Investigating the Effect of Structural Communication Grids as Conceptual Change Strategies on Student's Academic Achievement in Biology at Secondary Level

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Abstract

The conceptual understanding of students is closely related to circumstances such as teachers, textbooks, instructional strategies, and assessment techniques. The most critical factor which affect student's learning is the way we assess them. Structural communication grids being an alternative assessment technique is to measure meaningful learning and discovering students' misconceptions. Quasi-experimental design was used in this study to explore the effect of structural communication grids as conceptual change strategies on students' academic achievement in 9th grade biology. The sample of the study was comprised of 100 9th grade biology students (male=55 and female=45). The researcher conducted side by side experiments in two different institutions in G-9 sector, Islamabad. Biology achievement test as one of the data collections tools, were developed by the researcher and its reliability was found to be 0.85. In addition, 30 structural communication grids were used in the present study, which were developed by the researcher in consultation with experts in the subject of biology. After treatment results were collected and analyzed by the researcher using descriptive statistics (Mean and Standard deviation) and inferential statistics (Independent Sample t-test and Two-Way ANOVA). The results of the study revealed that structural communication grids are useful for improving student's achievement by diagnosing their misconceptions concerning grade 9 biology. Both male and female students performed similarly using structural communication grids. It was recommended that similar research studies may be conducted for other grades as well as for other subjects like Physics, Chemistry, Mathematics, General Science etc.

Keywords: structural communication grids, academic achievement, alternative assessment, techniques, conceptual change strategies

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Introduction

Learning is a deliberate, conscious and complex process (Adey, & Shayer, 1994). An important feature of learning is characterized by the fact that it is a complex interactive system that includes environmental, social, motivational, emotional, and cognitive factors (Baron, & Byrne, 2003; Huffman, 2004; Joyce, Weil, & Calhoun, 2004). While interacting with their environment, people acquire information, skills, attitudes and values. These practices are bases of learning. In general, learning can be viewed as an individual process of change (Erturk, 1993). Cognitive scientists viewed learning as a cognitive process that occurs only if a learner gives meaning to the known information. This cognition varies according to the understanding, the culture, the nature of the interactions and the role played by the students in this process (Nakiboglu, 1999). According to Malone and Dekher (1984), learning is meaningful when learners can assimilate new information with their current grids of concepts and schemas in their cognitive structures. The learning process which is partially meaningful will lead to insufficient mastery of students' concepts and ultimately give rise to misconceptions (Fratiwi, Utari, & Samsudin, 2019).

Assessment is a part of learning, there has been a paradigm shift from testing learning of students to assessing students for learning (Birenbaum, & Feidman, 1998). This clearly highlights the importance for application of assessment for learning (formative assessment) rather than assessment of learning (summative assessment). Assessment for learning provides students a number of opportunities to improve their own skills by evaluating their individual efforts (Race, Brown & Smith, 2005). A growing body of research studies showing dominance for formative assessment because it enables students to assess their learning and obtain feedback before trying summative assessment (Kamuche, 2005; Kornell, 2014; Kornell, Hays, & Bjork, 2009; Marzano, Pickering, & Pollock, 2001; Peterson & Siadat, 2009; Shirvani, 2009).

The fundamental function of science education is to inform learners about the essence of science while considering concepts as the ultimate goal. But in the real sense, in our traditionally teacher-centered education system, the student's passive approach to obtaining information, an overloaded program to be covered in a shorter period of time and the mere verbal meaning of the concepts give rise to a learning environment that relies heavily on rote learning. An increasing number of research studies show that students encounter many conceptual problems even after receiving formal education (Wandersee, Mintzes & Novak, 1994). Cognitive and behavioral theories have tried to describe the phenomenon

of learning. The impact of behavioral theories remained until the late 1960s; but because they focused solely on observable traits, behavioral theories lost their authority and gave rise to cognitive learning theories from 1970 onwards because of their inability to classify important and complex scientific processes such as perception, attention, personality and memory. There has been a paradigm shift from teacher centeredness to learner centeredness, from behaviorist approach in learning to constructivist approach in learning and from rote memorization to meaningful learning.

