Better Preparing Students for Basic Measurements Courses

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Abstract

This paper will examine the difference in performance between two groups of students enrolled in the junior-level Mechanical Engineering course Basic Measurements (MEEN 382). This course covers measurement theory and application in a lecture and laboratory format. The primary difference between these two student groups is their curriculum background, due to a change in the Mechanical Engineering curriculum at Louisiana Tech University. As a result of the transition from the old engineering curriculum to the new curriculum, there is a unique collection of students proceeding through our Mechanical Engineering program, particularly the current junior class: some of these students have been through a traditional engineering curriculum, while others have been through the integrated freshman and sophomore curriculum. Some details of this new curriculum will be offered in this paper; further information can be found in Nelson and Napper. [1] These performance data will be used to investigate the effectiveness of the new curriculum in preparing students for the material presented in the Basic Measurements course.

I. Background of the Freshman Integrated Curriculum

About four years ago, the College of Engineering and Science at Louisiana Tech University began developing an innovative freshman engineering curriculum. The cornerstone of this new curriculum is the creation of Engineering Problem Solving courses and the integration of these new courses with Engineering Mathematics courses and Science courses. The purpose of the integration is to provide experience with the engineering use of the skills being learned in math and science. The typical freshman year consists of three academic quarters. During each of these three quarters, an Engineering Mathematics course (three semester credit hours or SCH) is taught along with an Engineering Problem Solving course (two SCH). Two Chemistry courses and a Physics course are also required during this three-quarter academic period.

This freshman engineering curriculum began in the Fall quarter of 1997 with a pilot group of 40 self-selected students, who experienced the integration of the math, science, and engineering problem solving courses. The content and presentation of the math and science courses were examined as part of the creation of the engineering problem solving courses. The integration is provided through extensive links between the math and science principles, and the use of these principles in solving engineering problems. The following academic year, the curriculum was refined based on the pilot group's experiences and feedback, and the program was expanded to include 120 freshmen. Also, the pilot freshman integrated group became the pilot group for the integrated sophomore curriculum.

In the Fall quarter of 1999, all incoming freshmen engineering majors were required to participate in the new freshman curriculum, while the previous freshman curricula for the individual engineering programs were eliminated. Nelson and Napper [1] provide more details on the experiences with this freshman integrated curriculum.

II. The Mechanical Engineering Basic Measurements Course

The basic measurements course (MEEN 382 -- Basic Measurements) is a two semester credit hour (SCH) course combining lecture and laboratory activities. Topics covered in the lecture portion include static and dynamic signal characteristics, dynamic system behavior, uncertainty and error propagation, statistics, and sampling. The laboratory activities are designed to complement the lecture topics, and include such activities as static calibration, system response to a step input, uncertainty calculations, statistical analysis, and sampling of a dynamic signal. This course is part of the Mechanical Engineering degree program requirements, and is offered once a year in the fall quarter.

III. Student Performance in the Basic Measurements course

The performance in the Fall 2001 offering of MEEN 382 is particularly interesting because the student population consists of a mix of students with and without the freshman integrated curriculum background. Those mechanical engineering students who were beginning freshmen in the Fall quarter of 1999 will typically be enrolled in the basic measurements course in the Fall quarter of 2001. This is the first group of students under the mandatory integrated freshman and sophomore curriculum. This offers the opportunity to examine the differences in performance between two groups of students with the most obvious difference between the groups being their academic curriculum background: whether or not they participated in the freshman integrated curriculum.

In the Fall quarter of 2001, 57 students completed the basic measurements course. Of these 57 students, 21 had experienced the freshman integrated curriculum, while 36 had not. In this paper, the performance of these groups of students is examined, and comparisons are made between those who experienced the freshman integrated curriculum and those who did not.

Several performance characteristics, such as course average, average grade earned in the basic measurements course, average overall student grade point average (GPA), and curriculum background, have been examined. It should be noted here that the curriculum background of the students was not examined until after the final grades had been submitted. This removes any implicit bias by the instructor. Also of note is that the students received the same instruction, regardless of curriculum background. The course was offered as a single lecture section, with 3 laboratory sections, consisting of identical laboratory activities. The author was the sole faculty member responsible for the lecture and all laboratory sections.

Figure 1 shows the distribution of student performance measured by course average for the integrated and non-integrated student groups. In Figure 1, the histogram of the course averages of all the students is presented separated into integrated and non-integrated groups. The bin size is 5%, with the abscissa bin label representing the lower end of the range. For example, there is one non-integrated score between 55% and 60%. Although a complete statistical analysis has not been performed, both groups appear to follow a normal distribution. It also seems that the two groups should have different means, as indicated by the histogram. In fact, the means are 76.5% for the non-integrated group and 79% for the integrated group, a difference of 2.5%.

