



Formative Assessments as Scaffolds to Increase Mathematics Achievement of Grade 11 Students

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Abstract: A formative assessment is a written set of problems students are tasked to answer in class following a topic's discussion and preceding a quiz. This study examined the use of formative assessments as an instructional strategy to hone the mathematical abilities and improve the performance of Grade 11 students from a private Chinese school in Manila. It makes the assumption that such growth in terms of Mathematics achievement would be reflected in the summative assessment results – in particular, the quiz grades – of the students. Working on the premise that facilitating more non-graded formative assessments would equate to significant increase in the graded summative assessment results, the study compared the average quiz grades of a sample of 40 students across two quarters given a variation in the number of formative assessments facilitated. This quantitative-descriptive research utilized the paired samples t-test and a significance level of 0.05 in analyzing the two variables. Results of the present study revealed that the number of formative assessments has a significant impact on the resulting quiz grades of Grade 11 students in General Mathematics. The construct of scaffolding is explored as probable foundation for the efficacy of increasing the number of formative assessments being provided; considering such assessments as supportive activities capable of influencing students' Mathematics achievement reinforces the critical role of formative assessments in fostering students' competencies towards the targeted standards. Determining the appropriate number of formative assessments to administer reflects a teacher's responsiveness to the students' current knowledge, skills, and needs in the subject area; teacher discretion is thus discussed as integral to effective Mathematics pedagogy and enhanced Mathematics achievement, and is therefore recommended to be further investigated in future research.

Key Words: formative assessment; General Mathematics; mathematics achievement; quiz; scaffolding

1. INTRODUCTION

General Mathematics is a core subject in the Senior High School curriculum, as mandated by the Department of Education. Students are expected to learn to utilize analytical reasoning skills to solve

problems involving functions and their graphs and applications, as well as business-related concepts such as interest. Despite various attempts by educators to remedy poor academic performance in the Mathematics field as a whole, students continue to struggle with the fundamentals of mathematical

reasoning and problem solving (Mayfield and Chase, 2002), and thus global underachievement from students in this subject area persists (Mbugua, Kibet, Muthaa, Reche, and Chuka, 2012).

Though teacher quality is an important factor in determining the academic performance of students (Metcalfe, 2008), the teacher's responsiveness to the needs of the students would also play a major role in the students' learning and achievement. Effective pedagogy therefore would encompass a teacher's adaptability to the needs and progress of each individual student towards helping the latter achieve the target learning outcomes; his/her attitude in conducting frequent reflection on his/her teaching pedagogy and its impact on the learner; and his/her willingness to refine instruction as necessary (Siyepu, 2013; Christmas, Kudzai, and Josiah, 2013).

The use of formative assessments as an instructional strategy has recently risen in widespread recognition and implementation to enhance student learning and achievement in various subject areas (Brookhart, 2007; Magno and Lizada, 2015; Wiliam, 1999; Yorke, 2003). Formative assessments enable teachers to gauge their students' current capabilities, measured against learning objectives (Clark, 2012), and to refine their instruction based on such feedback and observations (Cauley and McMillan, 2010).

This study aims to determine the impact of manipulating the number of formative assessments administered in increasing the achievement grades and learning gains of Grade 11 students in their corresponding quizzes in the General Mathematics subject. The research is based on the premise that giving more formative assessments would equate to an improvement in terms of quiz grades, with formative assessments serving as supplemental activities or scaffolds that would facilitate learning, retention and mastery of the subject matter, thereby improving student performance and increasing Mathematics achievement.

2. THEORETICAL BACKGROUND

This section provides a brief overview of the functions of formative assessments, the relationship between formative and summative assessments, and the concept of scaffolding in relation to the Zone of Proximal Development.

2.1 Formative Assessment

Formative assessments go beyond merely evaluating and recording the students' current capabilities (Cauley and McMillan, 2010) by allowing teachers to modify instruction based on the results

(Bell and Cowie, 1999; Herman, 2013) in the hopes of further developing the students' skills and promoting further learning (Black, Harrison, Lee, Marshall, and Wiliam, 2003; Stiggins, 2005). The first use of formative assessments, then, is to provide concrete evidence (Boston, 2002) that would substantiate teacher decisions in terms of subsequent instructional adjustments and techniques to be employed (Magno and Lizada, 2015).

