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# The Pre-Algebra Course: A Bridge Program For Mathematically Under-Prepared College Entrants

One reality in our educational system is that a sizable number of our high school graduates are not prepared for college and a good portion of this are under-prepared to take regular college mathematics courses. A survey conducted in one of the state universities in Central Visayas, Philippines in school year 2004-2005 showed that about 90% of its college entrants have a hard time doing elementary operations on fractions, decimal, and percent. One resulting recommendation was that a bridge program be set up for these students. A subsequent study by Kilat (2006) noted five variables that most likely relate to students' grade in College Algebra: High School General Average (HSG), High School Mathematics Grade (HSM), Silliman University Admission and Placement Examination (SUAPE) Score, SUAPE Math component score (SM), and College Algebra Grade (CAG). Subjecting these variables to regression analysis reveals that CAG is strongly correlated with HSG and SM. The linear regression model with Durbin-Watson d statistic of 2.16 showed that CAG = 0.076HSG + 0.073SM - 6.23.

With this equation, a desired CAG can be set to a certain value and the values of the other two variables may also be computed. A flowchart was drawn to aid the university admission office in identifying students who need to take the pre-algebra course. Three semesters after its implementation, the percentage of those who obtained below average and failure significantly decreased from 39.77% to 29.67%. It is recommended that schools who wish to set up a bridge program for their incoming first year students adopt this method or a variation of this method according to the nature of their admission policy. If a school does not intend to put up a bridge program for their regular mathematics courses, it is suggested that students still be grouped according to their mathematical abilities in order to lighten the teacher's task of managing the classroom and diversifying one's approach to maximize effectiveness in transmitting mathematical knowledge to students.

## Introduction

The need for a program for mathematically under-prepared college entrants in Silliman University has long been felt by the faculty of the Mathematics Department of Silliman University. The suspicion that a good number of students enter college without adequate mathematical preparation was confirmed when the department made an actual count and percentage on the number of failures in College Algebra from school year (SY) 2001-2002 to SY 2005-2006. The data revealed that 721 students out of 6,568 obtained a grade of F. This excludes students who got Incomplete (INC), Withdraw (W), Dropped, and those who obtained a grade of less than 2.0 (a grade below which is considered a failure in many university units, e.g., the natural sciences, nursing, and business administration). When those who failed and those who got less than 2.0 were combined the percentage of students who fail College Algebra rose to about 37%.

In a study conducted at a local state university entitled "College Entrants' Knowledge on Division-Based Mathematics" (Mamhot, Lazalita, Manahon, Cepe, & Aurea, 2005), it was found that of the 1,660 entering first year students who took a 30-item exam on elementary operations such as fractions, decimals, and percent, only 10% or about 166 obtained a rating of 90% or higher. Ninety percent (90%) or 1,494 students got a score of 21 and below. Fifty percent (n=830) of the students obtained a score of less than 13. The mean score was 13.89.

It is suspected that this phenomenon is happening nationwide due to some crucial reasons. First, many students who enter college are unprepared, but the fault may not only be in the students. Barcenas (2000) has pointed to the shortening of elementary education in 1940 resulted in a tremendous deterioration of teaching standards. A second reason has to do with the possibility of incompetent teachers, corrupt administrators, lack of motivation by students, and negative influences of the society where patience and hard-work are seldom valued (Lee-Chua, 2001).

One recommendation of the study earlier mentioned was to screen students who enter college and conduct a bridge program for those who are found mathematically deficient in order to equip them with adequate mathematical skills before they enroll in regular college mathematics courses. The challenge had to do with how to segregate students who are mathematically ill-prepared for college from those who are well-prepared. In a subsequent study by Kilat (2006), the following factors were considered as the most likely variables that could relate to College Algebra grade: a) High School General Average (HSG), b) High School Mathematics Grade (HSM), c) Silliman University Admission and Placement Examination (SUAPE) Score, and d) SUAPE Math component score (SM). A regression analysis conducted with these as independent variables and College Algebra grade (CAG) as dependent variable, resulted in CAG = 0.076HSG + 0.073SM - 6.23, with a Durbin-Watson index of 2.16.

