Assimilation theory (1968) of cognitive learning, which aims at fostering meaningful learning by students. Concept mapping as a learning strategy uses a rich social environment, where learners work individually and in groups to scaffold and mediate learning of each other (Oakley, 2004; Novak & Gowin,1984; Ausubel, 1968).

Concept mapping is a technique of visually representing the structure of information, concepts,

and their relationship. Research studies in the field of science education reflect that concept mapping can be used as a successful teaching - learning strategy from primary school to university level. Concept maps are used as a tool for meaningful learning, assessment, instructional planning and finding out the alternative concepts or misconceptions held by the learners (Enger, 1998; Nesbit & Adesope, 2006; Novak & Cańas, 2006a, 2006b; Novak, 1980). Learning through concept mapping has long lasting effect on memory demonstrated in the form of better results in delayed post-test as compared with other teaching leaning strategies. It can also be useful in combination with other manipulative learning strategies like experiments etc. (Volk & Ritchie, 1999; Hilbert & Renkl, 2007; O'Donnell, Dansereau & Hall, 2002).

General science contents at elementary school level involve concepts related to biology, environment, physics, and chemistry. Researches conducted at secondary level in the subject of physics (Bascon & Novak, 1985; Pankratius, 1990) and biology (Jegede, Alaiyemola and Okebukola,1990; Esiobu and Soyibo,1995; Bilesanmi-Awarderu, 2002) show that the concept mapping is successful tool in teaching -learning . Few researches have addressed the effect of concept mapping on academic performance of elementary students. Hence study was designed to explore the effect of concept mapping as a teaching learning tool on the students of grade-7 who are at the threshold of Formal stage of cognitive development.

Gender difference in performance in science has been long debated issue. Various studies have found male students performing, on average, better than their female counterpart student. According to Lagoke, Fegede and Oyebanji (1997) the important factors that develop gender difference are sex role identification, culture and socialization. Few researchers have focussed gender differences in use of concept mapping and especially at the age of 12-13 years. Better performance of female students is revealed by short term researches on use of concept mapping as study tool in Chemistry (Boujaoude & Attieh, 2003) and Biology (Bilesanmi, 2002) in 10th grade showing that female students scored significantly higher than boys. While in studies of longer durations of using concept mapping by Ahlberg and Ahoranta (2004) and Keraro, Wachanga and Orora (2007) showed no gender difference in performance in science subjects.

This study was an effort to find out the effect of concept mapping on students academic achievement at elementary level in the subject of general science.

Major objectives of the study were to:

1. find out the effect of concept mapping as a learning strategy on the academic achievement of the students of 7th grade.
2. study differential effect of concept mapping on academic achievement of male and female students.
3. find out the interaction effect of teaching learning strategy and gender on students' academic achievement.

Research Design

This quasi experimental study involved two independent variables i.e. gender and teaching learning strategy, having two levels of each variable. The 2x2 factorial design was used to address all possible combinations of the selected levels of the two independent variables.

Table 1: Factorial design with number of students

	Teaching- Learning Strategy	
Gender	Concept Mapping	Traditional
Male	43	38
Female	46	40
Total	89	78

Sampling

Multistage sampling was done to select appropriate sample. At the first stage two secondary schools, one for male and one for female, were selected conveniently out of 15 male and 11 female schools in Sargodha city. Both selected school had four class sections of grade 7th, each consisting about 45 students. At the second stage of sampling, from each school two sections were selected randomly and subsequently one section was randomly assigned as control and the other as experimental group.

At the start of study, students were briefed about the purpose and duration of the research programme and their role. They were allowed to quit from the research anytime if they felt uncomfortable.

Research Tool

To measure the academic achievement of students a science achievement test was developed for this study spreading over the selected content from 7th grade General Science curriculum textbook.

The achievement test included items from all the areas i.e. Biology, Chemistry and Physics, with a distribution of items and scores as 40% (30 marks), 32% (24marks) and 28% (21 marks), respectively. Moreover, items in the test were also constructed with respect to levels of cognitive domain i.e. Knowledge, Comprehension and Application or above. As recommended by BouJaoude and Attieh (2003), about equal proportion of items regarding Knowledge (32%), Comprehension (36%) and Application or above levels (32%) were included in the test. The achievement test comprised of 41 multiple choice items and 17 restricted response items.

To ensure the accuracy of content and vocabulary the achievement test was reviewed by four subject matter experts. Pilot testing was conducted on 200 (117 male and 83 female) students from four schools. Item analysis was done to find out the "Difficulty Level" and "Discrimination Power" of each item. Items with discrimination index above 0.20 and difficulty index ranging from 0.20 to 0.70 were included in the test as recommended by Kubiszyn and Bolich (2004). Cronbach alpha for the test was 0.83 which is considered very suitable (Linn & Grunlund (2000) for an achievement test.)