Formative assessments also function as checkpoints or progress indicators of where the students currently are in terms of knowledge and ability relative to the learning objectives (Assessment Reform Group, 2002). Thus, these assessments can be utilized by teachers in developing the necessary intervention or instructional reform strategies to address the learning gap between what the student already knows and what the standards deem is a satisfactory level of achievement (Heritage, 2010).

Finally, formative assessments may serve as supplemental activities to increase learning and facilitate understanding, retention and mastery of a certain topic. In a study conducted in North Carolina, the number of formative assessments given to the participating students was shown to positively enhance their mathematical skills in terms of monthly growth (Wang, Martin, Lambert, and Pugalee, undated). Wiliam (1999) claims similarly, "[...] increasing the use of formative assessment in school classrooms does produce significant increases in students' learning," after having examined a series of studies spanning a decade.

2.2 Scaffolding and the Zone of Proximal Development

Scaffolds may be likened to supportive activities designed by the teacher to help the students (Donato, 1994) grasp certain concepts, hone particular skills and abilities, and develop mastery of the subject area (Christmas, Kudzai, and Josiah, 2013). The effectiveness of implementing such instructional structure is anchored on the premise that, with help, a student would be able to achieve more than what he/she could do alone (Vygotsky, 1987), implying an enhancement of his/her current knowledge and capabilities and progress towards maturation of certain functions and processes (Christmas, Kudzai, and Josiah, 2013). Learning and skills development that can be achieved with assistance or scaffolds would encompass what is called the zone of proximal development.

Teachers play an important role as the guide or expert person whom the student would rely on for help to increase competence and achieve the functions within his/her zone of proximal development (Christmas, Kudzai, and Josiah, 2013).

This indicates the teacher's responsibility to be responsive to the needs of the students through providing proper and adequate support in the form of scaffolds when deemed necessary (Donato, 1994), including upgrading the scaffolding provided or removing such depending on whether the student requires more or less assistance (Rogoff, 1990).

2.3 Formative and Summative Assessment

Summative assessments can be seen as the end goal or the standards that a student should reach (Taras, 2005); formative assessments, on the other hand, can be seen as the stepping stones and checkpoints towards attaining the level of mastery expected by the summative assessment. Formative assessments would be the scaffolds that facilitate the growth of a student, enhancing one's current capabilities to be able to achieve more independent of assistance (Vygotsky, 1987). In this sense, the results of summative assessments would be heavily dependent on the quality and effectiveness of implementation and utilization of the formative assessments preceding them as it would be much more difficult for a student to extend his/her skills beyond his/her current performance without the help of scaffolds (Christmas, Kudzai, and Josiah, 2013) in the form of formative assessments. Serving as extra and repetitive practice that would hone problem-solving skills and enhance performance (Mayfield and Chase, 2002; McKeown, Beck, Omanson, and Perfetti, 1983), the use of formative assessments may lead to improved quiz grades and increased student achievement.

3. METHODOLOGY

This quantitative-descriptive study sought to determine the impact, if any, of the number of written formative assessments in the General Mathematics subject on the quiz grades of Grade 11 students of St. Stephen's High School. It was hypothesized that the number of formative assessments administered to the students would not significantly impact the corresponding quiz grades in General Mathematics.

The respondents of the study were 40 Grade 11 students from St. Stephen's High School, a private Chinese school in Manila. Data about each respondent were collected from the teacher's class record. Specifically, the following data were gathered: the number of formative assessments administered for each topic in General Mathematics and the respective quiz grades of the students during the first and second quarter of school year 2015-2016. The 40 respondents were selected randomly using a systematic sampling technique; as the Grade 11 batch in the said school consists of four sections,

every third student (based on the class record) from each section was chosen until ten students had been selected from every section.

Each respondent's individual quiz grades were averaged for both the first and second quarters. Since two dependent variables were being compared in the present study, the paired samples t-test was utilized in examining the data between the two quarters. A level of significance of 0.05 determined the critical values. The t-stat value was computed using the following formula:

$$t = \frac{\bar{d}}{\frac{s}{\sqrt{n}}} \quad (\text{Eq. 1})$$

where:

- t = t-statistic
- \bar{d} = mean difference
- s = standard deviation
- n = sample size

In answering formative assessments, the students were permitted to ask the teacher for feedback and help and to discuss amongst themselves the solutions to the problems. The students were also allowed to reference their notes. This is in contrast to summative assessments – particularly, quizzes – which the students solved independently. Furthermore, summative assessments are graded work that are unlike formative assessments which have no bearing on the students' actual grade in the subject. Summative assessments are used to measure student learning; quiz results are considered valid indicators of a students' Mathematical knowledge and abilities. In addition, the quiz questions were patterned after or parallel to those in the formative assessments. Thus, the study makes the assumption that formative assessments can be used to enhance student achievement in summative assessments.