## Methodology

For five consecutive school years from 2001-2002 up to 2005-2006, 100 entering first year students were chosen at random from each school year and from these students the following data were obtained: a) High School General Average (HSG), b) High School Mathematics Grade (HSM), c) Silliman University Admission and Placement Examination (SUAPE) Score, d) SUAPE Math component score, and e) College Algebra Grade. Some of the 500 students did not have complete figures on these variables, and only 218 were included in the analysis.

Data on these variables were subjected to regression analysis after their validity for use was confirmed by the Durbin-Watson test. The regression analysis was utilized to determine which variables have significant effect on College Algebra grade and from the regression equation that was obtained, cut-offs were then set and recommendations to the University Admissions Office on how to sort students for a bridge program were considered. The bridge program in mathematics was intended to augment the mathematical preparation of the incoming students identified as under-prepared.

In order to test for the effectiveness of the program recommended, data of failures from SY 2001-2002 to SY 2005-2006 were gathered, tabulated, and compared with data of failures for the three semesters from SY 2006-2007 and first semester of SY 2007-2008. The z-test on proportions was then used to test the significance of the difference between the proportions of these two groups of students vis a vis those before the implementation of the program and those who were subjected to the program.

## Scope and Limitations of the Study

In sorting the students for the program, the authors relied mainly on the following factors: High School General Average (HSG), High School Mathematics Grade (HSM), Silliman University Admission and Placement Examination (SUAPE) Score, and SUAPE Math component score. Other factors like math anxiety (Arem, 1993; Scarpello, 2007), parental support (Lee-Chua, n.d.,), knowledge of English language (Esmeralda, 1989), study habits (Nochefranca, 1980), and aptitude for math (Smith, 1991) are beyond the scope of this study.

The students included in the study are those enrolled from SY 2001-2002 to the first semester of SY 2007-2008 in all colleges of Silliman University except those enrolled in the College of Engineering and Design. Furthermore, college grades considered in the study are the grades of those who took College Algebra for the first time. Students who dropped or withdrew as well as those who obtained INC (incomplete) and NG (No Grade) were also excluded from the study.

## The Pre-Algebra Course

The Pre-Algebra course is required for students identified as underprepared based on the criteria set by the University Office of Admissions. It is a 3-unit non-degree course with topics in elementary mathematics. The course is designed for students who find mathematics difficult to understand and even for those who find it "fearsome." The topics included mathematics orientation, proficiency on the four fundamental operations of integers, fractions, decimals, and percent, introduction to College Algebra, simple word problems, and the Cartesian coordinate system.

The main objective of the course is to give students more opportunities and time for engaging in mathematical activities thereby facilitating the transition to more abstract ways of thinking that is required in College Algebra and providing scaffolding for these students to be successful in college.

Through lectures, discussions, laboratory sessions, small group discussions, and reading and writing papers, students are assisted in exploring algebraic concepts in an informal way to build a foundation for subsequent formal study of algebra. Some of the features of the course are:

- A five-minute check that makes a bridge from previous lessons
- Bell-ringer questions to provide activities for the first few or last few minutes of class
- Error analysis that provides ways to monitor and adjust student learning
- Cooperative problem-solving activities that present a problem or mini-project for group work
- Models and manipulatives that use home-made or purchased materials to extend student mastery
- Applications and interdisciplinary activities to show the connection of math and the real world
- Portfolio of students' homework/assignment as an enrichment and practice

Although the topics in this course appear very similar to a regular College Algebra course, the exercises and examples discussed here are those among the simplest of forms. At the end of the semester, the students are given only grades of U (unsatisfactory) and P (passed). The grading criteria are as follows:

Attendance: 50%
Portfolio: 10%
Exams: 40%

The cut-off percentage set for a grade of P is 70% or higher. If a student obtains lower than 70% he or she is advised to repeat the course and is considered ineligible to take College Algebra. The recommended text for the course is the one by Price, Rath and Leschensky (1995) entitled *Merrill Pre-Algebra: A Transition to Algebra* published by McGraw-Hill. Teaching materials to guide the students are also prepared by the Mathematics Department.

