Comparison of Mathematics Performance of First-Year High School Students in Collaborative Learning and Formative Evaluation Methods

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Abstract
Educational system of Iran is suffering from the lack of active learning methods due to various reasons. Active learning methods motivate students to think and learn. One of these methods is collaborative learning which is more efficient than individual learning and develops a positive attitude in students toward teaching and learning. Another method is formative evaluation which enhances learning process. In this paper we investigate collaborative learning and formative evaluation in distinct groups. We use two hypotheses to address the difference between mathematics performance of students in conventional, collaborative learning, and formative evaluation methods. Adopting a semi-empirical approach and using multistage quasi-cluster sampling method, we chose 89 female students of the first year of secondary school in district 1 of Tehran in school year 2013-2014. We divided them into three groups of conventional, collaborative learning, and formative evaluation, and provided them with a researcher-made mathematics examination. ANOVA test results showed that students of formative evaluation group had better mathematics performance than conventional and collaborative learning groups. Therefore, formative evaluation seems to be an efficient method for teaching mathematics.

Keywords: Mathematics, formative evaluation, collaborative learning, conventional learning, active learning method.

1 Introduction

Education organization is one of the most important institutions in any country and has a significant role in training the new generation. School is the main place of teaching-learning processes and plays the central role in education system. Contemplation of these elements and investigation of obscure sides of educational system would help us to improve education process. The major educational activities take place in classroom. Development of any practice and process in the classroom entails the employment of appropriate methods. These methods facilitate the process of achieving educational goals. Likewise, teaching in classroom, as one of the main ways of education, and transfer of knowledge to students should be based on efficient methods. Unfortunately, educational system of Iran is suffering from the lack of active learning methods. These methods are efficient tools as they motivate students to think and learn. One of the active learning methods is...
collaborative learning which is far more efficient than individual learning, enhances student’s motivation, and develops a positive attitude in students toward teaching process. In his book "Principles of Education", Shariatmadari enumerates "being active" as one of the seven principles of learning. He believes that student should be active during learning process and attempt to learn things under guidance of teacher (Shoarinejad, 1989) [2]. On the other hand, formative evaluation which is based on frequent examinations can enhance student's performance. It is an efficient tool for evaluating students during learning progress as well as for exploring their personal identities. Paying attention of continuous activities of students in the form of assessing their performance would reveal their potential abilities and help them to be creative (Motamednia et al., 2013) [1]. An efficient educational system calls for using active methods in schools. This is particularly important in mathematics. Mathematical concepts in high school are taught in a fully abstract way and students have to learn them without objective perception. To enhance mathematics performance, it is essential to use active teaching methods. One of these methods is collaborative learning which enhances the spirit of cooperation, thinking, creativity and learning. So far, no study has been made to compare collaborative learning and formative evaluation. In this study, we execute collaborative learning and formative evaluation in distinct groups and compare the results. Our hypothesis in this study is "students have similar mathematics performance in collaborative learning method, formative evaluation method, and conventional method".

2 Collaborative Learning

Collaborative learning is an educational method in which students work together in small groups, thereby enhancing their collective achievements. The main feature of this method is that group members work together to achieve a shared goal, so that both group and individual will benefit (Seif, 2000) [3]. Prior to executing collaborative learning method, a teacher has to answer the following questions:
- How many members should each group have?
- Which students should work together?
- Where should students work?
- What tools should they work with?
- How should they work?
- What subjects can be discussed in the form of collective activity?
- To what extent should I help and guide students?
- How much should they work?
- How should group activities be evaluated? (Fazlikhani, 1999) [5].

