Student Grade Prediction Based Upon Prerequisite Lab or Topic Course Performance

Alize J. Trinquet, John K. Schueller, Bruce F. Carroll, John D. Abbitt
University of Florida, Mechanical and Aerospace Engineering, Gainesville, FL 32611-6300

Abstract

Undergraduate students in mechanical engineering and aerospace engineering at the University of Florida are required to take laboratory courses that apply what they have learned in previous theory courses. Some students perform well and some not-so-well. A database of 2580 students over the last ten years was analyzed. It was found that poor performance in a junior-level laboratory course was more strongly correlated with poor performance in an earlier laboratory course than in the theory course that supported the junior-level course. Other observations on grade inflation and the student performances in three courses in the database are also made.

Keywords

grades, prediction, laboratory, mechanics of materials

Introduction

A significant number of undergraduate engineering students do not move to degree completion in a timely manner. Early identification of such students who will likely have problems in later courses would allow remediative and corrective actions to be taken to encourage success in the later courses.

Colleges of engineering are concerned for their students and try to improve curricula and provide the best advice. Although engineering faculty and advisors are bright and committed, their actions will be based upon their perceptions, which may be unduly influenced by the particulars of extreme or recent cases. Databases and data analysis tools provide an opportunity to develop better and more reliable understandings of the true situations in their educational programs.

This paper investigates whether poor performances in a junior-level laboratory course correlates more with the performances in a previous laboratory course or with the performances in the theory course which provides the subject matter background for the junior-level laboratory course. Data was acquired from the database of grades maintained by the Registrar to support this investigation.

Example Course: Mechanics of Materials Laboratory

The Department of Mechanical and Aerospace Engineering has more students than any other department at the University of Florida. All undergraduate students majoring in mechanical engineering or aerospace engineering are required to take the three courses studied here.

Students who had different majors or who did not complete all three courses in the last ten years were removed from the analyses.

There still were 2580 students in the analyzed data, allowing us to be reasonably confident that the analysis is reliable with respect to sample size. Since the students were admitted through a very competitive process to a leading university in a populous state, the pre-university performance of the students would seem to indicate that they likely have the ability to be successful with proper effort. Although the instructors are always trying to improve the courses, no major changes were made during the study period. And the instructors assigned to the courses were very constant during the period. For example, the laboratory portions had the same instructors for all thirty semesters analyzed.

EML 3301C (Mechanics of Materials Laboratory, hereafter MoMLAB) is a three-credit course comprised of one-period lectures on Tuesday and Thursday to review the mechanics of materials theory and provide instructions for the laboratory and a two-hour laboratory experience. The conduct and analysis of the laboratory experiments and the resulting laboratory reports are the most important part of this course. It is usually taken by third-year students.

EGM 3520 (Mechanics of Materials, hereafter MoM) is a three-credit lecture class which covers the traditional mechanics of materials subjects. This is a firm prerequisite for MoMLAB and is usually taken by students in their second year.

EML2023L (Design and Manufacturing Laboratory, hereafter DML) is a two-credit course with one period of lecture and a two-period laboratory section. It is very "hands-on" course with students designing and building a device, as well as operating manufacturing machines.

Grade Inflation and Resolution

The University of Florida is not exempt from the rampart grade inflation that has permeated the United States' educational system. Yilmaz, et al., [1] documented the rise in engineering average grades at the University of Florida compared to Middle East Technical University in Turkey, as shown in Figure 1.

Figure 2 shows the grade distributions from Fall 2016 at the University of Florida. It is obvious that grade inflation has continued, almost to the point that "A" means "average" and "B" means "bad". It is also obvious that, contrary to widespread opinion, grades in engineering are not lower than in other areas of study.