## The Independent Variables

*High School General Average.* Out of the 218 students included in the study about 80% of them have a high school grade average of 85 and above (Figure 1). About 2.29% are boundary students while about 38.07% have grades above 90. The rest of the students (59.64%) fall in between.

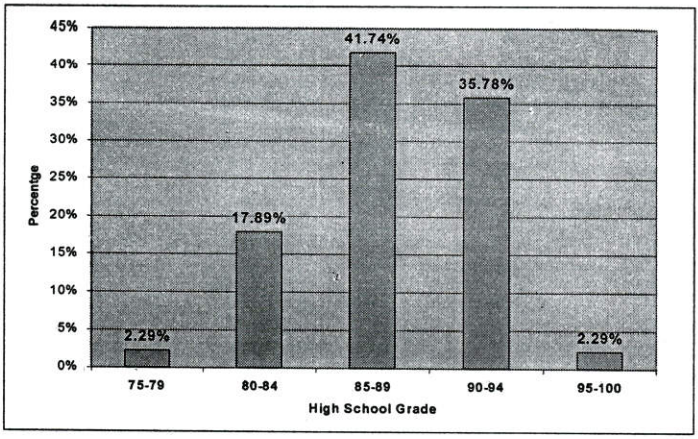


Figure 1. Percentage Distribution by High School General Average of First Year Students from SY2001-2002 to SY2005-2006.

*High School Math Grade.* About 40% of the students have grades that are less than 85, while 16.51% have grades less than 80, and only about 22.02% have grades of 90 or higher (Figure 2).

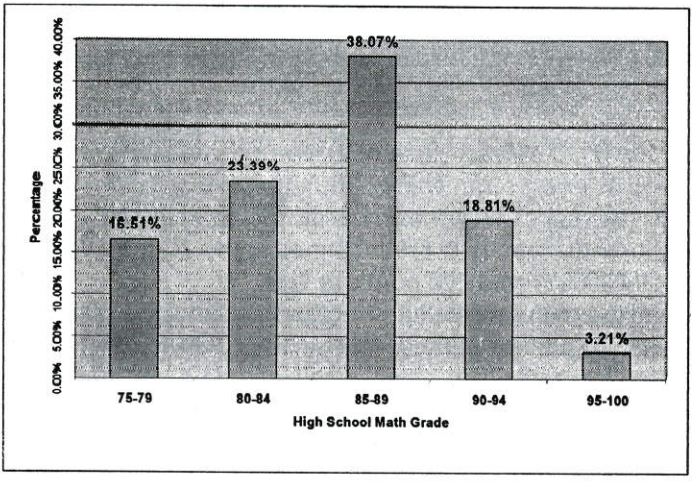


Figure 2. Percentage Distribution by High School Math Grade of Entering First Year Students from SY2001-2002 to SY 2005-2006.

*SUAPE Math Component.* The SUAPE Math Component was assessed by point system with a highest score of 50 and with 0 as lowest. Most students (56.88%) obtained scores between 21 to 30 points and only about 0.46% got scores above 40. About the same percentage scored 10 or below (Figure 3). Thus, 99.09% of them have scores between 11 and 40.