3 Formative Evaluation

The aim of formative evaluation is to explore learning progress of students, so as to identify their strengths and weaknesses as well as to identify the problems of educational method used by teacher. This method is called formative evaluation because it is executed during educational course when teaching and learning is in progress. In formative evaluation, the goal is to determine success of students in achieving each educational objective, without any comparison between students. The advantages of formative evaluation are:
- Preventing accumulation of lessons
- Reducing educational failure
- Reducing test anxiety
- Enhancing student motivation to eliminate weaknesses
- Enhancing student’s strengths
- Preventing students from having to study all lessons before test
- Arousing curiosity of students and motivating them to think more deeply.
The major role of formative evaluation is to prepare educational materials in best form and quality. The term of "formative evaluation" was introduced by Skreyon (1967) four decades ago. He used this term to clarify structure of the concept which had been developed by Cronbach (1963). From then on, many scholars have emphasized the importance and necessity of this type of evaluation. Skreyon distinguished formative evaluation from summative evaluation and provided free-goal evaluation model. In his opinion, formative evaluation is carried out to determine to what extent the educational program conforms to educational goals and is able to meet consumer needs; summative evaluation on the other hand is performed when the educational program or project has finished. In defending his model, Skreyon says: "educational goals should not be accepted with closed eyes; they should be evaluated like any other thing. Further, educational goals are merely words and seldom reveal the major objectives of a program". He believes that the major role of free-goal evaluation model is to reduce orientation and increase objectivity (Mansoub Basiri, 2004) [4].

4 Review of Literature

Santrcok (2004) [10] suggests that when the requirements of collective reward and individual responsibility are met, collaborative learning promotes students in all educational fields and in all educational assignments, from essential skills to problem solving. Woolfolk believes that collaborative learning enhances friendship, self-confidence, and participation in school. Studies suggest that collaborative learning contributes considerably to success, perception, and emotional factors such as mental maintenance, cognitive perception, friendship, integration, self-respect, attitude, anxiety, and control. Terator (2007) believes that formative evaluation gives students the opportunity to pay attention to what they learn, foster their mental skills and capabilities, know their weaknesses and strengths, and strive for achieving their educational goals, eliminating their weaknesses, and enhancing their strengths. Formative evaluation contributes to an efficient teaching process. Formative evaluation does not mean to cause stress and anxiety in students by frequently examining them; rather it is at the center of class activities, giving students the opportunity to evaluate themselves, eliminate their weaknesses, and learn individual management (Seif, 2000) [3]. Also, Ganji (1992) [6] and Sepasi (1994) [7] suggest that there is a significant relationship between educational progress and the number of formative examinations. Gholamali Lavasani (2011) [8] conducted a research on the effect of collaborative learning on mathematics anxiety and help-seeking behavior of first-year high school female students. He taught some lessons of mathematics book for control and test groups, using conventional method for the former and collaborative learning method for the latter. Both methods reduced mathematics anxiety and help-seeking behavior of the students, but the changes in test group was significant. Motamednia et al. (2013) [1] used a number of checklists (a type of formative evaluation) for Chemistry book lessons and found that it enhanced student motivation and increased competition between groups.

5 Methodology

In studies where it is not possible for researcher to fully control or change effective (independent) variables, he attempts to adopt a somewhat empirical approach by identifying the variables and gaining the required knowledge. In other words, while it is not possible to fully control the existing variables in many natural and social situations, researcher tries to take an approach similar to empirical method in order to study the situation. In this study, we use a semi-empirical method.

5.1. Statistical Population

Statistical population consists of first-year high school students of district 1 of Tehran in school year 2013-2014. Using multistage quasi-cluster sampling method, we chose one girls' school in the city of Tehran. Then we randomly selected three classes from among first-year classes of the school and applied the intended
teaching methods for them. Next, we analyzed data and estimated sample size using Cochran formula. Finally, we chose 89 first-year high school female students.

5.2. Instruments
To study the hypothesis, we used researcher-made mathematical tests in two sections: formative tests for executing formative evaluation in the classroom, and researcher-made posttests for all three groups of conventional method, formative evaluation, and collaborative learning for the lesson of "second-degree equations". In pretest step, we used the first semester scores of students. In formative evaluation, we held five examinations containing questions from the lessons of delta method, analysis method, full square method, Kharazmi method, and test and trial method for determining the roots of second-degree equations. Each test contained four questions with total points being 10. For the posttests, we designed and used 14 questions for each of the three groups. These questions contained questions from all the lessons mentioned above. Total point of the researcher-made posttest was 20.

