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Feedback Effect on Secondary School Students Achievement in Mathematics

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Abstract *This study provides empirical support as to how feedback supports students to improve their achievement in mathematics. The sample of the study was 87 students of Mathematics in grade 9. There were 43 students in the control group and 44 students in the experiment group. Groups were matched on students' results in Mathematics in grade 8 to ensure the equivalence of both groups. Furthermore, a pretest was also conducted to confirm equivalence. The researchers employed different techniques and strategies of feedback while teaching mathematics to the experiment group. At the end of the intervention, the participants of this study were post-tested. The collected data was analyzed by using SPSS version 15. A comparison of pretest and posttest scores of control and experiment group has shown a significant effect of feedback on students' achievement in mathematics. The average and the low ability learners in the experiment group outperformed the learners of the respective abilities in the control group.*

Key Words
Formal and Informal Feedback, Verbal and Written Questioning, Dialogue, Achievement

Introduction

Giving feedback and involving students are important techniques of formative assessment. Questioning is a powerful tool for eliciting information about gaps in students' understanding (Cowie & Bell, 1999; William & Thompson, 2007). A feedback component in response to the thought-provoking questions often takes the form of productive dialogue between teacher and student and his or her peers (Chin, 2006). The selection of different feedback was based on the common practices employed by teachers, including formative feedback, summative feedback, evaluative feedback, descriptive feedback, norm-referenced feedback, and self-referenced feedback. Feedback can act on the means and the ends in the conceptual understanding. According to Francis, Mahlomaholo, and Nkoane (2010), effective feedback motivates teacher and peer dialogue, supports the development of self-assessment in students' learning, and offers information to teachers and learners that is very useful to plan both teaching and learning. It also provides an opportunity to narrow the gap between students' current and required performance. However, although feedback is known as a central part of formative assessment it is still a challenge to teachers and learners.

Feedback can be given in different ways. Interactive feedback cannot be planned in advance. It is an activity where evidence about learning is generatedin the course of teachers' day to day classroom activities. Hattie and Timperley (2007) said that the main purpose of any type of feedback is to lessen the gap between current understanding, performance, and a goal. According to a model presented by Hattie and Timperley, feedback must address three questions: a) where am I going? b) How am I going? c) Where to next. According to Francis, Mahlomaholo and Nkoane (2010) length and complexity of feedback should be considered when it is given to the learners because feedback is a more complex activity than giving grades.

Generally, formative feedback is delivered to encourage students to improve their performance in the future. Randall and Mirador (2003) have shown that summative feedback is considered as a single comment about the quality of the students' work, while formative feedback is expected to provide a comment which is developmental in nature. According to Shute (2008), the main purpose of formative feedback is to enhance students' knowledge, understanding, and skills in some content area. The quality of feedback depends upon immediacy, relevance, reliability and the type and amount of feedback provided. Nicol and Dick (2004) have shown that effective feedback is information that supports students to act for closing the gap between intent and effect.

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The studies on the effectiveness of feedback (e.g., Black & William, 1998; Crooks, 1988; Maclellen, 2001; Nicol & Dick, 2004) have disclosed that feedback is most useful when it emphasizes the task rather than students and escapes from extensive praise as it may have a negative effect on students' performance. Feedback needs to be immediate to students' work as delays may have a negative effect on students' learning and may upset their skill attainment and knowledge. Moreover, feedback can be seen as a powerful promoter as well as generate motivation among students when it encourages them to close the gap in their understanding (Irons, 2008).

Crooks (1988) has mentioned that low achievers may need more praise along with immediate feedback than high achievers. In a study, Irons (2008) has told some practical issues that should be addressed in formative feedback: 1) the workload involved in feedback, 2) the type of helpful support and 3) to give timely and good quality feedback to advance student learning. Therefore, students did not take part in the reflection of their experiences. The explanation here is that informal formative assessment has come up without immediate feedback. This may decrease the predictable effect of this type of assessment because its importance is primarily based on the bringing of immediate feedback (Heller, 2004; Irons, 2008). Moreover, the absence of immediate feedback can discourage students and may lead them to unsuccessful learning (McDowell, 1995).