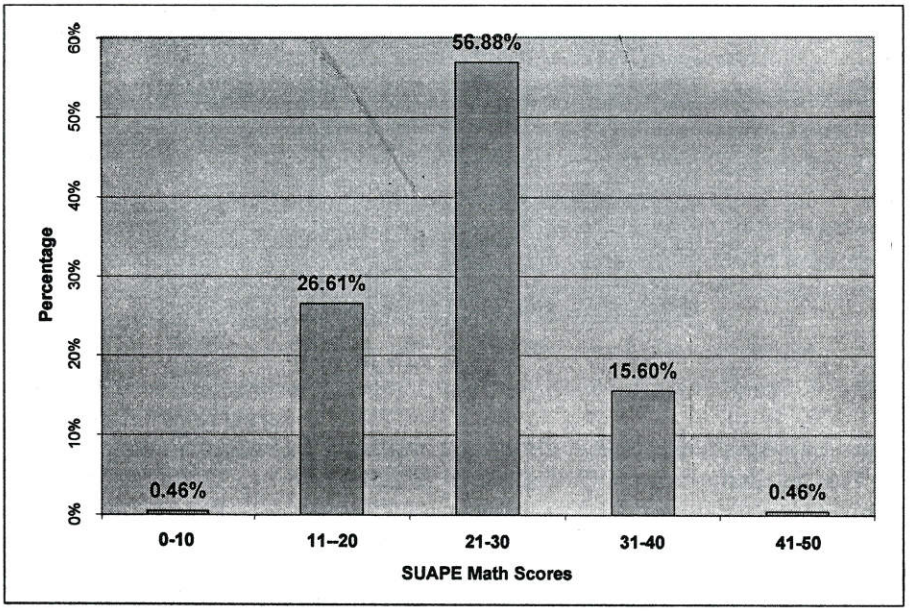


Figure 3. SUAPE Math Component Scores of First Year Students from SY2001-2002 to SY2005-2006.

*SUAPE Scores.* SUAPE scores were assessed using raw scores where each question is worth one point. The examination consists of 150 questions, therefore, the highest possible score from SUAPE is 150. A percentage distribution shows that about 95.87% obtained scores of more than 100 points and only about 4.13% scored 100 points or less.

After all of the scores are gathered at the Silliman Admission Office, they were converted into percentile ranks that are then used to determine whether or not a student is admitted into the University, and to which academic unit because different colleges usually specifies a cut-off SUAPE percentile rank.

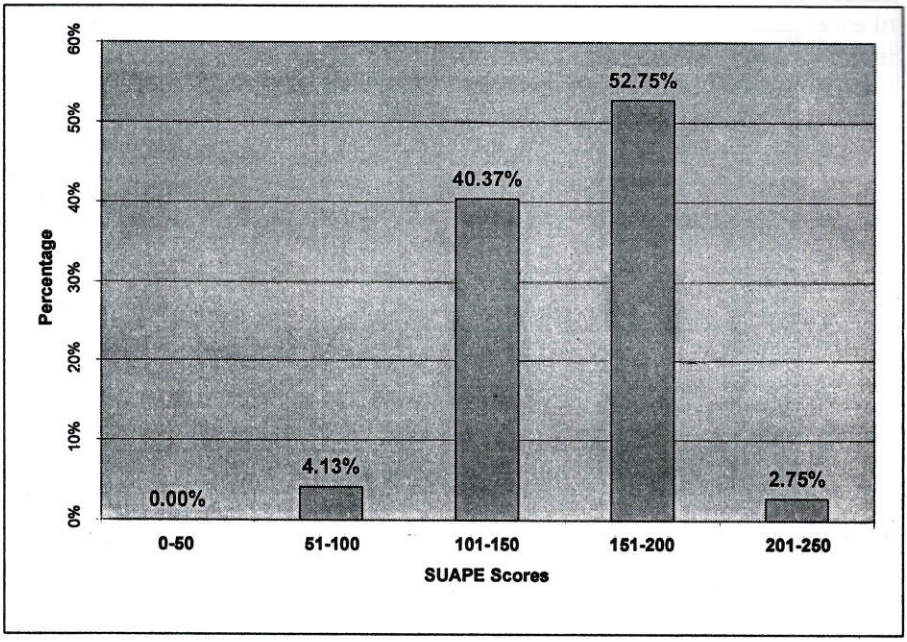


Figure 4. SUAPE Scores of First Year Students from SY2001-2002 to SY2005-2006.

*College Algebra as Dependent Variable.* Each of the preceding independent variables were tabulated vis-a-vis students' corresponding grades in College Algebra (Figure 5) for analysis as to their relationships. The 6.42% obtaining the grade F (failure) in College Algebra combined with those with grades below 2.0 comprised close to 37%. Some colleges and departments like the College of Nursing, It must, however, be noted that particular colleges at Silliman University such as College of Business Administration, the Mathematics department, and natural sciences departments consider a grade below 2.0 as a failure.