5.3. Data Collection Method
To study our hypothesis, we formed three groups out of the selected statistical samples. The first group was taught by conventional method (control group), the second group was taught by formative evaluation method, and the third method was taught by collaborative method. First, we set the pretest to be mathematics scores of the students in the first semester in school year 2013-2014. Then the topic of "determining the roots of second-degree equations" was taught for the three groups. In control group, we taught the students by conventional method. In collaborative learning group, we took the following steps:

- Forming groups
- Preparing individuals
- Group work
- Grading individual and group answers
- Grading table and calculation of learning effectiveness

After taking the above steps and teaching the lesson of second-degree equations, students took a posttest. In formative evaluation group, we determined each step and implemented formative evaluation according to the plan mentioned in second chapter.

- Preparing the proposed checklists to evaluate group discussions in the class on second-degree equations.
- Preparing proposed checklists to evaluate wall newspaper on second-degree equations.
- Preparing proposed checklists to evaluate project on second-degree equations.
- Preparing proposed checklists to evaluate data collection on second-degree equations.
- Preparing proposed checklists to evaluate the knowledge on second-degree equations.
- Preparing checklists to evaluate activities of the students on second-degree equations.

After the above steps, students took a posttest and completed a questionnaire on their views regarding formative evaluation. It should be noted that execution of each method took one and a half month.
6 Results

6.1. Descriptive statistics

In this part, we calculate descriptive statistics such as mean, standard deviation and mode for pretest and posttest scores in conventional, formative evaluation, and collaborative learning methods. Table 1 shows the results:

Table 1: Descriptive statistics results for conventional, formative evaluation, and collaborative learning methods

<table>
<thead>
<tr>
<th>Educational Method</th>
<th>Conventional Method</th>
<th>Formative Evaluation</th>
<th>Collaborative Learning</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pretest</td>
<td>Posttest</td>
<td>Pretest</td>
</tr>
<tr>
<td>Number</td>
<td>28</td>
<td>28</td>
<td>32</td>
</tr>
<tr>
<td>Mode</td>
<td>4.25</td>
<td>9</td>
<td>14.25</td>
</tr>
<tr>
<td>Mean</td>
<td>12.49</td>
<td>9.91</td>
<td>13.55</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>4.78</td>
<td>4.59</td>
<td>4.27</td>
</tr>
</tbody>
</table>

As you can see in Table 1, there is no considerable difference between the mean scores of three groups in pretests. In posttests, the mean scores of formative evaluation group are higher than other groups. The highest score frequency belongs to posttest of formative evaluation group. Also, the lowest score distribution belongs to posttest of formative evaluation group.

6.2. Inferential Statistics

We first investigate the normality using One-Sample Kolmogorov-Smirnov test. Since the obtained P Values are higher than 0.05, the assumption of data normality is met. We performed the assumption test using ANOVA method. Table 2 shows the results.

Table 2: ANOVA test results for pretests of conventional, formative evaluation, and collaborative learning groups

<table>
<thead>
<tr>
<th></th>
<th>Total squares</th>
<th>df</th>
<th>Mean square</th>
<th>F</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between groups</td>
<td>18.31</td>
<td>2</td>
<td>9.15</td>
<td>0.39</td>
<td>0.67</td>
</tr>
<tr>
<td>Inside groups</td>
<td>1991.79</td>
<td>86</td>
<td>23.16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>2010.1</td>
<td>88</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

As you can see in Table 2, P value is bigger than 0.05 (0.67>0.05) and there is no significant difference between mean scores of three groups. So we can say that in conventional, collaborative learning, and formative evaluation groups, mathematics performance of students in pretests is similar. Now we are going to compare the three groups in posttests using ANOVA. Table 3 shows the results:

