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Effect of Synectics Model of Teaching in Enhancing Students' Understanding of Abstract Concepts of Mathematics

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Abstract

Abstract concepts of mathematics are always difficult for the students to comprehend. These concepts are a continuous source of low achievement in mathematics. A study was conducted to explore the effect of Synectics Model of teaching in enhancing understanding of abstract concept of mathematics. It was a form of quasi-experimental study using nonequivalent Control group design. The sample was two intact groups of grade eight (Control, N=35) and (Experimental, N=33). Two schools were selected among high schools of district Haripur where the researcher could seek permission to conduct the study. The instrument was a self-developed achievement test from three units (Operations on Sets, Polynomials and Fundamentals of Geometry) of eighth class mathematics textbook. The results of the study revealed that when abstract concepts were taught using analogy, students were able to: (i) redefine the concept using their own words, (ii) relate concept to their daily life, (iii) apply the concept in daily life.

Keywords: Synectics model, teaching of mathematics, students' understanding, abstract concepts of mathematics

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Introduction

Abstract concepts are always a source of continuous annoying and irritation for the students. They feel much difficulty in comprehending the intangible attributes of the concepts. Particularly it is hard for the young children to grasp meaning of the abstract concept as such concepts do not exist in reality but only in sensory experiences.

The subject of Mathematics at every level has plenty of abstract concepts or ideas. As these concepts have no physical referent. Students can not touch, see, or smell them. So due to these attributes students take mathematics as dull or boring subject (Bibi, 2009; Yadav, 1992) and hence low achievement in this subject. This perception of the students is further strengthened due to the teachers' attitude,motivation, style and teaching methods based on teacher-centered approaches (Bibi, 2009).

Teaching methods used by our teacher for teaching mathematics are outdated and do not match with on ground realities. Research shows that our teachers impart only textual knowledge and assess learning only through reproduction or mere application of rules (Amirali & Halai, 2010). Our system of examination also does not focus on assessing comprehension of subject (Bibi, 2009). It is due to these facts that student go on learning mathematics based on the rote memory without comprehending the concepts. Tayyba (2010) investigating mathematics achievement of middle grade students noted that students only memorize and reproduce facts and passed low-rigor items but they failed to pass high-rigor items; such items need deep understanding. Learning without comprehension cannot nurture analytical, logical and critical thinking in students (Ali, 2011).

No attention is usually paid on clarifying concepts in general and abstract concepts in particular, in mathematics classroom in Pakistan (Ali, 2011; Bibi, 2009). Research within and across Pakistan, has traced out poor performance in Mathematics in rote memory and not paying attention to concept understanding (Punjab Education Assessment System PEAS, 2005, 2008; Korn, 2014; Das & Barunah, 2010; Wildy & Wallace, 1992).

One of the major problems stated above is low understanding of abstract concepts of mathematics, due to which it seems bore and dull subject. Expected solution of this problem is to use Synectics Model to teach abstract concepts of mathematics. Various studies validate the use of Synectics Model for understanding concepts (Wald, 1975; Evans, 1996; Dykstra and Dykstra, 1997; Heid, 2008; Duin, Hauge, & Thoben, 2009; Kallonis & Sampson, 2011; Sierra-Jones, 2011; Shabani, 2011, Abed, Davoudi, & Hoseinzadeh 2015; Chandrasekaran, 2014; Girija, 2014; Yousefi, 2014), clarifying concepts (Dastjerdi, 2001, as stated in Abed, et al. 2015), and finding new ways of understanding a concept (Dastjerdi, 2001; Shabani, 2011) [as stated in Abed, et al. 2015].

The model is relatively unknown and underused in Pakistan and no significant research has been carried out concerning applying Synectics Model for the understanding of abstract concept of mathematics. The review of the related literature leads to conclusion that there is need to study the utility of this model and apply it to enhance students' understanding of abstract concept of mathematics.