The cognitive structure is a hypothetical construct referring to the organization of concepts or the pattern of relationships in memory (Kempa, & Nicholls, 1983). Many strategies and techniques are used to expressing ideas and altering misconceptions in the cognitive structure of the learners. These strategies can be called conceptual change strategies (Wandersee et al., 1994). Some of these strategies includes: 1) Concept Map 2) Diagnostic Tree Tests 3) Structural communication Grids 4) Mind maps 5) Word Association Tests 6) Prediction-Observed-Explain (POE) etc.

Structural Communication Grid (SCG) is an alternative assessment technique in the form of numbered grid mainly focused on highlighting the cognitive structures of students. This technique which is quite different from Multiple Choice Tests (MCQs), students is probable to choose those boxes apposite to answer the question and finally to put them in logical sequence. That is why this technique is known as "Structural Communication grid" (Johnstone, Bahar, & Hansell, 2000). The most important feature of SCG is to measure meaningful learning and discovering students' misconceptions (Johnstone et al., 2000). Solas (1992) highlights the usefulness of SCGs for assessment purposes. Durmus and Karakirik (2005) considered it a substitute for multiple choice questions.

Traditional assessment techniques are relying only on test items that highlights presence or absence of knowledge but tell nothing about cognitive structures exists in the mind of a learner. On the other hand, alternative assessment techniques are known for partial knowledge judgement. Structural communication grids assess students' learning partially and highlights the weaknesses of an individual. In the present study the researchers used structural communication grids to explore its effect on student's academic achievement in 9th grade biology.

Rationale of the Study

Learning in science classes can take place in at least three conditions of prior knowledge. In first case, a student may have no knowledge or information about "concepts to learn", secondly, a student can have correct prior knowledge of the concepts to be learned, but this knowledge is incomplete and thirdly, a student may have acquired ideas, either by school or daily experience that conflict with the concepts to be learned (Vosniadou, 2004). The acquisition of knowledge in this third case is a conceptual change kind. It is assumed that prior knowledge is incorrect or ill-conceived. Here, some conceptual change strategies are required to correct students' learned concepts according to scientifically accepted truths. The focus of the present study was to "Investigate the Effect of Structural Communication Grids as Conceptual Change Strategies on Student's Academic Achievement in 9th Grade Biology".

Objectives of the Study

The present study includes following objectives:

i.   To find out the effect of structural communication grids on student's academic achievement in 9th grade biology.
ii.   To study the differential effect of structural communication grids on the academic achievement of male and female students in 9th grade biology.
iii.   To determine the interaction effect of structural communication grids and gender on student's academic achievement.

Research Hypotheses

The researchers formulated following research hypotheses for achieving objectives regarding present study:

H_{01}:   No statistically significant variation was found in the mean achievement scores of overall students using structural communication grids or traditional methods.

H_{02}:   No statistically significant variation was found in the mean achievement scores of male students using structural communication grids or traditional methods.

H_{03}:   No statistically significant variation was found in the mean achievement scores of female students using structural communication grids or traditional methods.

H_{04}:   No statistically significant variation was found in the mean achievement scores of male and female students using structural communication grids.

H_{05}:   No statistically significant interaction effect of gender and structural communication grids on mean gain scores of students.

Literature Review

Biology is a science and open to new development and also natural. It helps people to understand themselves anatomically and physiologically, improves their perception of the world and teaches them to act scientifically, understands the basic idea of nature so that living culture is produced (Sulun, Gurbuz, & Kandemir, 2004). In the high school biology program, we come across many concepts and sub-concepts related to various topics. It is essential that the teacher of a subject teaches his / her students so that they understand these concepts and the links between the different concepts. This is only possible through the active participation of the student in the learning process by organizing various types of activities during teaching.

Gamor (2001) conducted a study and found that alternative assessment techniques increased the probability of constructing information and phenomena over traditional assessment techniques. Kirikaya and Vurkaya (2011) conducted a study to determine the effect of alternative assessment activities. They concluded that the techniques (structural communication grids, concept maps) had a positive effect on the attitude and success of students in science and technology courses. In another study by Karahan (2007) "structural communication grids", "concept maps" and "diagnostic trees" were used as alternative assessment techniques and attempted to determine its effect on students' achievement. He concluded that alternative assessment techniques improved students' academic performance. Structural Communication grids being useful diagnostic assessment tool is considered as alternative to multiple choice test. A study conducted by Buyukturan and Demirtash (2013) focused on the comparison of multiple-choice test and structural communication grids. The results of study revealed that the items of structural communication grids were much easier than the multiple-choice test items and further measurements obtained using structural communication grids were more reliable than that of multiple-choice test.