4. RESULTS AND DISCUSSION

Three topics were covered in the first quarter; for each, one formative assessment was given to the Grade 11 students prior to a quiz. As with the first quarter, the second quarter covered three topics in General Mathematics. Three topics were also discussed in the second quarter; in contrast to the preceding quarter, however, three formative assessments were given before a quiz for each lesson tackled.

Table 1 presents the average quiz grades in General Mathematics for the first quarter. This can be visualized in Figure 1. Out of 40 respondents, 12 students or 30.0% of the sample size got an average grade between 45-58, which is the mean from this sampling. The same number of students (2 or 5.0%) received the lowest and highest average quiz grades

ranging from 17-30 and 87-100, respectively. Such data resulted in an approximately normal frequency distribution.

Table 1. Average Quiz Grades in the First Quarter

Average Quiz Grades	Number of Students	Percentage of the Respondents
17-30	2	5.0%
31-44	7	17.5%
45-58	12	30.0%
59-72	11	27.5%
73-86	6	15.0%
87-100	2	5.0%

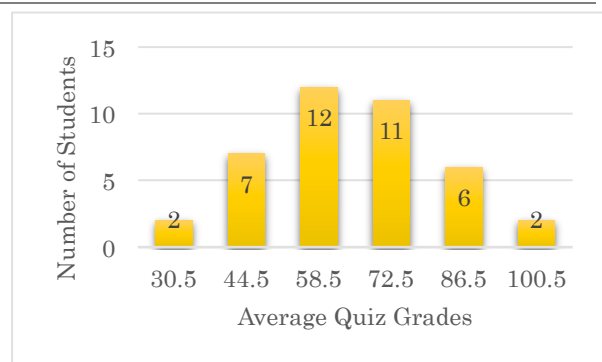


Figure 1. Average Quiz Grades for First Quarter

Table 2. Average Quiz Grades in the Second Quarter

Average Quiz Grades	Number of Students	Percentage of the Respondents
15-29	1	2.5%
30-44	4	10.0%
45-59	7	17.5%
60-74	13	32.5%
75-89	11	27.5%
90-104	4	10.0%

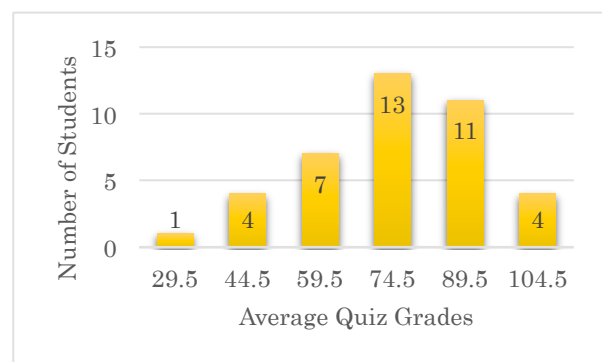


Figure 2. Average Quiz Grades for Second Quarter

Table 2 presents the average quiz grades in General Mathematics for the second quarter. This is visualized in Figure 2. 13 out of 40 respondents (32.5%) received grades that are within the average range of 60-74. Four students (10.0%) graded between 90-104, the highest average grades; on the other hand, only one respondent (2.5%) attained the lowest average, which is between 15-29.

As with the first quarter results, the data on the average quiz grades in the second quarter produced a frequency distribution that appears to be approximately normally distributed.

Table 3. t-Test of the Two Sample Means

	Variable 1	Variable 2
Mean	57.625	66.2
Variance	326.4967949	354.6769231
Observations	40	40
Pearson Correlation	0.780694535	
Hypothesized Mean Difference	0	
df	39	
t Stat	4.430468823	
P(T<=t) one-tail	3.70439E-05	
t Critical one-tail	1.684875122	
P(T<=t) two-tail	7.40878E-05	
t Critical two-tail	2.02269092	

Table 3 lists the data computed from the results of the t-test conducted for the two sample means. Using such method (i.e., $t = \frac{\bar{d}}{\frac{s}{\sqrt{n}}}$) returned a t-stat value of 4.430468823. Using a level of significance of 0.05 resulted in t critical values of ± 2.02269092 .