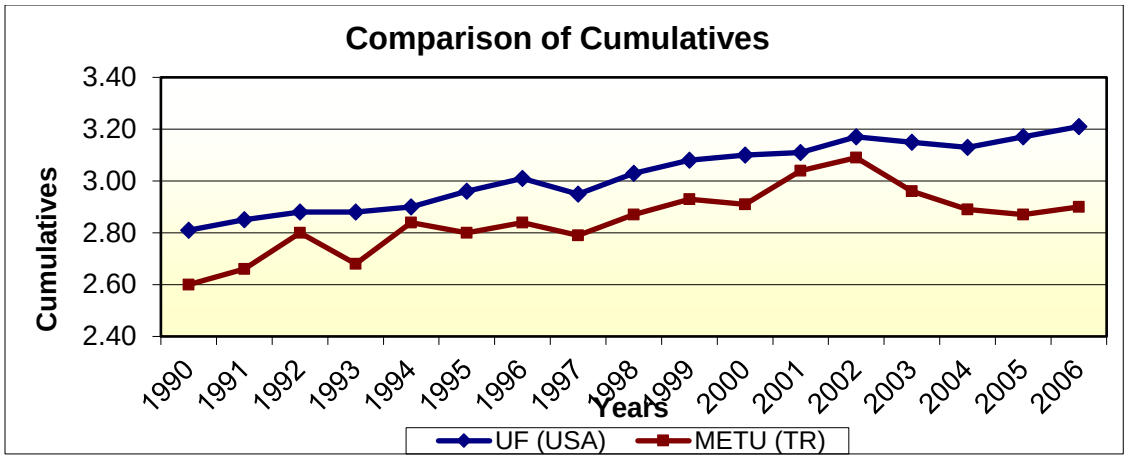

Figure 1: Average cumulative engineering grade point averages at the University of Florida and Middle East Technical University (from Yilmaz, et al., [1])

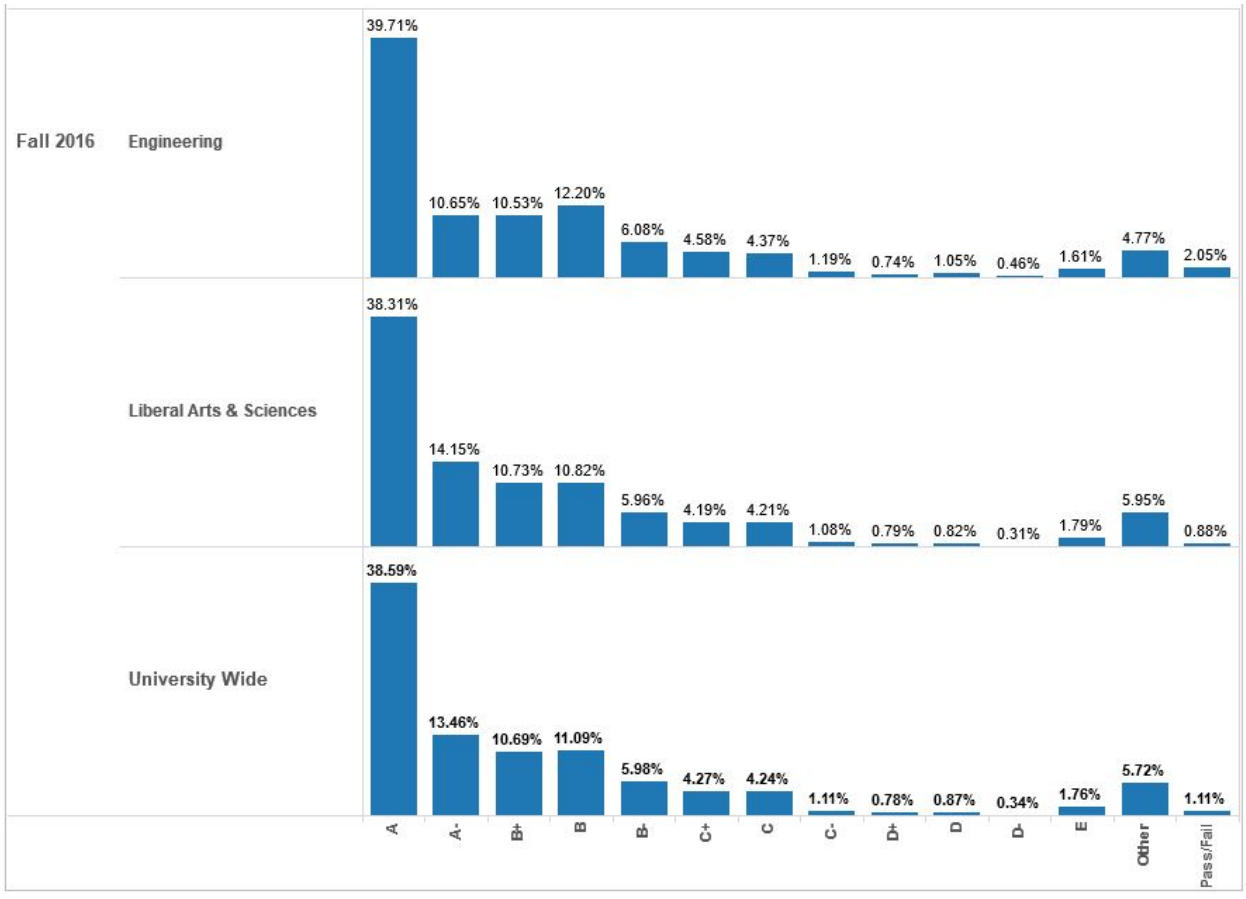

Figure 2: Fall 2016 grade distributions at the University of Florida

These high grades make it difficult to differentiate between students. It is hard to identify the top students or draw conclusions when about half the students have A's or A-'s. Figures 3 and 4 provide the matrices of the 2580 students included in this study. The columns represent the

grades received in DML or MoM and the rows represent the grades received in MoMLAB. Only the grades earned on the first attempt of the course are included in the tables. The combined percentages of A's and A-'s are 70%, 32%, and 28% for DML, MoM, and MoMLAB respectively. Seven percent earned an "A" in all three courses. The high percentage for DML is not unexpected as that is an effort and mastery course in which almost any student should have the capability to get any grade with sufficient effort.