Bahar (2003) conducted a study for investigating students' misconceptions in biology using SCGs, concept maps and POE as conceptual change strategies. He concluded that the conceptual change strategies should be used for diagnosing and modifying misconceptions.

A review of related literature concluded that there is a need to study the effectiveness of alternative assessment techniques in the academic performance of high school biology students. Previously, research is available for general science at the elementary level. At the high school level, students take biology as an option and it is important to examine

the effect of alternative assessment techniques on students' academic achievement in biology at 9th grade.

Structural Communication Grid (SCG) is an alternative assessment technique used to reveal the cognitive structures of students. The size of the SCG test varies and is determined by the number of cells per grid prepared according to the age level of the students. There is no hard and fast rule for the size of the SCG test. Structural communication grids of different sizes, such as 3x3, 3x4, 4x4, are developed in harmony with the age of the learners and the cells of the grid are numbered (Johnstone et al., 2000). The researcher developed 3x3 structural communication grids for present study (Figure 1).

1	2	3
4	5	6
7	8	9

(Johnstone, Bahar & Hansell, 2000).
Figure 1: The Basic Structure of the SCG.

The numbered boxes may contain a word, phrase, symbol, diagram, picture, equation or formula. Due to variation in the content of grid it is equally appropriate both for visual and verbal learners. The superiority of SCGs over MCQs is lies in the fact that it is completely free from guessing factors. There are two different types of scoring criteria for two different forms of questions, namely regular questions and ordered questions. In case of regular questions, only to put selected boxes against each question. But for ordering question, it is equally important to put different cell numbers in logical sequence.

Conceptual Framework

The conceptual framework of the study included constructivist and traditional strategies as independent variables, while student performance at different cognitive levels constituted the dependent variables. Figure 2 shows how independent variables interact with extraneous variables, giving different dependent variables.
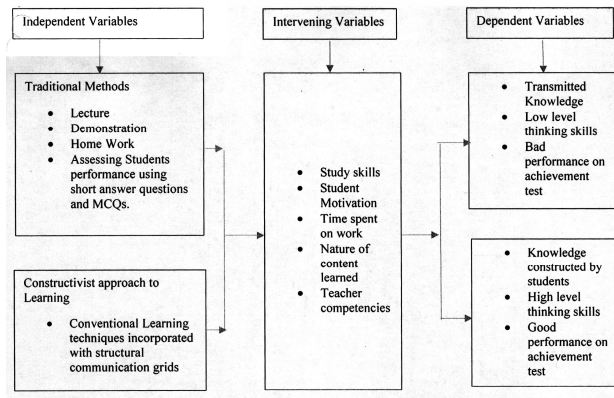
Figure 2: Conceptual Framework

Research Design

The present study includes the effect of an independent variable (Structural communication grids) on learner's academic achievement in biodiversity and cells & tissues from 9th grade biology. The design of the study was qusai-experimental design. The non-equivalent pretest-posttest control group design was used in the present study. The researcher selected intact groups for conducting experiments side by side in two different institutions for both genders. Both experimental and control groups in each institution were performed equally when pretest was administered. The design of the study discussed in the Table 1.

Table 1
Qusai-Experimental Design

Pre-test	Independent Variable	Posttest
Y_b	X	Y_a (Experimental)
Y_b	Y	Y_a (Control)

Y_b = Measures on dependent variable taken before actual treatment (Pretest)
Y_a = Measures on dependent variable taken after actual treatment (Posttest)
X = traditional method incorporated with structural communication grids
Y = Traditional method

Population and Sample

The population of the present study was comprised of all 9th grade biology students in different institutions under the administrative control of Federal Directorate of Education (FDE), Islamabad. The total number of institutions for boys and girls were 136 (61 for boys and 75 for girls). The researcher, randomly selected two institutions one for each gender in G-9 sector, Islamabad. The institutions involved in this study were:

- Islamabad Model College for Boys, G-9/4.
- Islamabad Model School for Girls, G-9/3.