Keeping in view the national standards of curriculum, the primary purpose of conducting an experiment as the present one is to make use of feedback in a more constructive way to get better mathematics learners and to reconsider teaching and learning strategies through the lens of feedback. The present research has viewed empirically the need of feedback practices in Pakistani secondary schools' mathematics classrooms to move towards student-centered learning to fulfill the requirement of the national curriculum for mathematics. The mathematical skills are foundations to gain further education and training. People without basic mathematical skills have fewer opportunities for gainful employment, entrepreneurial activity or civic participation (UNESCO, 2015). In this experimental study, the researcher will explore the role of feedback in overcoming the issues related to students' achievement in mathematics currently experiencing in Pakistani public sector secondary schools.

Methodology

Research Design

In this study, the researcher has used a quantitative method that followed a quasi-experimental design, namely, the matching-only pretest-posttest control group design.

Sample

Two intact classes of grade 9 students from the selected school were taken as the sample of the study. One section with 44 students was selected to serve as an experiment group and other as a control group with 43 students by using random assignment technique. Researcher matched the groups on students' results of Mathematics in grade 8 to find the equivalence of both groups. Control group and experiment groups were further classified into three ability groups (high achiever, average achiever, and low achiever).

Procedure

To see the equivalence of the groups, the researcher collected results from grade 8 in the subject of Mathematics. Students' scores in Mathematics were analyzed by applying independent samples t-test to ensure no significant difference between the two intact classes. After getting evidence about the equivalence of selected intact classes, one of both classes was randomly assigned as the experiment group whereas the other as the control group. After assigning groups, the researcher conducted a pre-test to the students of both the experimental group and the control group at the beginning of the intervention. For this purpose, the researcher gave an achievement test (Mathematics Achievement Test) to the students of both the experiment group and the control group at the beginning of the intervention. The pre-test scores provided data to determine the differences in students' achievement in mathematics between both experiment group and control group.

The researcher gave feedback to the experiment group by teaching as a co-teacher with teacher already teaching with the traditional method. The control group was taught by the teacher already teaching with the traditional method without proposed feedback. Feedback was given on students' in-class work, independent practice assignments, daily homework and teacher's discussion with a student, a group of students or the whole class.

Two modes of feedback, Planned or Formal feedback and Interactive or Informal feedback, were used. Planned or formal feedback was given in the beginning, in the middle and at the end of the lesson in the form of discussion, written or verbal work. At the start of the lesson, the feedback was given when the teacher was using questions to know about students' previous knowledge to start a new lesson, in case of any misconception or misunderstanding appropriate feedback was given.

Similarly, in the middle of the lesson when the teacher's objective was to check students' understanding of the concept taught, the researcher gave them some written work in the form of problem-solving or discussion. If there was evidence about difficulty with understanding the concept, the researcher gave them feedback in the form of written or verbal corrections or discussion to guide them and involve them in thinking process so that they can grasp the true meaning of the concept.

However, planned or formal feedback was not only used for collecting information about students' learning; rather it was introduced so as to engage students in mathematics. It was also in the form of verbal or written comments on students' answers on white-board or notebooks. Students were asked to answer the question with the think-pair-share technique, and they were asked to discuss or consult with their peer. After giving students some time for thinking, the researcher was prepared for further questions. This type of feedback was depending upon students' responses.

The interactive or informal feedback took place when the teacher was interacting with a student, group of students or the whole class. The questioning was the main instrument for such feedback. The response of the student to the question enabled the researcher to decide what to do next: whether to extend discussion or question-answer session or give appropriate feedback to guide the student towards the correct answer. As it was built on the students' response which cannot be anticipated, therefore, the teacher kept on switching from formal to informal and informal to formal feedback.

