Comparison of Math Skills to Final Course Grade in a
Math Intensive Dynamic Systems Course

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Abstract

Engineering students utilize basic math skills in all engineering courses, some courses more than others. Dynamic Systems I (MECH 330) students must apply knowledge from trigonometry, calculus, differential equations, and linear algebra to develop mathematical equations which define a dynamic system (electrical, mechanical, and/or fluid). The defining differential equations are then solved. System characteristics are extracted from the mathematical equations and can be analyzed to understand and control the system's behavior. Since MECH330 is mathematically intensive, a math review (covering the subjects specific for the course) is given on the first and/or second course meeting. Subsequently, a math skills test is given on the third course meeting. Over several semesters, scores on the math skills test were correlated to the student's final course grade. With nearly 200 students studied, the data indicates that students who do well on the math skills test do not necessarily do well in the course. But, students who do well in the course, do well on the math skills test.

Introduction

In a recent curriculum change at Kettering University, three (3) courses, Mechanical Vibrations, Systems, and Controls were combined into two courses, Dynamic Systems I and Dynamic Systems II with Lab[1]. With a decrease of lecture contact hours with the students, from ten hours to eight, the material from the original three courses were evaluated for redundancies and syllabus subjects were reduced. Dynamic Systems I within the new curriculum, focuses on mathematical modeling of uni- and multi- discipline systems involving electrical, fluid, and mechanical (linear and angular motion) systems. The subsequent mathematical models (differential equations) are evaluated in the time domain. Since multidiscipline systems are analyzed, Dynamic Systems I has several prerequisites and corequisites namely Mechanical Dynamics, Circuits, Fluids, and Differential Equations. A prerequisite course of Numerical Methods is being added in 2003.

With many higher math concepts used in the system modeling process, it was deemed necessary to evaluate the students mathematical skills with some sort of pretest or posttest (in a previous course). Since Dynamic Systems I was first in the systems course thread, a pretest was chosen. The students are given a written and two to three hour lecture review of the higher math concepts focused on in the course, mainly matrix math, solutions of 1st and 2nd order linear differential

equations with constant coefficients, and Laplace transforms solution methods for differential equations.

Results

During five terms in 2001 and 2002, the math pretest was utilized. The test consisted of seven to ten questions focusing on the mathematical concepts necessary for the subjects covered in Dynamic Systems I. The test questions were changed each term so students could not review and memorize previous tests. The concepts of the questions covered were kept consistent. The students were not allowed any type of equation sheet or calculator during the test except a list of Laplace transform pairs which was supplied by the instructor. The tests were written and graded by one instructor to assure similar grading practices. The subsequent grades on the math pretest were recorded as a percentage. This pretest does count as 5% of the students overall grade so the students do have an incentive to study and do well.

At the end of the semester, the students overall final grade is recorded. Kettering University uses a point scale ranging from 100 to 70. A failing grade is 65. The 100 to 70 range is associated with the A through E scale as follows:

Kettering Scale	Letter Grade	Common Scale
100 - 92	A	100 - 90
91 - 85	B	89 - 80
84 - 77	C	79 - 70
76 - 70	D	69 - 60
65	E	$\leq$59

The Kettering scale is easily converted to the Common Scale by using linear interpolation.

With 199 students sampled, their final course grade, using the common scale, was analyzed with the grade the student received on the math pretest (Figure 1). The final course grade was adjusted so that the 5% weight of the math pretest itself was not included in the grade. All 199 students were from the Dynamic Systems I course, taught by the same instructor, covering the same material during the semester.