DML MOMLAB	A	A-	B+	B	B-	C+	C	C-	D+	D	D-	W/E	total MOMLAB
A	313	0	12	17	0	5	4	0	3	2	1	7	364
A-	284	0	20	22	0	5	7	1	2	3	0	10	354
B+	305	0	26	27	2	8	11	1	2	4	3	7	396
B	412	0	39	42	3	19	16	0	4	9	2	18	564
B-	155	0	26	31	0	8	11	0	5	9	1	6	252
C+	93	0	17	18	2	2	7	2	3	7	1	7	159
C	103	1	12	16	1	10	14	0	1	2	3	11	174
C-	27	0	3	8	0	3	5	0	1	7	1	9	64
D+	15	0	3	5	0	2	3	0	3	2	1	1	35
D	17	0	5	5	1	4	0	0	0	2	0	3	37
D-	7	0	1	2	0	0	2	0	1	4	0	1	18
W/E	83	1	10	10	0	6	14	0	1	7	2	29	163
total DML	1814	2	174	203	9	72	94	4	26	58	15	109	

Figure 3: MoMLAB Grades (rows) Compared to Grades in DML (columns)

MOM MOMLAB	A	A-	B+	B	B-	C+	C	C-	D+	D	D-	W/E	total MOMLAB
A	207	32	47	45	7	11	8	0	0	1	0	6	364
A-	115	48	60	72	14	14	15	2	0	6	0	8	354
B+	115	39	46	98	32	19	29	1	0	3	0	14	396
B	103	62	99	151	38	37	47	6	3	6	0	12	564
B-	31	10	42	67	26	25	28	2	2	2	0	17	252
C+	9	14	16	41	22	17	25	6	0	1	2	6	159
C	7	12	15	57	15	24	12	5	6	6	1	14	174
C-	1	5	3	20	5	12	10	1	2	1	0	4	64
D+	1	0	1	4	7	7	11	1	0	1	0	2	35
D	0	1	3	5	3	7	10	0	1	1	0	6	37
D-	1	0	0	1	4	5	3	1	2	0	0	1	18
W/E	11	8	15	32	18	17	28	4	4	6	2	18	163
Total MOM	601	231	347	593	191	195	226	29	20	34	5	108	

Figure 4: MoMLAB Grades (rows) Compared to Grades in MoM (columns)

Poor Performances of Students

Legislators, administrators, parents, and the students themselves all seem to be increasing concerned with the time-to-completion. Unsuccessful completions, whether a failure or a withdrawal, extend the student's time in the university and may impact subsequent courses in the convoluted and extensive prerequisite network of the B.S.A.E. and B.S.M.E. degree programs. For the analysis here, failures (E's) and withdrawals (W's) were lumped together. That is somewhat problematic because W's are not only due to poor performance, but may also be due to medical problems, family commitments, etc. But there is no way to differentiate the causes of the W's.

Coincidentally, almost the same number of students earned an E or W in both the prerequisite courses, 109 in DML and 108 in MoM. But there was a real difference in the poor performances of those students in MoMLAB. For the 109 students who got an E or W in DML, 29 earned an E or W in MoMLAB and had a 1.98 GPA in MoMLAB. However, for the 108 students who got an E or W in MoM, only 18 earned an E or W in MoMLAB and they had a 2.22 GPA in MoMLAB. Therefore, it is more likely that a student will do more poorly in MoMLAB if they have a failing DML grade than a failing MoM grade.

Although not a failure, grades in the D range (D+, D, and D-) are indications of poor performance. The number of grades among the 2580 students in the D range were 89, 59, and 90 for DML, MoM, and MoMLAB respectively. About 25% of the students who earned a D range grade in each of the two prerequisite courses also earned a D in MoMLAB

Other Findings

Large databases such as the ten-year database of grades can be interrogated in an almost-infinite number of ways. The database used here will be further studied to see if similar results are obtained for other course combinations. Other types of studies can also be done.

One thing found by such a study was that the grade averages of the three courses were stable over almost thirty semesters, as Figure 5 shows below. Of course, this is likely partly a result of a stable curriculum and stable instructors. Other courses tend not to have the same stability, even within one semester if there are different instructors for different sections.