Table 3: ANOVA test results in posttests of conventional, formative evaluation, and collaborative learning groups

<table>
<thead>
<tr>
<th></th>
<th>Total squares</th>
<th>df</th>
<th>Mean square</th>
<th>F</th>
<th>P - Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between groups</td>
<td>447.61</td>
<td>2</td>
<td>223.8</td>
<td>10.19</td>
<td>0.00</td>
</tr>
<tr>
<td>Inside groups</td>
<td>1887.6</td>
<td>86</td>
<td>21.94</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>2335.22</td>
<td>88</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

As you can see in Table 3, P value is smaller than 0.05 (0.00<0.05), so the assumption of zero is rejected, i.e. there is a significant difference between mathematics performance of students in at least two out of three methods. To determine the methods in which there is a difference in performance, we compare the methods two by two assuming that variances are equal. This is done by Scheffe test. Table 4 shows the results.
As you can see in Table 4, in comparison of formative evaluation method with conventional and collaborative learning methods, P value is smaller than 0.05, which means the better mathematics performance of the students in this method compared to other methods. In comparison of mathematics performance in conventional and collaborative learning methods, P value is bigger than 0.05 which means that there is no significant difference between the two methods. Finally, we conclude that there is a difference between mathematics performance of the students in conventional, collaborative learning, and formative evaluation methods.

7 Conclusion

Teachers can use a variety of methods for to teach students. For each method to be executed properly and efficiently, teacher has to provide students with the required opportunities and equipment. Obviously, the more students participate in teaching-learning process, the better, faster and more deeply learning process will be. Student’s participation in learning process is more in some methods and is less in some others. By choosing an efficient method, teacher can enable students to participate actively in learning process (Vatani, 2004) [9]. In this research, we employed two teaching methods other than conventional teaching. The results indicated that there is a difference between mathematics performance of students in conventional, collaborative learning, and formative evaluation methods. The difference between mean scores of conventional method and collaborative learning method was not significant and formative evaluation method produced better results compared to other two methods. One of the reasons for this is that formative evaluation, as the name implies, is executed when educational activities are still in progress and learning process is being formed. The fulfillment of educational goals and change of students’ behavior usually takes a long time. For this reason, teacher has to expect educational goals to be fulfilled in specified time periods proportional to capabilities and conditions of students. To ensure that educational goals are fulfilled in each time period, he has to evaluate students at the end of each section. This way he becomes aware of the progress of educational goals and can take necessary actions to eliminate the problems in learning process. One of the most important advantages of formative evaluation is to help step-by-step learning. This means that students learn the lessons step by step and do not proceed to a lesson unless they have learned the previous one. The results of formative evaluation motivate students to learn new topics. The students who achieve good results are encouraged to learn more and more
and those who do not achieve satisfactory results pass remedial education and are consequently encouraged to learn more. In collaborative learning method, despite strong and weak students face the challenges by cooperating with each other, the problems of learning mathematics in weak students are not accurately identified. In formative evaluation, thanks to frequent individual tests, such problems can be accurately identified. In the lesson of determining delta for calculating the roots of second-degree equations, for example, if a student is unable to determine x and x^2 coefficients and fixed number and if the strong student does not explicitly point to the subject, then the weak student does not understand the subject deeply. In formative evaluation, on the other hand, all weaknesses are accurately detected. This explains the considerable difference between the mean scores of conventional, collaborative learning, and formative evaluation groups.

Recommendations:

- It is recommended that collaborative learning and formative evaluation methods be studied in other educational programs as well. For example, these methods might be more efficient in primary school.
- It is recommended that formative evaluation be executed for male and female students in different educational programs in order to compare their performance in formative evaluation and collaborative learning methods.
- It is recommended that compilers of textbooks, mathematics in particular, design the contents of textbooks in such a way that teachers can implement collaborative learning and formative evaluation methods in classroom efficiently.
- It is recommended that formative evaluation and collaborative learning methods be instructed for mathematics teachers in training workshops by specialists of educational disciplines.

References