The researcher assigned homework in the form of daily homework and independent practice assignments to the students, to write answers to the given questions. Instead of telling students about the right or wrong answer, a possible solution to the question was given on notebooks in case of homework. Independent practice assignments were given at the end of each chapter. Grades were given to the independent practice assignments by using grading rubrics. The researcher observed all mistakes and misunderstandings in the assignments and gave appropriate feedback through discussions and written explanations according to the need in class.

Occasionally, the technique of peer assessment was also used. In this technique, students got grades or comments leading to the correct answer from their peers. The marked answer sheet was back to the relevant students. Then they were asked to correct their mistakes. This experiment lasted for 16 weeks. At the end, a post-test was conducted. The post-test scores provided the data to find out the effect of intervention.

Results

The mean achievement scores were analyzed with the help of SPSS. This analysis provided the base to draw some results about students' achievement.

Table 1. Comparison of Marks of Objective Type Test (Mathematics Achievement Test) in Pretest

	Control group		Experiment group			
Pretest	M	SD	M	SD	t (85)	p(two-tailed)
MCQs	10.49	4.10	10.43	4.37	0.063	.951

**p<.05, **p<.01, MCQ = Multiple Choice Questions*

An independent samples t-test was conducted to compare the marks obtained in the objective type test. Results revealed in an analysis of scores that there is no significant difference between the mean gain in marks obtained in the objective type test of experiment group (Mean =10.43) and control group (Mean =10.49) having t value (0.06) and $p = 0.951$. The mean difference (0.06) in students MCQs scores among control and experiment group students was not significant. It indicates that students in the experiment group have no higher gain in marks obtained in the objective type test as compare to the students' gain in marks obtained in the objective type test in the control group.

Table 2. Comparison of Marks of Subjective Type Test (Mathematics Achievement Test) in Pretest

	Control group		Experiment group			
Pretest	M	SD	M	SD	t (85)	p(two-tailed)
RRIs	1.16	1.34	1.59	1.63	-1.33	.186

**p<.05, **p<.01, RRI = Restricted response items*

An independent samples t-test was conducted to compare the marks obtained in the subjective type test. Results revealed in the analysis of the subjective type test scores with t value (- 1.33) and $p = .186$ shows that there is no significant difference between the mean gain in marks obtained in the subjective type test of experiment group (Mean =1.59) and control group (Mean =1.16). The mean difference (-0.42) among students' scores was considered insignificant. It indicates that students in the experiment group have no higher gain in marks obtained in the

subjective type test as compare to the students' gain in marks obtained in the subjective type test in the control group.

Table 3. Comparison of Marks of Objective Type Test (Mathematics Achievement Test) in Posttest

	Control group		Experiment group			
Posttest	M	SD	M	SD	t (85)	p(two-tailed)
MCQs	14.98	3.39	30.05	3.90	-19.18	<.001

**p<.05, **p<.01, MCQ = Multiple Choice Questions*

An independent samples t-test was conducted to compare the marks obtained in the objective type test. It was found that mean score value having t = -19.51, p <.001 shows that there is a significant difference between the mean gain in the marks obtained in the objective type test in posttest of experiment group (Mean = 30.90) and control group (Mean = 14.98). The mean difference in marks obtained in the objective type test between control and experiment group students (-15.06) was reasonable. The eta squared value (.08) has a reasonable effect size. It indicates that students in the experiment group have higher gain in the marks obtained in the objective type test as compare to the students of the control group. Therefore, the intervention has a significant effect on the students' marks obtained in the objective type test in the experiment group.