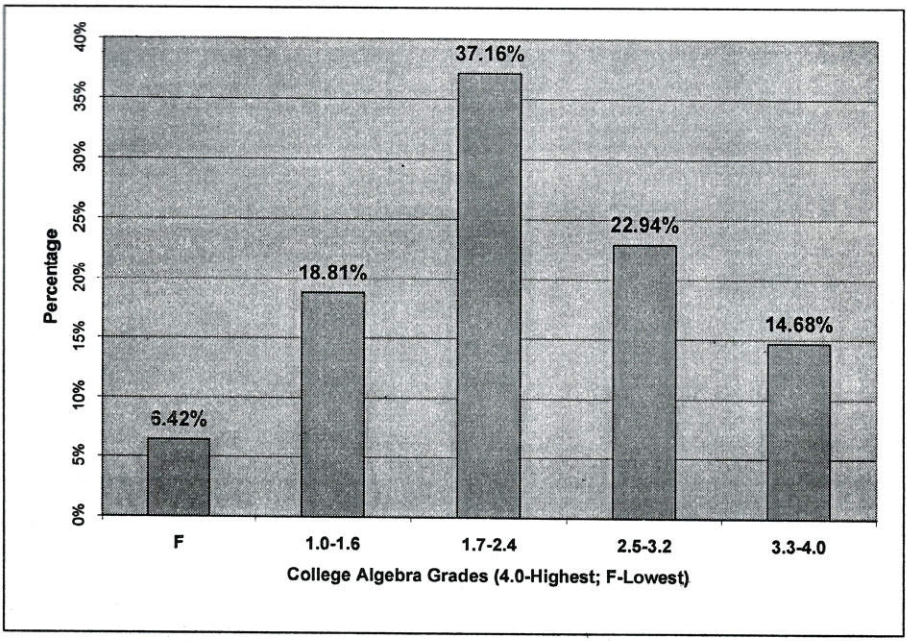


Figure 5. College Algebra Grades of First Year Students of Silliman University from SY 2001-2002 to SY 2005-2006.

**Regression Analysis**

When the gathered data were subjected to analysis of variance modelled on regression analysis with the null hypothesis that College Algebra Grade is **not** related to any of the variables—High School General Average, High School Mathematics Grade, SIlliman University Admission and Placement Examination (SUAPE) Score, and SUAPE Math component score, it was found that at least one of the independent variables is associated with College Algebra Grade, with a p-value of 0.00 (Table 1).

Table 1.
Analysis of Variance Model with all Variables Entered

| | Degrees of Freedom | Sum of Squares | Mean Square | F–value | P–value |
|---|---|---|---|---|---|
| Regression | 4 | 91.60 | 22.90 | 48.83 | 0.00* |
| Residual | 213 | 99.89 | 0.47 | | |
| Total | 217 | 191.49 | | | |

* p-value of 0.00 means at least one of the independent variables is correlated with the dependent variable.

To find out which of the variables significantly related to the grades in College Algebra, the linear regression model was employed. It was found that College Algebra grade is significantly related to the High School General Average (p-value = 0.00) and the Math SUAPE Component also with a p-value =0.00 (Table 2).

Table 2.
Parameter Estimates of College Algebra Grade Using Linear Regression Analysis.

| | Coefficients | Standard Error | t–stat | P–value |
|---|---|---|---|---|
| Intercept | –6.230 | 1.032 | –6.035 | 0.00 |
| SUAPE Math Score(SM) | 0.073 | 0.009 | 8.387 | 0.00 |
| High School General Average(HSG) | 0.076 | 0.013 | 5.976 | 0.00 |

It appears that one's College Algebra Grade (CAG) can be estimated using SUAPE Math Score and High School General Average using this linear regression equation: **CAG = 0.076HSG + 0.073SM 6.23**. This Regression Analysis has a Durbin-Watson d statistic of 2.16, meaning that the use of this analysis for the given data is statistically valid.

As a matter of policy, those who obtain SUAPE Percentile of 40 and above are automatically admitted to the university and thus, need not take the pre-algebra course. The regression equation formulated above, hence, applies only to those who obtain a SUAPE Percentile of below 40.