According to Gay (1996), the number of subjects in each group should be at least fifteen for conducting experimental study. In order to confirm internal validity of the experiment the researcher selected more than twenty students in each group. The detailed sample for the current study is given below in Table 2.

Table 2
Sample in detail

Name of Institution	Total Section	Students in Experimental Group	Students in Control Group	Total Students
IMCB, G-9/4.	02	30	25	55
IMSG, G-9/3.	02	22	23	45
Total	04	52	48	100

Research Instruments
Structural Communication Grids (SCGs)

The structural communication grid was developed by Egan (1972) and has been used by several researchers to date (Johnstone & McGuire, 1987; Johnstone et al., 2000; Talbi, 2003 and Bahar, Aydin & Karakirik, 2009). The present study involved 3x3 numbered grid with a series of questions that students should answer by choosing the appropriate boxes next to the following questions. The student can use the response options in the grid for more than one question. The researcher selected two 9th grade biology units "Biodiversity" and "Cell & Tissues" for preparing structural communication grids. The main function of SCGs is to highlight student's gaps in knowledge by detecting misconceptions in selected units. These thirty SCGs were validated after incorporating

valuable suggestions from subject experts and teachers teaching biology at 9th grade (One example of SCG is given below).

Vertebrates and Invertebrates

1. Gnat	2. Dolphin	3. Butterfly
4. Crab	5. Trout	6. Lizard
7. Goshawk	8. Worm	9. Salamander

Use the above nine box (es) to answer the questions below.
You can use a box as many times as you wish.
More than one box can be used for each question.
Write the number given in the upper left side of the boxes to show the right answer.

1   Which box (es) show the names of vertebrates' animals?

2   Which box (es) show the names of invertebrates' animals?

3   Which box (es) show the names of animals whose appearance and action seems like a fish however it categorized under mammals?

4   Which box (es) show the names of vertebrates/ invertebrates' animals that live on land?

5   Which box (es) show the names of vertebrates/ invertebrates' animals that live in water?

6   Which box (es) show the names of animals that are amphibians?

7   Which box (es) show the names of animals that are reptiles?

8   Which box (es) show the names of animals that are insects?

9   Which box (es) show the names of animals that are mammals?

10   Which box (es) show the names of animals that are fish?

Biology Achievement Test (BAT)

Biology Achievement Test (BAT) was developed using the topics and subtopics of two units of 9th grade biology curriculum for the purpose of formulating pretest and posttest, later on used in experiment conducted by the researcher. Development of an achievement test being a complex and rigorous process includes: planning of the achievement test, developing items bank on different topics and sub-topics of two selected units, editing of test items in the light of test of specification, administration of preliminary draft of test items followed by the

procedure of item analysis, validity and reliability of the test. Initially, the researcher developed an item bank of 200 test items on different concepts of "Biodiversity" and "Cell & Tissues". After laborious process of item analysis, the researcher left with 80 test items for preparing pretest and posttest and each includes 60% items on knowledge level, 30% items on comprehension level and 10% items on application level of cognitive domain.

The validity of each individual test items was established after discussion with subject specialists and experts in the field of educational measurement and evaluation. Items which seems to be irrelevant and comes repetitively were discarded. Reliability of the biology achievement test was determined by using Kuder-Richardson's formula i.e. KR_{20} found to be 0.93 which shows it is highly reliable test. Finally, the researcher prepared pretest and posttest each consists of 40 test items.

Procedure of the Treatment

The researcher conducted side by side experiments in two different institutions, one for male students and other for female students. Initially, pretest was administered to all students of both experimental and control groups. Students were informed in advance about the terms and conditions of the pretest. Results of pretest were recorded and arranged in MS-Excel. The experimental group was taught using traditional methods incorporating structural communication grids. Initially, the students were introduced to structural communication grids on the topics other than the content selected for the study. The students were tested using structural communication grids prepared on different topics, one per day. During the first stage, structural communication grid techniques were provided to students and allowed them to diagnose their misconceptions, knowledge gaps, and so on. Then in the light of observation obtained through structural communication grids tests, remedial teaching sessions were arranged for students to discuss their deficiencies and inadequacies in learning. At the end of each unit, the researcher provided a list of student's misconceptions in different topics. Both experiments were performed for six weeks. This process continued separately for the two units selected for this study, namely biodiversity and cells and tissues. The control group was taught using traditional techniques, namely the lecture method, the question-answer, class tests involves MCQs. and the allocation of work at home. At the end of the treatment period (six weeks), a posttest was administered to all students of both experimental and control groups. Results of posttest were recorded and arranged in MS-Excel.