Table 4. Comparison of Marks of Subjective Type Test (Mathematics Achievement Test) in Posttest

	Control group		Experiment group			
Posttest	M	SD	M	SD	t (85)	p(two-tailed)
RRIs	2.95	1.97	13.73	1.80	-26.53	<.001

*p<.05, **p<.01, RRI = Restricted response items

An independent samples t-test was conducted to compare the marks obtained in the subjective type test (i.e. RRIs) of mathematics achievement test in posttest for both groups. Analysis of scores, having t = -26.53, p <.001 shows that there is a significant difference between the mean gain in the marks obtained in the subjective type test in posttest of experiment group (Mean = 13.73) and control group (Mean = 2.95). The mean difference between control and experiment group students (-10.77) was significant. The eta squared value (.09) has a reasonable effect size. It indicates that students in the experiment group have higher gain in the marks obtained in the subjective type test as compare to the students in the control group. Therefore, the intervention has a significant effect on the marks obtained in the subjective type test of students' in the experiment group.

Table 5. Comparison of Total Marks in Mathematics Achievement Test in Pretest

	Control group		Experiment group			
Pretest	M	SD	M	SD	t (85)	p(two-tailed)
Total Marks	11.60	3.94	11.84	5.23	-2.37	.811

*p<.05, **p<.01

An independent samples t-test was conducted to compare the total marks obtained in mathematics achievement test in pretest for both groups. Analysis of scores having t = -2.3, p = .81 shows that there is no significant difference between the mean gain in the total marks obtained in the pretest of experiment group (Mean = 11.84) and control group (Mean = 11.60). The mean difference between control and experiment group students' score (-0.24) was not significant. It indicates that students in the experiment group have no higher gain in the total marks obtained as compared to the students of the control group. Therefore, the intervention has a significant effect on students' total marks obtained in the experiment group.

Table 6. Comparison of Total Marks in Mathematics Achievement Test in Posttest

	Control group		Experiment group			
Posttest	M	SD	M	SD	t (85)	p(two-tailed)
Total Marks	17.67	4.39	43.77	4.29	-28.02	<.001

*p<.05, **p<.01

An independent samples t-test was conducted to compare the total marks obtained in mathematics achievement test in posttest for both groups. Analysis of scores, having t = -28.02, p <.001 shows that there is a significant difference between the mean gain in the total marks obtained in posttest of experiment group (Mean = 43.77) and

control group (Mean = 17.67). The mean difference between control and experiment group students (-26.09) was significant. The eta squared value (.09) has a reasonable effect size. It indicates that students in the experiment group have higher gain in the total marks obtained as compared to the students of the control group. Therefore, the intervention has a significant effect on the total marks obtained by students in the experiment group.

Table 7. Comparison of Total Marks of High Achievers in Mathematics Achievement Test in Pre and Posttest

	Control group		Experiment group			
Ability group	*M*	*SD*	*M*	*SD*	t (14)	p(two-tailed)
High achievers pretest	5.63	1.84	3.25	1.28	2.982	.021
High achievers posttest	13.88	2.90	33.63	2.65	-20.54	<.001

*p<.05, **p<.01

An independent samples t-test was conducted to compare the total marks obtained in mathematics achievement test in pretest by high achievers of both control and experiment group. It indicates a significant difference in mean scores for control group (*M*ean =5.63) and experiment group (M =3.25) with t = 2.98 and $p = .021$. The magnitude of the differences in the means (-2.37) was significant. Similarly, an independent samples t-test was conducted to compare the total marks obtained in mathematics achievement test in posttest of both control and experiment group. It indicates a significant difference in scores for control group (Mean =13.88) and experiment group (Mean =33.63) having t (14) = -21.54 and $p < .001$. The magnitude of the differences in the means (-29.75) was considerably large.

Table 8. Comparison of Total Marks of Average Achievers in Mathematics Achievement Test in Pre and Posttest

	Control group		Experiment group			
Ability groups	M	SD	M	SD	t (53)	p(two-tailed)
Average achievers pretest	11.78	1.90	12.43	2.86	-.98	.324
Average achievers posttest	17.00	3.41	43.29	4.62	-23.32	<.001

*p<.05, **p<.01

An independent samples t-test was conducted to compare the total marks obtained in mathematics achievement test by average achievers in the pretest of both control and experiment group. It shows no significant difference in scores for control group (Mean=11.78) and experiment group (Mean =12.43) having t (53) = -23.32 and $p = .32$. The magnitude of the differences in the means was very small. Likewise, an independent samples t-test was conducted to compare the total marks obtained in mathematics achievement test in posttest by average achievers of in both groups. It was seen that there was a significant difference in scores for the control group (Mean =17.00) and experiment group (M =43.29) having t (53) = - 23.32 and $p <.001$. The magnitude of the differences in the means (-25.76) was very large.