From this equation, if the SUAPE Math Score is set at 25, the student with High School General Average of 75 to 84 has a good chance of getting a College Algebra grade of 1.4 to 2.0. Thus, based on this regression equation, it was recommended that those who obtain a SUAPE Math score below 25 take the pre-algebra course, while those who obtained SUAPE Math scores of 25 and above may take the regular College Algebra course even if his or her SUAPE percentile is only between 20 and 40. With this policy in place, even those who obtain SUAPE percentiles of less than 20 can still be admitted into the university if they enroll and pass the pre-algebra class as a condition for their admission. SUAPE percentile of 20 is the minimum cut-off percentile for admission into the university.

## The SUAPE and the Process of Student Selection for the Bridge Program

The Silliman University Admission and Placement Examination (SUAPE) is the official admission and placement examination administered to incoming college first year students of the university. Certain academic units in the university require specific cut-off percentile scores for admission into their

unit but the lowest passing percentile score is 40. Incoming college students who obtain a percentile score of less than 40 are given provisional status, but those who get less than 20 %ile are refused admission.

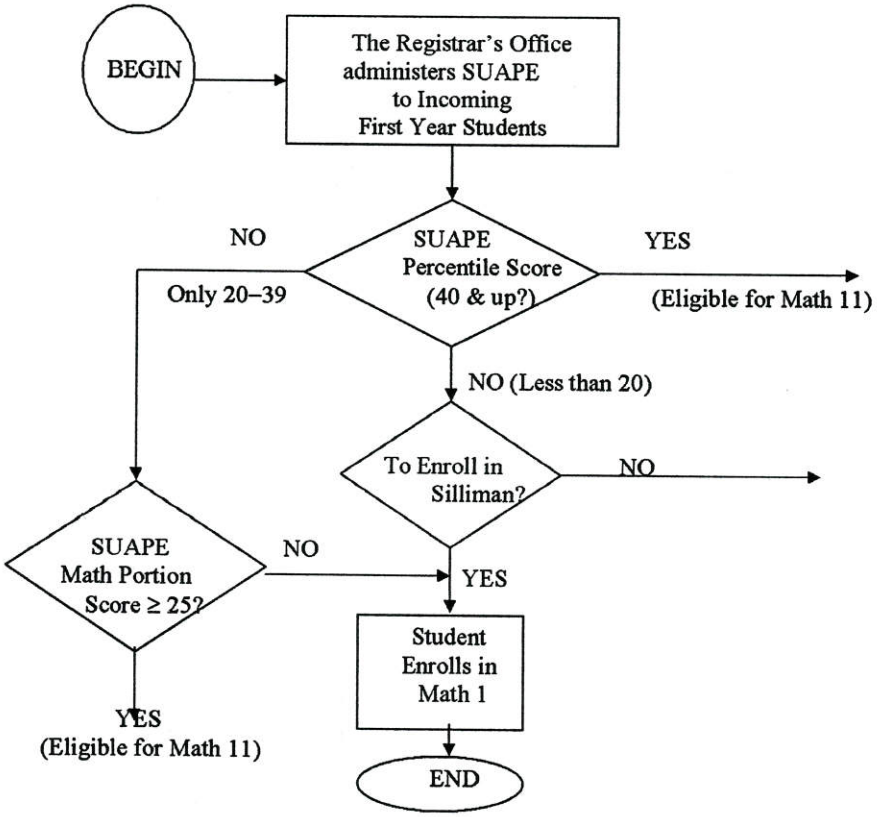


Figure 6. Flowchart for Math 1 Students.

It must be noted that Silliman University adopts the following grading system for its students:

3.8 - 4.0 Excellent
3.3 - 3.7 Superior
2.8 — 3.2 Good
2.3 - 2.7 Above Average
1.8 - 2.2 Average
1.3 - 1.7 Below Average
1.0 - 1.2 Passing
F — Failure

The Effects Of Administering A Pre-Algebra Course to Mathematically Under-Prepared First Year Students

Three semesters after the implementation of the pre-algebra course to first year students, an analysis based on the percentages of failure in a regular College Algebra course was made. All grading sheets in College Algebra course from SY 2001-2002 to SY 2005-2006 were collected and the following figures were recorded: a) number of those who obtained failing grades, b) all those who obtained grades from 1.0 to 1.9, and c) the total number of students enrolled in College Algebra. Likewise, data of similar nature were also obtained from grading sheets for SY 2006-2007 to first semester of SY 2007-2008.