As seen in Figure 1, there is considerable scatter in the data but there are some trends that are depicted. The students who receive an "A" in the course (100 - 90 range) scored overwhelmingly over 80% on the math pretest. Only three of the 46 students (6.5%) who received an "A" in the course scored below 80% (67%, 53%, and 40%). The average and mean on the math pretest for the "A" students were in the "A" range as well, 90% and 91% respectively. On the other hand, the students who earned a "D" in the course (69 - 60 range) score low on the math pretest with an average and mean below 60%, 57% and 58% respectively. It is clear, to do well in the course, on average, the student must have strong math skills.
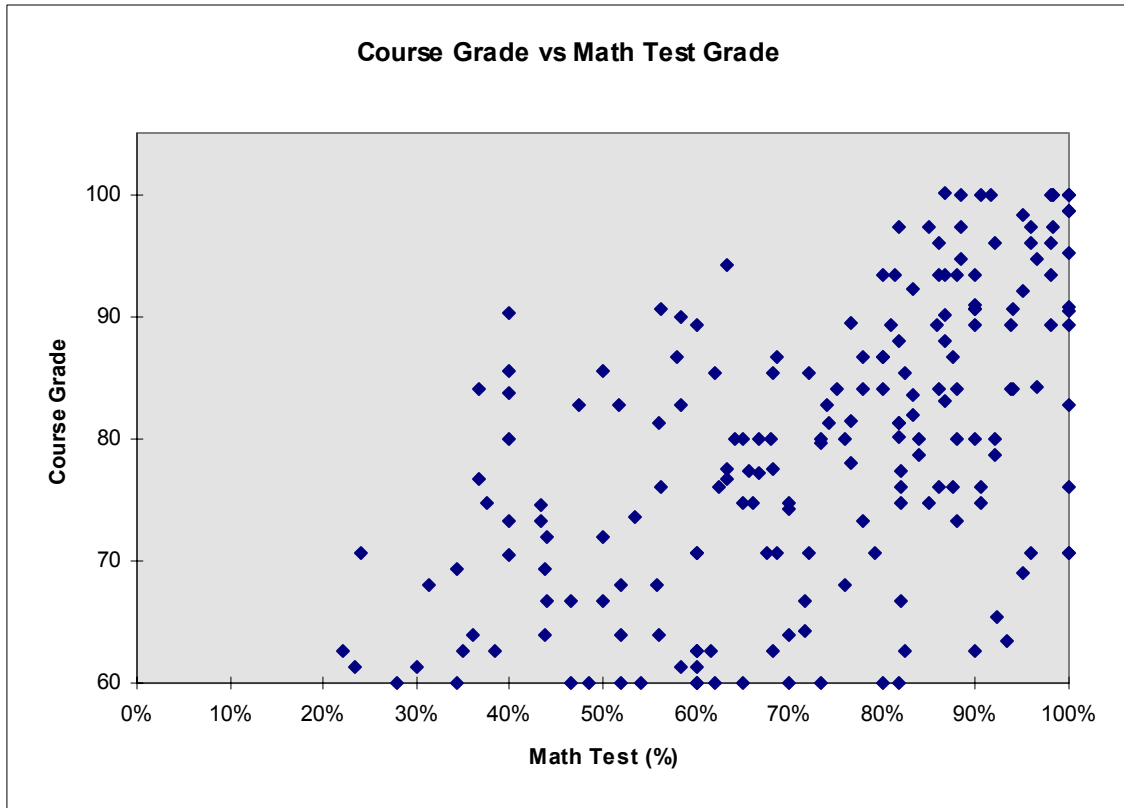
Course Grade vs Math Test Grade

Figure 1: Comparison of final course grade to math pretest grade for Dynamic Systems I course

There were five students who completed the course assignments including the final exam but failed the course. The data for these students is not represented in Figure 1. The five students that did fail the course did not do well on the math pretest with scores of 68%, 55%, 38%, 83%, and 31%. Again indicating that strong math skills are needed to succeed in the course.

The students that score over 90% on the math pretest end up with final course grades from 100 to 62, with the majority earning a grade over 75. One possible reason that some students did well on the math skills but did not do well in the course could be their knowledge (or lack of) within the other prerequisite courses namely Dynamics, Circuits, and Fluids.

Conclusions

Clearly, spending time on math review is time well spent. A student must have strong math skills to earn a high course grade in a math intensive engineering course such as Dynamic Systems I. But, strong math skills alone do not guarantee an "A". On the other hand, weak math skills do contribute to a lower grade in the course. Further programs should be included in Dynamic Systems I to enhance the math skills of the students. Since lecture time is limited within Dynamics Systems I and three hours are already being devoted to math review, other methods of math skills enhancement should be implemented such as web based learning. Self-learning, computer based modules could be completed by the students prior to the first day of class and the math review lectures would bolster the much needed skills for the course.

Further analyses can be done to correlate the student final course grade to the grade that students received in the engineering based prerequisite classes (Dynamics, Circuits, and Fluids) to determine if their knowledge of these subjects contribute to a lower course grade even if their math skills are strong. A review and pretest in these subjects could also be administered but time constraints within the Dynamic Systems I class limit this option. Web based learning may also be a useful tool.

References

1.   Chandran, R. and Brelin-Fornari, J. "The New Dynamic Systems Sequence at Kettering University" Proceedings of the 2002 American Society for Engineering Education Annual Conference & Exposition. June, 2002.

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