Table 9. Comparison of Total Marks of Low Achievers in Mathematics Achievement Test in Pre and Posttest

	Control group		Experiment group			
Ability groups	M	SD	M	SD	t (14)	p(two-tailed)
Low achievers pretest	17.00	1.51	18.38	0.91	-2.205	.052
Low achievers posttest	22.00	5.09	45.63	4.03	-10.012	< .001

*p<.05, **p<.01

An independent samples t-test was conducted to compare the total marks obtained in mathematics achievement test in pretest by low achievers of both groups. Results revealed that there was a significant difference in scores for control group (Mean=17.00) and experiment group (Mean=18.38) having t = -2.20 and $p = .05$. The magnitude of the differences in the means (-1.37) was noteworthy. The eta squared value (.25) has shown a significant effect size. Alike, an independent samples t-test was conducted to compare the total marks obtained in mathematics achievement test in posttest by low achievers of both groups. There was a significant difference in scores for control group (Mean =22.00) and experiment group (M =45.63) having t = -10.01 with $p <.001$. The magnitude of the differences in the means (-23.62) was very large.

Discussion

The findings of this research suggest that students have benefited from feedback, which, therefore, resulted in an increase in students' achievement in the mathematics classroom. Giving appropriate feedback to students in

mathematics is necessary for grade 9 students because in the Pakistani context students perceive mathematics as a boring and difficult subject at the secondary school level. In this situation, the clarity of concepts may help students to increase their achievement in mathematics (Narciss & Huth, 2004). In the changing scenario of education policies and curriculum change, there is a need to put more focus on feedback in the content of the mathematics textbook to increase students' achievement in mathematics.

Feedback on new concepts and relevancy to their difficulty level is the main thing that must be addressed. Teacher's feedback accelerates students' knowledge and its application in mathematics classroom learning. It also proves that teaching of content alone is an incomplete assumption in teaching mathematics. Feedback on every topic of mathematics is necessary to enhance students' knowledge, understanding and application of different topics of mathematics that enhance mathematics achievement. Several types of research have confirmed this statement that feedback has a remarkable effect on students' performance (e.g., Bangert, Kulik, Kulik, & Morgan, 1991; Kluger & DeNisi, 1996; Kulhavy & Wager, 1993; Mory, 2004; Narciss & Huth, 2004). However, other studies on feedback have shown no effect on students' performance (e.g., Corbett & Anderson, 1990; Hodes, 1985; Merrill, 1987). Effective feedback in mathematics classroom during the teaching-learning process is one of the indicators leading towards quality education. Different methods of feedback prevail that can be used to enhance the effectiveness of mathematics teaching and learning (Yorke, 2003) that may enhance students achievement in mathematics in secondary schools. Pakistan being a developing country, struggling hard for factors leading towards the quality education and learning of mathematics is one of them. Effective mathematics learning needs different feedback strategies and techniques in order to enhance students' achievement in the mathematics classroom (Gibbs & Simpson, 2005).

Conclusion and Recommendations

Ignoring feedback in teaching and learning of mathematics may not help the accomplishment of the required goals. This study focuses on one aspect of students' achievement in mathematics that is the effect of the feedback given to students. There are gaps in meaning associated with feedback which encompass achievement and expectations sufficient to meet the challenge of effective education. Feedback expertise plays a vital role in the delivery of concepts with the best range of ways making the concepts more meaningful and understandable to the students. Therefore, the role of feedback in the mathematics classroom is credible and must be explored to determine the level of emphasis at the time of teaching and completing mathematics syllabus.

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