Methods of Data Analysis

The data were collected by the researcher before and after 6 weeks' treatment. The collected data were analyzed using descriptive statistics of mean, standard deviation and inferential statistics of t-test and ANOVA. Independent sample t-test was used to determine the significant variation between the mean values of two set of data. Two-way analysis of variance (ANOVA) was used to identify the interaction effect of gender and independent variable on mean gain scores of students.

Findings and Results

Two instruments were administered to obtained data concerning student's performance in the subject of biology in grade 9. In order to determine student's misconceptions and gaps in knowledge regarding 9th grade biology the researcher developed thirty SCGs on different topics and sub-topics of "Biodiversity" and "Cell and Tissues".

Difference between Student's Achievement in Biology before Experiment

The detail of student's responses on pretest is presented in table 3, 4, 5 and 6.

Table 3
Comparison of Achievement of Overall Students before Experiment

Group	N	Mean	SD	*df*	*t*	Sig. (2-tailed)
Experimental	52	20.26	5.42	88.63	1.39	.168
Control	48	18.52	6.98			

Level of significance $= \alpha = 0.05$.

Table 3 show results to compare the scores of pretests of overall students in experimental and control group. Both experimental and control group were found to be almost equal before the start of actual treatment.

Table 4
Comparison of Achievement of Male Students before Experiment

Group	N	Mean	SD	*df*	*t*	Sig. (2-tailed)
Experimental	30	21.43	5.46	53	1.25	.217
Control	25	19.20	7.74			

Level of significance $= \alpha = 0.05$.

Table 4 show results to compare the scores of pretests of male students in experimental and control group. Both experimental and control group were found to be almost equal before the start of actual treatment.

Table 5
Comparison of Achievement of Female Students before Experiment

Group	N	Mean	SD	*df*	*t*	Sig. (2-tailed)
Experimental	22	18.68	5.06	43	.534	.596
Control	23	17.78	6.14			

Level of significance $= \alpha = 0.05$.

Table 5 show results to compare the scores of pretests of female students in experimental and control group. Both experimental and control group were found to be almost equal before the start of actual treatment.

Table 6
Comparison of Achievement of Male and Female Students before Experiment

Group	N	Mean	SD	*df*	*t*	Sig. (2-tailed)
Experimental	30	21.43	5.46	50	1.848	.070
Experimental	22	18.68	5.06			

Level of significance $= \alpha = 0.05$.

Table 6 show results to compare the scores of pretests of male and female students in experimental group. Both experimental groups were found to be almost equal before the start of actual treatment.

Objective No. 1
H_{01}: No statistically significant variation was found in the mean achievement scores of overall students using structural communication grids or traditional methods.

Table 7
Summary of the Statistics on Scores of Posttests of Overall Students

Group	N	Mean	SD	*df*	*t*	Sig. (2-tailed)
Experimental	52	24.65	4.77	98	7.05	.000
Control	48	17.12	5.87			

Level of significance $= \alpha = 0.05$.

Summary of the results in the above Table 7 comprising $t(98)= 7.05$ and $\rho = .000$ indicates that there exists a statistically significant variation in mean scores of students in experimental group ($M = 24.65$, $SD = 4.77$) and students in control group ($M = 17.12$, $SD = 5.87$). Hence the null hypothesis, H_{01}, was rejected.

It is decided that students taught by using structural communication grids have higher achievement scores as compare to the students in the control group.

Objective No. 2

H_{02}: No statistically significant variation was found in the mean achievement scores of male students using structural communication grids or traditional methods.

Table 8
Summary of the Statistics on Scores of Posttests of Male Students

Group	N	Mean	SD	*df*	*t*	Sig. (2-tailed)
Experimental	30	25.13	4.89	53	4.56	.000
Control	25	18.36	6.10			

Level of significance = $\alpha = 0.05$.