From these figures the z-values and their corresponding p-values of the significant difference between two proportions were computed on the following percentages: i) percentages of failures between the two sets of data, ii) percentages of those who obtained grades from 1.0 to 1.9, and iii) combined percentages of these two. The formula for the z-score is

$$z = \frac{\hat{p}_1 - \hat{p}_2}{\sqrt{\hat{p}\hat{q}[(1/n_1)+(1/n_2)}}$$

where $\hat{p} = \frac{x_1 + x_2}{n_1 + n_2}$, $\hat{q} = 1 - \hat{p}$, $\hat{p}_1 = \frac{x_1}{n_1}$, $\hat{p}_2 = \frac{x_2}{n_2}$,

$x_1$= Number of F grades; Number of grades below average; Both numbers combined; From SY 2001-2002 to SY 2005-2006;

$x_2$= Number of F grades; Number of grades below average; Both numbers combined; From SY 2006-2007 to First semester of SY 2007-2008;

$n_1$ = Number of students who took College Algebra from SY 2001-2002 to SY 2005-2006;

$n_2$ = Number of students who took College Algebra from SY 2006-2007 to First Semester of SY 2007-2008;

In computing for z-values and p-values (Table 3), note that a p-value is the smallest level of significance for which the null hypothesis of equality of proportions can be rejected. The alternative hypothesis is that the proportion computed for SY 2001-2002 to SY 2005-2006 is greater than the corresponding proportion for SY 2006-2007 to First Semester of SY 2007-2008. At 0.05 level of significance, this sets a minimum z-value of 1.645 for the null hypothesis to be rejected.

Table 3.
Computation of the z-values and pvalues for Grades F, Below Average,and Combination of Both.

| Grade Category | $n_1$ | $n_2$ | $\hat{p}_1$ | $\hat{p}_2$ | $\hat{p}$ | $\hat{q}$ | z –value | P –value |
|---|---|---|---|---|---|---|---|---|
| F Grades | 6568 | 2292 | 0.1098 | 0.0720 | 0.100 | 0.900 | 5.20 | 0.0000 |
| Below Average | 6568 | 2292 | 0.2580 | 0.2247 | 0.249 | 0.751 | 3.17 | 0.0009 |
| Combined F and Below Average | 6568 | 2292 | 0.3677 | 0.2967 | 0.349 | 0.651 | 6.23 | 0.0000 |

Table 4.
Comparison of Percentages Between Two Groups in Terms of Failures, Below Average Grades, and Combination of Both.

| School Years | F Grade (Failure) | Percentage | Below Average | Percentage | F Grade and Below Average | Percentage |
|---|---|---|---|---|---|---|
| SY 2001–2002 to SY 2005–2006 (N = 6, 568) | 721 | 10.98% | 1, 694 | 25.80% | 2, 415 | 36.77% |
| SY 2006–2007 to First Sem of SY2007–2008 (N = 2, 292) | 165 | 7.20% | 515 | 22.47% | 680 | 29.67% |
| z–value | | 5.20 | | 3.17 | | 6.23 |
| p–value | | 0.0000 | | 0.0009 | | 0.0000 |

A p-value of 0.0000 means that there is a significant decrease in the proportion of those who obtained grades of 1.9 and below until F. Since 0.0000 is below the 0.01 level of significance, this result is highly significant. This is also true for the decrease in the number of F grades as well as Below Average grades. The results indicate that the program significantly and dramatically reduced the number of failures and below average grades. Hence, based on the objectives of the program, one could conclude that the pre-algebra course was indeed a success.

The final bar graph (Figure 7) is the graphical representation of the decreases in percentages in the grades categories.