This study has provided initial data on the impact of the number of formative assessments administered to Grade 11 students on their corresponding quiz grades in General Mathematics.

The findings indicate an increase in terms of quiz grades from the first to second quarter. Such improvement is similar to the results of Wang, Martin, Lambert, and Pugalee (undated) wherein the development of students' mathematical abilities observed in terms of monthly growth was influenced by the number of formative assessments

administered in that particular set-up. Such results may also be attributed to the concept of scaffolding as proposed by Christmas, Kudzai and Josiah (2013) as an operationalization of the Zone of Proximal Development theory. This indicates that additional practice would equate to improved resulting grades (Mayfield and Chase, 2002; McKeown, Beck, Omanson, and Perfetti, 1983); providing the students with more scaffolds in the form of formative assessments would facilitate progress towards the learning objectives and standards as expected by the quiz through developing their current capabilities (Heritage, 2010; Taras, 2005).

The study also corresponds with the notion that beyond teacher quality or mere subject content knowledge, a teacher must also employ the proper and appropriate instructional strategies and tools to enhance student learning and achievement (Siyepu, 2013). In this particular case, the issue revolved around the adequacy of the help provided by the teacher through the formative assessments serving as supplemental activities or scaffolds. Manipulating the number of formative assessments administered prior to a quiz may be seen as teacher responsiveness, which has been asserted to be crucial to effective mathematics pedagogy (Christmas, Kudzai and Josiah, 2013), to the needs expressed by the students (Cauley and McMillan, 2010; Herman, 2013). Since effective teaching is a major factor influencing the academic performance of students in Mathematics (Siyepu, 2013), proper decisions on the number of formative assessments to be administered, through being a mark of appropriate teacher reform and consequentially teacher effectiveness, would positively benefit students' grades and achievement. Increasing or decreasing the number of formative assessments given is similar to upgrading or removing the scaffolding to provide more or less assistance as deemed necessary based on the teacher's own discretion (Donato, 1994).

5. CONCLUSIONS

As discussed in the previous section, the paired samples t-test resulted in a t-statistic of 4.430468823. Since the computed t-stat is greater than the critical value of 2.02269092, the null hypothesis that the number of formative assessments does not significantly impact the quiz grades in General Mathematics is thus rejected. A claim contradicting this may then be proposed instead – the results of the present study reveal that the number of formative assessments does have a significant impact on the resulting quiz grades of Grade 11 students in General Mathematics. In particular, increasing the number of formative assessments administered to the students from one

in the first quarter to three in the second quarter corresponded with an increase in their average quiz grades.

It may be concluded then that there exists a relationship between the two variables tested in that increasing the number of formative assessments effected an increase in quiz grades. Such findings have implications for the use of formative assessments as a teaching strategy to enhance students' mathematical skills, improve quiz grades and increase achievement in the General Mathematics subject.

To solidify further the argument that increasing the number of formative assessments given would indeed positively benefit student learning through improving summative assessment (i.e., quiz) grades, future studies may want to focus on some of the unexplored aspects that had not been considered in the scope of the present study. For example, the possible difference in level of difficulty between the topics and assessments administered in General Mathematics may have also contributed to the increase in average quiz grades. As such, controlling for the topics discussed would result in an experimental research design that may arguably be more suitable in an attempt to determine the relationship between formative and summative assessments in isolation from other moderating factors. Furthermore, since the present study provides initial grounds to suggest the functioning of formative assessments as scaffolds, the ideas and implications for Mathematics teaching posited by the Zone of Proximal Development theory may be investigated and applied in relation to teacher responsiveness and discretion. Another future direction for formative assessment research may then be to explore the teacher's crucial responsibility of determining and deciding whether to provide more or less scaffolds; this would point towards examining and assessing the sufficiency and propriety of the formative assessments being facilitated by evaluating their efficacy in eliciting achievement gains.

In closing, the present study's findings can be considered as a step towards delineating the role of formative assessments as an integral part of Mathematics pedagogy – particularly the number of these administered scaffolds hinging on teacher discretion in relation with summative assessments and overall mathematics achievement in the Senior High School curriculum.

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