Review of Related Literature

Synectics Model of teaching was developed by William J. J. Gordon and his colleagues in 1961. This model uses a series of analogies in the classroom. Synectics is a creative word coined to mean "amalgamation of different and apparently irrelevant elements" (Gordon and Poze, 1981). It brings diverse and apparently irrelevant elements together. The process of Synectics invokes creative process by discovering and unifying themes in seemingly disconnected parts (Gordon, 1961; Gunter, Estes and Mintz, 2007). Synectics Model operates on the principle of using mind's remarkable capacity to connect seemingly irrelevant elements of thought (Weaver & Prince, 1990).

There are primarily three Synectics Models: the original Synectics Model, corporate Synectics Model, and K-12 Synectics Model (Gunter, et al., 2007). In current study K-12 Synectics Model was used. This model follows two basic activities; making the familiar strange/ creating something new and making the strange familiar (Gunter et al., 2007). The activity "making the strange familiar" was used in this study and according to Seligmann, (2007) this activity often begins with the teacher's direct guidance. This prevents students from drawing inappropriate analogies and cause to learn new material incorrectly. Steps of the activity "making the strange familiar" are given in the figure below.

Synectics Process (Making the Strange Familiar)

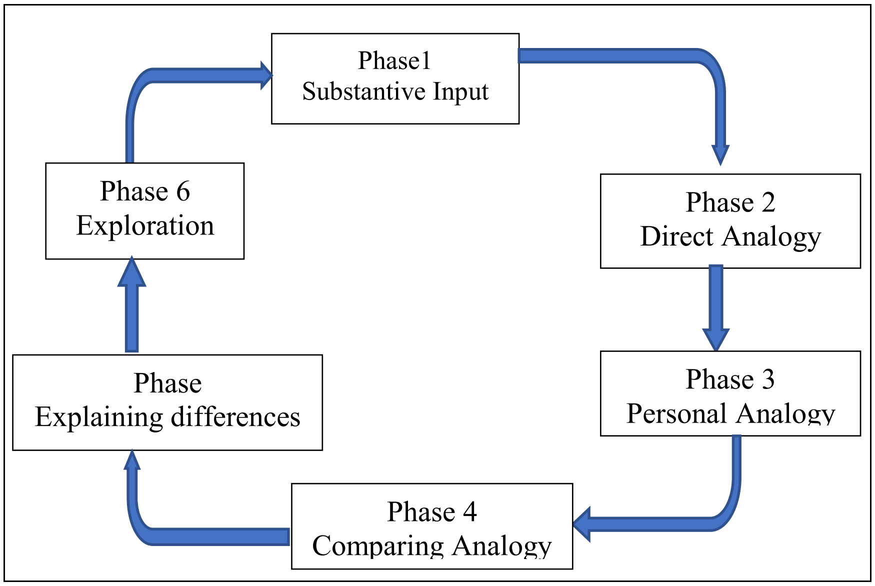

Fig 1: Process of the activity "making the strange familiar"

This study seeks theoretical support from three main theories – constructivism, situated learning theory and experiential learning theory. Constructivism asserts that knowledge can be constructed, through active involvement, on the basis of what learner already knows or has learnt. Situated learning focuses on the activity, content and the culture in which learning occurs or where it is situated. Social and active interaction is vital for situated learning. Learner is engaged in real activities of daily life with other learners of the similar interests. While according to experiential learning theory knowledge is created on the basis of previous experiences through active and personal involvement.

During this study, previous experiences of everyday life of the learners were used and an opportunity was given to each learner to construct new knowledge on the basis of his previous experiences. Learners used analogies from their local life and developed understanding of abstract concepts of mathematics. Researcher observed form the response of students that each learner was personally engaged in knowledge construction process. As all analogies and examples were coming from everyday local experiences of the learners so they were enthusiastic and motivated and also actively involved in the process of developing understanding of new concepts.