Procedure of the Experiment

Steps of the experiment were as follow:

1. Concept maps of all topics of included material were developed by the researchers with the consultation of teachers having academic qualification of B. Sc or higher, M. Ed in Science Education and minimum 10 years experience of teaching science subjects. These concept maps were used as standard for comparison with students' made concept map during treatment.
2. Achievement test was administered as pre -test

Table 2: Table of Specification of Achievement Test

Content Area	Levels of Cognitive Domain			Scores/Marks
	Knowledge	Comprehension	Application	
Biology	11	11	8	30(40%)
Chemistry	8	10	6	24 (32%)
Physics	5	6	10	21 (21%)
Total	24 (32%)	27 (36%)	24 (32%)	75

Table 3: Two-way Analysis of Variance for main effect of teaching-learning strategy on experimental and control group

	Group	N	Mean	S.D	Df	F	Sig
1	Experimental	89	12.79	8.86	163	74.15*	0.000
	Control	78	3.41	5.85			

3. Experiment was carried out for a period of five months
   i. First researcher taught the experimental groups of both the selected boys and girls schools, to develop concept maps.
   ii. After three weeks training of developing concept maps, students in experimental groups were asked to prepare concept maps of their own from the general science content. This activity followed the construction of concept maps in groups by negotiation and discussion.
   iii. The students' developed concept maps were compared by the teacher/ researcher with the already validated relevant concept maps to guide them for possible improvement or correction and to improve their concept mapping skill for the next lessons/topics
4. Achievement test was administered as post -test

Finding and Results

Two-way (2x2) ANOVA was used to find out the main effects and the interaction effect of gender and teaching-learning strategy on the students' academic achievement.

ANOVA reveals a significant effect of treatment suggesting that students in experimental group gained significantly more than their counterparts in control group.

Analysis of the gain scores in table 4 reveals a significant effect of treatment for both the genders. i.e male F (1,79)= 98.59, ρ=0.00 suggesting that male students in the experimental group (X=16.41, SD= 8.20) gained significantly higher than those in the control group (X=2.00, SD= 3.79). Female students in experimental group gain significantly greater than the female students in the control group.

Differential effect of concept mapping on male and female students was also sought out.

Table 4: Gender based Analysis of variance of achievement scores in experimental and control groups

Group		N	Mean	S.D	df	F	Sig
Experimental	Male	43	16.41	8.20	79	98.59	0.000
Control		38	2.00	3.79			
Experimental	Female	46	9.42	8.16	84	7.91	0.006
Control		40	4.75	7.08			

Table 5: Analysis of gain in achievement scores of male and female students in experimental group

Gender	N	Mean	S.D	Df	F	Sig
Male	43	16.41	8.20	87	16.24*	0.000
Female	46	9.42	8.16			

In table 5 ANOVA reveals a significant effect of gender F (1,87) = 16.24, ρ=0.00 suggesting that male students in experimental group (X=16.41, SD= 8.20) had significantly greater gain than female students (X=9.42, S.D= 8.16) within experimental group.

An important objective of the study was to explore any existing interaction effect of gender and teaching learning strategy on academic achievement of the student.

Levene's test was used to probe error variance among the groups. Lavene's test value (F= 8.5, df= 3, ρ= 0.00) shows that error variance in gain achievement score was not equal in all groups. Hence significance level for F test was set to 0.01 to satisfy statistical assumptions for using ANOVA.

Figure 1 and data of descriptive analysis (table 6) shows that in experimental group the mean gain scores of male students (16.41) was significantly greater than the mean gain scores of female students (9.42). While in control group female students had greater mean gain scores (4.40) than mean gain scores of male students (2.00). It is concluded that both male and female students of experimental group outperformed the male and female students of control groups but there was methodology gender effect on academic achievement in general science. It is also concluded that girl students were less affected by the teaching-learning strategy adopted, as compared with boy students.

Table 6: Two-way Analysis of Variance for interaction effect of gender and methodology in control and experimental groups.

	Experimental group			Control Group			df	F	Sig
	N	Mean	SD	N	Mean	S.D			
Male	43	16.41	8.20	38	2.00	3.79	163	19.33	0.000
Female	46	9.42	8.16	40	4.41	7.08			

A Two-way between Groups Analysis of Variance shows a significant interaction effect, F(1,163) =19.33, ρ= 0.00 of teaching-learning strategy and gender on the mean gain in achievement scores.