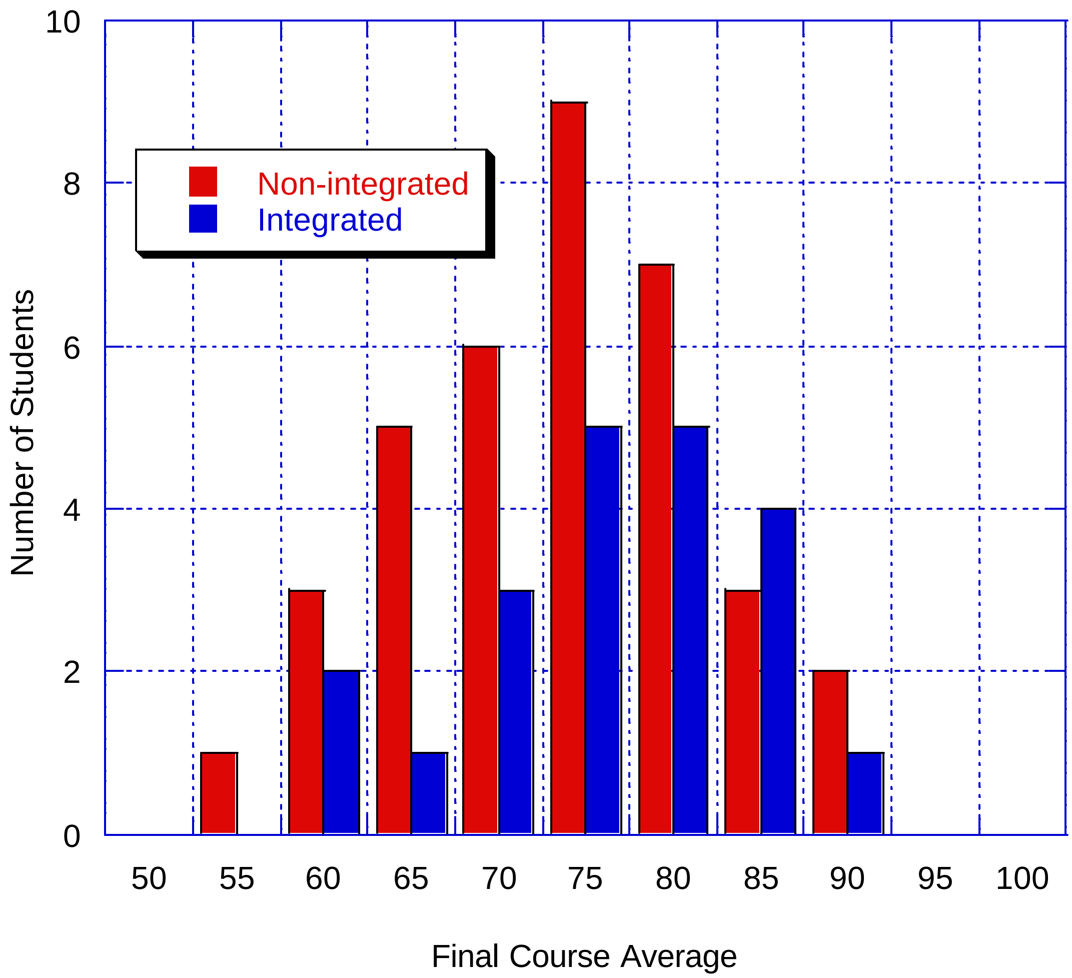

Figure 1. Histogram of course average by student curriculum background.

Table 1 shows selected performance characteristics of students in the Fall, 2001 Basic Measurements course. The average GPA and the course grade are presented, for all students in the course, as well as grouped by the student's curriculum background. These data show that all students typically scored below their average GPA. The difference between the GPA and the course grade is approximately the same for both groups, 0.48 for the integrated background group and 0.53 for the non-integrated group. This information also shows that the students with the freshman integrated curriculum background scored higher in the basic measurements course than those students without the integrated curriculum background. Specifically, the students with the integrated background achieved an average course grade 0.23 higher than the non-integrated group. Similarly, the average overall GPA of the integrated group is higher than that for the students with a traditional curriculum background by 0.18.

Table 1. General performance characteristics of Basic Measurements students, Fall, 2001.