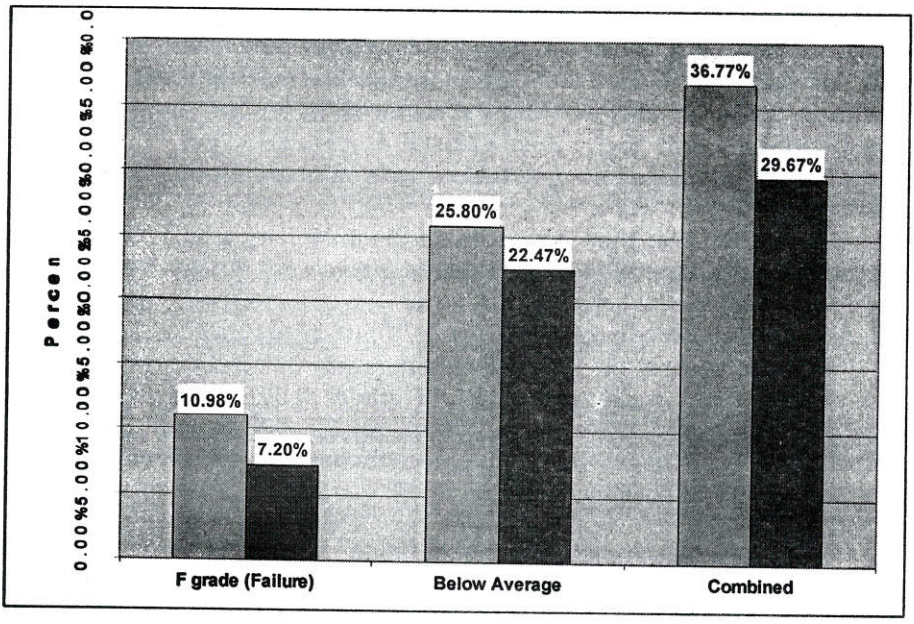


Figure 7. Comparison of Percentages of Failures and Below Average Grades Before and After Implementation of the Bridge program

## Conclusions and Recommendations

One reality in our educational system is that a sizable number of our high school graduates are not prepared for college and a good portion of this are under-prepared to take regular courses in college mathematics. In Silliman University, a program was set up to cater the mathematical needs of these students, dubbed as Math 1, a non-credit 3-unit course with description *Pre-Algebra Course.*

To identify the group of students who need to take this course, data were retrieved from students who took the regular College Algebra course for the last five years. The study includes the following variables: 1) High School General Average (HSG), 2) High School Mathematics Grade (HSM), 3) Silliman University Admission and Placement Examination (SUAPE) Score, 4) SUAPE Math component score (SM), and 5) College Algebra Grade. A regression analysis revealed that a grade in College Algebra (CAG) is strongly correlated with 1) High School General Average (HSG), and 2) SUAPE Math Score (SM).

The linear regression model with Durbin-Watson d statistic of 2.16 showed that

$$CAG = 0.076HSG + 0.073SM - 6.23.$$

With this equation, a desired College Algebra grade can be set to a certain value, and one can compute for the possible values of the other two variables that will come up with the pre-set grade. Hence, if one sets the College Algebra to a grade between 1.0 and 2.0, one can set the SUAPE Math Score (SM) to 25 and the student with High School General Average (HSG) of 75 to 84 has a good chance of getting a College Algebra grade of 1.4 to 2.0, using the equation above.

A flowchart was then drawn to aid the university admission office to identify students who need to take the pre-algebra course. After three semesters of implementation, the percentage of those who obtained below average and failure has significantly decreased from 36.77% to 29.67%. Using the z-test on the difference of two proportions, this decrease has a p-value of 0.0000. Likewise, the difference in percentages of F-grades (failures) has lowered from 10.98% to 7.20%. This decrease has a p-value of 0.0000 as well. Finally, the difference in percentages with those who obtained below average (grades between 1.0 and 1.9) has lowered from 25.08% to 24.47%. This decrease has a p-value of 0.0009.

Hence, the objective of decreasing the number of failures in College Algebra and insuring success in college is, in a way, achieved by offering the pre-algebra course.

It is recommended that schools who wish to set up a bridge program for their incoming first year students adopt this method or a variation of this method according to the nature of their admission policy. One drawback in offering a non-credit course is that it entails extra expense for the parents and extra time for the students in college. Thus, if a school does not intend to put up a bridge program for their regular mathematics courses, it is suggested that they group students according to their mathematical abilities. This will lighten the teacher's task of managing the classroom and diversifying one's approach to maximize effectiveness in transmitting mathematical knowledge to students.

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