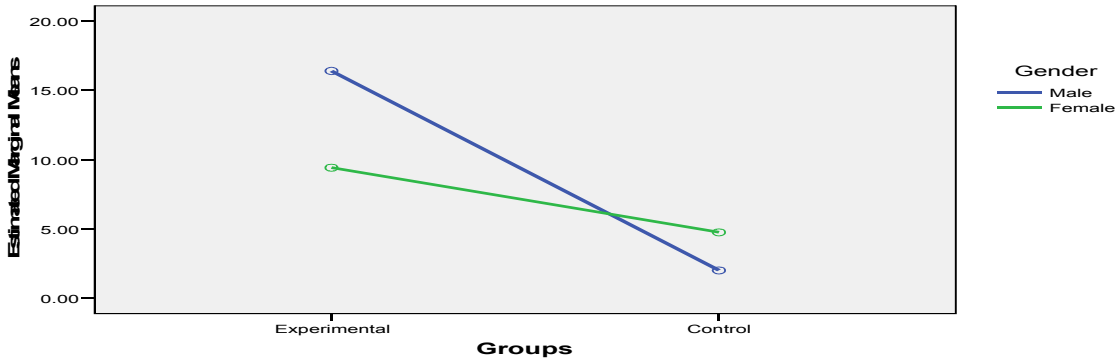

Figure 1: Graphic presentation of interaction effect of treatment and gender on mean gain in achievement scores.

Discussion

This empirical study showed that concept mapping is more effective teaching learning strategy than the traditional method, to improve academic achievement of the students of both genders in subject of General Science The results of this study extend the findings of Hall and O'Donnell (1996), Bilesanmi-Aworderu (2002), Ahlberg and Ahoranta (2004), Malik (2009), Khawaldeh and Al-Olimat (2010), Snead and Young (2003), Czerniak and Haney (1998).The major reason is that concept mapping provides opportunity for active involvement of students in their learning process and hence enhances their thinking ability while cross questioning and thinking for seeking solution. Concept mapping facilitates and even stimulates imaginations of the learner (McAleese, 1999). Presentation of the concepts to the fellow students brings a greater conceptual clarity for themselves (Freeman, 2004). During the discussion among the peers, learners become aware of their misconceptions. Inconsistent reasoning leads to cognitive conflict. In normal discourse there is a chance that misconceptions of the learners are gone unchecked. But when concept map is drawn, the misconceptions can be traced very easily by the teacher or by comparing student made concept maps with the scientifically accepted concept maps. Hence it can be concluded that concept mapping improves academic performance of both male and female students due to their active involvement in learning, discussion, sharing of concepts and removal of misconceptions.

Concept mapping as a teaching learning tool is more effective for the male students than female students with respect to achievement in science. Hence gender has moderating role in defining the effect of concept mapping on academic achievement in the subject of science. This could be attributed to the significant difference between mean achievement scores of the male and female students on Pre-test. In experimental group female students surpassed male students on pre-test, so there was less room for improvement for female students as compared to male students. According to Brandt et. al., (2001) the students with low pretest scores show significantly larger gain scores than those with high pretest scores. Few studies are available in literature relating to gender in differential effect of concept mapping on the academic achievement. The researches carried out on college and university level show that female outperformed male students in benefits from concept mapping. While Ahlberg and Ahoranta (2004) and Bilesanmi-Aworderu, (2002) stated no gender difference in the use of concept mapping for meaningful learning. The better performance of female students is also reported by Boujaoude and Attieh (2003) on use of concept mapping as study tool in Chemistry and Biology in 10^{th} grade.

Recommendations

On the basis of findings of this study and the discussion it is recommended that concept mapping is beneficial in enhancing student achievement of 7^{th} graders in the subject of general science. Therefore, it is recommended that

1. Curriculum developer may incorporate this strategy in curriculum guidelines for achievement of intended learning outcomes and content development for meaningful and higher order learning
2. Textbook being a primary tool to deliver the concept to the students lays a heavy responsibility on the textbook writers to develop a balanced textbook in terms of content, methodology, practical activities and assessment exercises. The textbook writers are urged to include concept maps and concept mapping activities in the textbooks
3. Examination bodies like the Punjab Examination Commission and boards of intermediate and secondary education may include concept mapping as an evaluative tool in their examinations. It will also promote concept mapping as evaluation tool in formative and summative assessment in schools. The impact will then filter down to the teachers requiring them to use it as classroom teaching-learning strategy
4. Concept mapping is an emerging teaching-learning strategy. Pre-service and in service teacher education programs ought to incorporate it in the curriculum to prepare teachers with respect to its philosophical background, theoretical base and practical usage.

Suggestions for further research

1. This study was carried out in subject of General Science for 7th grade students and proved concept mapping as a beneficial teaching learning strategy for cognitive development of students. So it is suggested to conduct such research studies for other grades and subjects
2. The results of this study revealed that concept mapping is found to be more beneficial for male than female students. Hence a qualitative or quantitative research is recommended for the exploration of those variables that affect learning patterns of male and female students.
3. In this study whole classes were taken as experimental groups. The students in each grade belong to mixed ability levels. It is suggested that research may be conducted to find out the effect of concept mapping on students with different ability levels.

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