Synthesis of Findings of Previous Research

A brief synthesis of the findings of previous studies which used Synectics Model of teaching reveals that there are not many studies in this area. Particularly in Pakistan, it is relatively unknown and underused. Available studies across the globe highlight the effectiveness of this model in academic achievement, conceptual understanding, and the components of creativity. A brief review of these studies is as under:
Synectics Model helps learners to construct new knowledge (Seligmann, 2007; Abed, et al. 2015). This model clarifies concept (Dastjerdi, 2001, as stated in Abed, et al. 2015) and helps learners to develop understanding of new concepts (Wald, 1975; Evans, 1996; Dykstra and Dykstra, 1997; Heid, 2008; Duin, Hauge, & Thoben, 2009; Kallonis & Sampson, 2011; Sierra-Jones, 2011; Shabani, 2011, as stated in Abed, et al. 2015; Chandrasekaran, 2014; Girija, 2014; Yousefi, 2014). This model provides learners an opportunity to think and find new ways of understanding problems, concepts or ideas. And it also enables teachers to find and apply new ways of thinking about students, their learning, their motivation, nature of punishment and nature of problems that learners often face (Dastjerdi, 2001; Shabani, 2011) [as stated in Abed, et al. 2015]. As a result, the habit of deep thinking develops (Walker, 2009).

Abstract concepts are always difficult for the students particularly for the novice. It is because they are unable to comprehend ambiguous, intangible attributes of the concept. Synectics Model while using of analogies concretizes such attributes of the concept. The students taught using this model become able to generate prototype substitute for the concept (Newby & Stepich, 1987). This model can also help them to visualize intangible attributes (Middleton, 1991; Thiele & Treagust, 1994; Iding, 1997; Ramos, 2011). Particularly pictorial analogies are useful to enhance visualization process (Thiele & Treagust, 1994) and make abstract concept easier to learning (Newby & Stepich, 1987; Thiele & Treagust 1994; Arifiyanti & Wahyuningish, 2015).

Statement of the Problem

The problem under investigation was "the effect of Synectics Model of teaching in enhancing students' understanding of abstract concepts of mathematics".

Objectives

Following were the objectives of the study.

1. To determine the baseline understanding of selected abstract concepts of mathematics of 8^{th} class students.
2. To determine the effect of Synectics Model of teaching in enhancing students' understanding of abstract concepts of mathematics.

Limitations of Research Study

Intact groups of students were involved in this research study.

Methodology

The study was quasi-experimental in nature and non-equivalent control group design was used. It was an eleven-week long study.

Sample

Two Intact groups of students of grade eight from two boys' high schools of district Haripur (KP) were selected. Only those schools were selected where the researcher could get permission to conduct the study. Selected schools were representative of typical government high schools. They were representative in terms of facilities, school environment, socioeconomic status of the students, their family background, teachers' qualification and process of their recruitment and promotion, provisions of AV aids, etc.

Instrument

The instrument used in the study was a self-developed achievement test in the subject of 8^{th} class mathematics. Items were developed in knowledge, application and synthesis level of Bloom taxonomy. The instrument contained questions to check (a) factual knowledge of the students, (b) their ability to apply mathematical knowledge by using questions from outside the book, (c) their ability to connect mathematical knowledge to daily life. The content and construct validity was ensured by experts.

Threats to Internal Validity

Students in experimental and control group were similar in their academic achievement. The teachers of both groups had same teaching experience.

Data Analysis

Data were analyzed and results were interpreted and presented in tabular form.

Table 1

Comparison of control and experimental groups before treatment initems involving abstract concept

	Total Scores	Group	N	Mean	SD	*t*	*df*	*Sig.*
Pretest Sum of Abstract concepts/items	63	Control	35	.83	1.90	-.68	66	.49
		Experimental	33	1.12	1.61			

Table 1 shows a comparison between the mean scores of control and experimental group before treatment in items involving abstract concepts. Levene's Test for Equality of variances gives value of significance equal to .91 which was greater than .05, so equal variance was assumed. *p* value for both control and experimental group was .49 [N = 35, Mean = .83 and SD = 1.90 for control group and N = 33, Mean = 1.12, SD = 1.61 for experimental group. *t* value for both control and experimental groups was *t* (66) = -.68 at *p*>.05]. As *p* value was greater than .05 so there was statistically no significant difference between the groups before treatment in items involving abstract concepts.