Group	Average Overall GPA	Average MEEN 382 Grade	Number of Students in Group
All Students	3.13	2.61	57
Integrated Background	3.24	2.76	21
Non-integrated Background	3.06	2.53	36

It is interesting to compare these results with those of Jordan and Pumphrey [2], who gathered data in a sophomore level materials course to compare the performance of students from the freshman integrated curriculum to those without the integrated curriculum background. The materials course is a required course for all of the engineering programs in the College of Engineering and Science, while the Basic Measurements course is required only for Mechanical Engineering majors. Typically the materials course is taken in the sophomore year, while the measurements course is taken in the junior year. Some of their data are shown in Table 2 for comparison with the data from the present study.

Table 2. General performance characteristics of basic materials students, Fall, 2000. [2]

Group	Average Overall GPA	Average MEMT 201 Grade	Number of Students in Group
Integrated Background	3.30	3.00	38
Non-integrated Background	2.89	2.43	37

In the Fall 2000 offering of the materials course, they found that the average course grade was 3.00 for those with the integrated background, and 2.43 for those with the non-integrated background. Their data show a larger difference between the integrated and non-integrated student performances than does the present study. This difference is also larger when comparing the average overall GPA, 3.30 for integrated and 2.89 for non-integrated students. However, the difference between the average course grade and the average overall GPA for the integrated students is 0.3, versus 0.46 for the non-integrated students. It is important to note that Jordan and Pumphrey's data are for students of all engineering programs, while the present study is for Mechanical Engineering majors only. Many of the Mechanical Engineering students in this study should be present in Jordan and Pumphrey's Fall 2000 data.

IV. Conclusions

In the comparisons made in this study, the performance of the integrated students is measurably better than the non-integrated students. At present, no detailed statistical analysis of the data has been performed. Nevertheless, the freshman integrated curriculum background seems to have a positive effect on the student's grade in the basic measurements course.

The data from the present study seem to suggest that the freshman integrated curriculum provides students with a better understanding of the engineering and science fundamentals, as evidenced by the higher GPA. This is also evident in the higher average course grade for the integrated students. However, by comparison with a sophomore-level course, the difference between the performance of integrated and non-integrated students is greater at the sophomore level than at the junior level.

In examining the data presented here, there are some questions that should be addressed.

1. Is the integration of the math, science, and engineering courses responsible for the better performance of the integrated students? The basic measurements course contains several topics that are mathematical in nature, particularly the statistical analysis and uncertainty analysis components. Statistics is one of the topical areas emphasized throughout the freshman and sophomore integrated curricula. The evidence here supports the conclusion that topics such as this from the math portion of the curriculum have been reinforced by the integration of the math and engineering problem solving courses.

2. Is the performance gap between the integrated and non-integrated students actually closing, and if so, why? More information would be required to adequately answer this question. However, it is possible that the experiences of the non-integrated students in the integrated *sophomore* curriculum could produce many of the skills likely to improve student performance. One of the skills believed responsible for the improved performance of the integrated students is the peer-level interaction. For example, the collaboration on homework projects and other assignments is believed to lead to the development of critical thinking skills and a better understanding of the concepts as the students share ideas and information in working these projects together. This teamwork is a required part of the freshman integrated curriculum. It has also been adopted to a certain extent in many of the sophomore engineering courses. So it is likely that by the junior year, those non-integrated students have begun to acquire this particular skill introduced to them in their sophomore year and are using it to their benefit.

3. Are there other factors, such as the maturity of the junior students, or the interest level in the course material, which are responsible for the closing performance gap? It is also possible that there are factors other than the experience the integrated curriculum provides responsible for the closing performance gap. However, factors such as maturity and interest level in the material are factors that are typically more difficult to measure.

There is a need for a more complete analysis of the data available in order to properly address the possible causes of student performance differences found in this study. This would include a statistical analysis of the data obtained in the present study, as well as the data obtained by Jordan and Pumphrey. Subjective data could be obtained that might indicate the presence of factors other than the changes in the curriculum. It does appear that the freshman integrated curriculum better prepares Mechanical Engineering students for their course in Basic Measurements. However, the performance difference between the two student groups seems to be decreasing as the students progresses through the Mechanical Engineering curriculum.

V. Bibliography

1. Nelson, James and Stan Napper, Ramping Up to an Integrated Curriculum to Full Implementation, Proceedings of the Frontiers in Education Conference, San Juan, Puerto Rico, November, 1999.

2. Jordan, William and Norm Pumphrey, Better Preparing Students for Materials Classes, Proceedings of the 2001 ASEE Annual Conference, Albuquerque, June, 2001.

VI. Biographical Information

MARK BARKER is an Assistant Professor of Mechanical Engineering at Louisiana Tech University. He has a B.S. in Mechanical Engineering from Louisiana Tech University. His M.S. and Ph. D. degrees, also in Mechanical Engineering, are from Clemson University. He teaches courses in the thermal fluid sciences and experimental measurements areas, as well as the freshman integrated program.