Summary of the results in the above Table 8 comprising $t (53) = 4.56$ and $\rho = .000$ indicates that there exists a statistically significant variation in mean scores of male students in experimental group ($M = 25.13$, $SD = 4.89$) and male students in control group ($M = 18.36$, $SD = 6.10$). Hence the null hypothesis, H_{02}, was rejected.

It is decided that male students taught by using structural communication grids have higher achievement scores as compare to the male students in the control group.

H_{03}: No statistically significant variation was found in the mean achievement scores of female students using structural communication grids or traditional methods.

Table 9
Summary of the Statistics on Scores of Posttests of Female Students

Group	N	Mean	SD	*df*	*t*	Sig. (2-tailed)
Experimental	22	24.00	4.62	43	5.45	.000
Control	23	15.78	5.42			

Level of significance = $\alpha = 0.05$.

Summary of the results in the above Table 9 comprising $t(43)= 5.45$ and $\rho = .000$ indicates that there exists a statistically significant variation in mean scores of female students in experimental group ($M = 24.00$, *SD* $= 4.62$) and female students in control group ($M = 15.78$, $SD = 5.42$). Hence the null hypothesis, H_{03}, was rejected.

It is decided that female students taught by using structural communication grids have higher achievement scores as compare to the female students in the control group.

H_{04}: No statistically significant variation was found in the mean achievement scores of male and female students using structural communication grids.

Table 10
Summary of the Statistics on Scores of Posttests of Male and Female Students

Group	N	Mean	SD	*df*	*t*	Sig. (2-tailed)
Experimental	30	25.13	4.89	50	.844	.403
Experimental	22	24.00	4.62			

Level of significance $= \alpha = 0.05$.

Summary of the results in the above Table 10 comprising $t(50)= .844$ and $\rho = .403$ indicates that there exists a no statistically significant variation in mean scores of male students in experimental group ($M = 25.13$, $SD = 4.89$) and female students in experimental group ($M = 24.00$, $SD = 4.62$). Hence the null hypothesis, H_{04}, was accepted.

It is decided that male and female students taught by using structural communication grids have similar gain in achievement scores in the experimental groups.

Objective No. 3
H_{05}: No statistically significant interaction effect of gender and structural communication grids on mean gain scores of students.

Table 11
Summary of Posttest Scores of Overall Students on Biology Achievement Test

	Experimental Group			Control Group		
	N	Mean	SD	N	Mean	SD
Male	30	25.13	4.89	25	18.36	6.10
Female	22	24.00	4.62	23	15.78	5.42

Summary of descriptive analysis in Table 11 shows that the mean gain score so of male students in experimental group (25.13) was significantly higher than mean gain scores of female students (24.00). Similarly, the mean gain scores of male students in control group (18.36) was significantly greater than mean gain scores of female students (15.78). It is concluded that male students of both experimental and control groups performed better than female students of both experimental and control groups. It is further concluded that both male and female students were equally affected by structural communication grids (See figure 3).
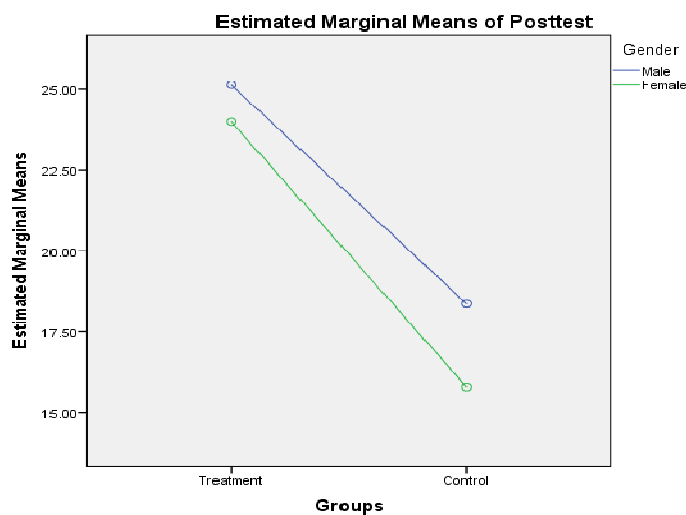

Figure 3: Graphical presentation of interaction effect of SCGs and gender on mean gain in achievement scores.

Table 12
Summary of the Statistics on Scores of Posttests of Male and Female Students

Source	df	SS	MS	F	Sig
Group* Gender	1	12.85	12.85	.459	.500
Residual	96	2687.14	27.99		

Level of significance $= \alpha = 0.05$.