Table 2

Comparison of control and experimental groups after treatment in items involving Abstract concept

	Total Scores	Group	N	Mean	SD	*t*	*df*	*Sig.*	Eta^2
Final Posttest Sum of Abstract concepts/ items	63	Control	35	21.54	6.27	-37.33	36.85	.00	.95
		Experi-mental	33	61.94	1.24				

Table 2 shows a comparison between the mean scores of control and experimental groups on after treatment in items involving abstract concepts of mathematics. Levene's Test for Equality of variances gives value of significance equal to .00 which was less than .05, so equal variance was not assumed. *p* value for both control and experimental groups was .00 [N = 35, Mean = 21.54 and SD = 6.27 for control group and N = 33, Mean = 61.94, SD = 1.24 for experimental group. *t* value for both control and experimental groups was t (36.85) = -37.33 at $p < .05$]. As *p* value was less than .05 so there was statistically significant difference between the groups after the treatment in items involving abstract concepts of mathematics.The magnitude of the effect (Eta^2) was .95. This was a very large effect which shows better achievement of experimental group in items containing abstract concepts in all the three units "operation on sets, polynomials and fundamentals of geometry" of eighth class mathematics.

Conclusion and Discussion

On the basis of the results of the study it is concluded that of experimental group outperformed control group with larger effect size. Achievement of the students of both control and experimental groups was same, in selected abstract concepts of mathematics, before the treatment. After the treatment, students of experimental group significantly outperformed the students of control group. As all threats to internal and external validity were controlled so it was concluded that better performance of experimental group was the contribution of Synectics Model of teaching. Synectics Model uses a series of analogies during the teaching(Joyce, et. al, 2008). During the treatment students of experimental group chose and used analogies from every-day life experiences under the guidance and supervision of the teacher. Use of analogies from everyday life reduced the level of abstraction of the abstract concepts and enhanced power of imagination(Newby & Stepich, 1987;Middleton, 1991;Thiele & Treagust, 1994;Iding, 1997; Ramos, 2011). This factor made abstract concepts more concrete and tangible and facilitated understanding of the abstract concepts and contributed more to the high achievement of the experimental group. The result is in harmony with the results of Newby and Stepich (1987), Biermann (1988), Thiele and Treagust (1994), Kaper and Geodhart, (2003), Richland, Holyoak and Stigler (2004), CALIK and AYAS (2005), Dilber and Duzgun (2008), Heid (2008), Wichaidit, Dechsri, and Chaivisuthangkuru (2011), BM de Almeida, Salvador, and Costa (2014), Chandrasekaran (2014), Abed, et al., (2015), and Arifiyanti and Wahyuningish (2015).

Use of everyday familiar analogies increased interest and motivation level of the students of the experimental group and contributed to their high achievement and better understanding of abstract concepts of mathematics. This is in harmony with the results of Weaver & Prince (1990), Benkoski & Greenwood (1995), Venville & Treagust (1996), Seligmann (2007), Patil (2012), Chandrasekaran (2014), and Fatemipour & Kordnaeej (2014).

Recommendations

Synectics Model of teaching is an interesting model that uses a series of analogies. During the course of this experiment, mostly, analogies from everyday life experiences of the students were used. This provided low cost / no cost AV aids with little effort on the part of teacher and also reduces abstraction level of concepts of mathematics. So it is recommended that:

- Synectics Model may be used to teach mathematics to students of elementary level. Particularly, abstract concepts of mathematics may be taught using this model. Abstract concepts of other subjects at various levels may also be taught using this model.
- Staff of the institutions responsible for material and AV aids development may be trained to develop suitable analogies for teaching as low cost / no cost AV aids.
- Such analogies may be incorporated in the curriculum.
- Teachers in the training institutions may be trained to use such analogies during teaching of various subjects.

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