Summary of the results in the above Table 12 containing F= .459 and $\rho = .500$ indicates that the interaction effect of structural communication grids and gender is not statistically significant. Hence the null hypothesis, H_{05}, was accepted.

It is decided that there was no treatment and gender effect on academic achievement in biology. It is further concluded that both male and female students were equally affected by structural communication grids.

Discussion

The present research has been carried out in order to examine the effect of structural communication grids on the academic achievement 9th grade biology students. The results of this empirical study clearly show that structural communication grids are more effective than traditional methods in improving the academic achievement of male and female students in the subject of biology at 9th grade. Structural communication grids tests concerned with partial knowledge judgement and providing no scope for guessing answers. The most important feature of SCGs is to measures meaningful learning and discovering student's misconceptions (Johnstone et. al., 2000). The researcher, develop and validate 30 SCGs on different topics and sub-topics of "Biodiversity" and "Cells & Tissues". On daily basis, SCGs on two sub-topics were provided to students to diagnose their misconceptions and gaps in their knowledge. After carefully reviewing students' responses on SCGs, the researcher conducted remedial teaching sessions. All of these practices permit students in the experimental group to understand the different biological concepts of two selected units much better than students in the control group to whom instructions were given using traditional methods. The results of this study outspread the findings obtained from other studies (Duban, & Kucukyilmaz, 2008; Sasmaz Oren, Ormanci, & Evrekli, 2011; Yildiz & Uyanik, 2004; Ozturk, Yalvac, Hasturk, & Demir, 2013; Karahan, 2007; Harurluoglu, & Kaya, 2011; Powell-Moman, & Brown-Schild, 2011; Whannell, Whannell, & Allen, 2012).

The results of this study show that structural communication grids as conceptual change strategies are useful for improving student's achievement by diagnosing their misconceptions and gaps in knowledge regarding biology. This is in line with Alkan (2013), who stated that structural communication grids as alternative assessment techniques could be considered as an effective assessment tool, as well as teaching materials. The comparison of different teaching methodologies was made in the last part of the research. The impact of traditional methods embedded in the structural communication grids and traditional teacher-centered practices was examined on the post-test scores of the experimental and control groups. The post-test scores for both types of practice were found to differ significantly in favor of the experimental group. The study also revealed that both male and female students performed identically when exposed to structural communication grids. Therefore, gender don't play any moderating role in defining the effect of structural communication grids on academic achievement in biology.

Recommendations

Keeping in view the findings of the present study and discussion it is recommended that structural communication grids are useful in enhancing student's academic achievement in biology at 9th grade. Therefore, it is recommended that

1. Structural communication grids did better for the academic achievement of the students: therefore, it is recommended that SCGs should be the part of day to day teaching-learning process.
2. The textbook is playing a central role in teaching learning process which guides teachers for effective delivery of concepts to the students. Therefore, it is suggested that SCGs may include in textbooks like biology, physics and chemistry at secondary level to provide students a chance to assess themselves as well as their peers.
3. In the present study the researcher used SCGs (3x3 and focusing only on regular questions). Therefore, it is suggested that 2x2 grids should be used at elementary level particularly for the students of general science.
4. Teachers should be trained in developing and using SCGs in order to improve their teaching by diagnosing difficulties related to the learning of students in particular discipline.

Suggestions for Further Research

1. Similar research studies may be conducted for other grades as well as for other subjects like Physics, Chemistry, Mathematics, general science etc.
2. The present study mainly focused on SCGs as conceptual change strategies therefore, more studies should be conducted with other strategies like concept maps, mind maps, words association test, the predict-observe-explain, diagnostic tree test etc.
3. The researcher used only 3×3 SCGs (focusing only on regular questions) for conducting present study. There is need to conduct studies with other kind of grids like 4×4 with ordering questions.

Conclusion

From the findings of the study, it was concluded that structural communication grids are useful for improving student's achievement by diagnosing their misconceptions related to the subject of biology. Structural communication grids, being alternative to multiple choice questions, known for partial knowledge judgment. It provides help to the subject teachers to assess their students' partially and highlights weaknesses and gaps in their knowledge. Both male and female students in the experimental groups perform identically.

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