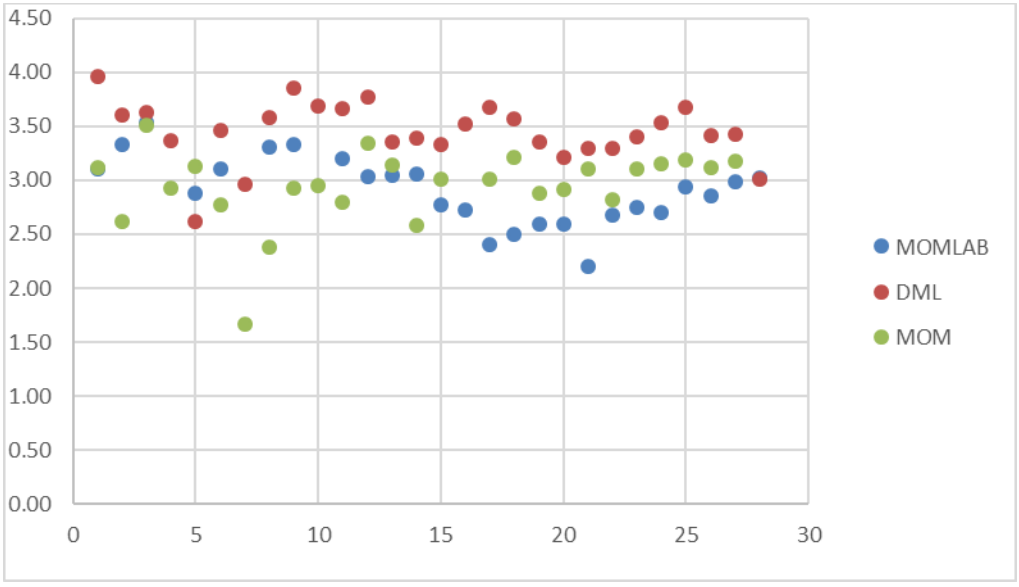

Figure 5: Class GPA of the Three Courses Studied by Semester

Another finding was that the number of students with A's in the lab classes was slightly higher in the Summer than in the Fall and Spring semesters even though there are less weeks to complete the course. For example, the Fall/Spring/Summer percentage of A's for DML was 67/71/72 and

for MoMLAB was 15/13/16. It might be hypothesized that students do not need to be "full-time" during the Summer and may take lighter loads, thereby allowing them to devote more time to the laboratory courses, resulting in more A's.

This paper assumed that both DML and MoM are prerequisites to MoMLAB. But DML is not a required prerequisite. It is just much earlier in the suggested schedule. So we computed the GPA in MoMLAB based upon when DML was taken in comparison. Of the 2580 students, 2107 did complete DML before MoMLAB and received a 2.88 average in MoMLAB. If they were one of the 156 students who took both courses the same semester, they received a 2.75. If they did the opposite of recommended and took DML after MoMLAB, they earned a 2.72 GPA. The results at first seem to indicate that the students should follow the recommended course completion order, but we are hesitant to state that firmly. There may be other confounding factors, such as the students who take courses out of order may not follow the schedule due to job, family, personality, or other issues which might result in a lower course GPA even if they followed the recommended schedule.

Conclusion

Although the subject matter theory courses are an obvious perquisite for laboratory courses, it should be recognized that performance in a previous lab course may be more strongly correlated. Attention should be paid to students who did poorly in previous laboratory courses, reasons for the poor performance be found, and measures taken to remediate the problems and insure subsequent success.

The large grades databases can be analyzed to see trends and correlations. There is a seemingly-infinite number of possibilities for analyses. Those analyses which are most needed and most reliable should be made. However, care must be taken in making interpretations and drawing conclusions. Grades are not totally accurate measures of competence and can vary widely between instructors. There are very co-variants which affect analyses and reduce their reliability.

References

1 Yilmaz Ozturk, Isik Ekin, Sencer Yeralan, and John K. Schueller. "Grade Normalization for International Graduate Students". ASEE International Conference. Istanbul. 2007. Paper GC 2007-131.

Alize J. Trinquet

Ms. Alize J. Trinquet has completed a B.S.M.E. degree from the University of Florida. She has taken the courses studied in this paper and was a teaching assistant for the example course.

John K. Schueller

Dr. John K. Schueller is a Professor of Mechanical and Aerospace Engineering at the University of Florida and chair of the Mechanical Engineering Program Committee.

John D. Abbitt

Dr. John Abbitt is a Senior Lecturer in Mechanical and Aerospace Engineering at the University of Florida and a member of the Aerospace Engineering Program Committee.

Bruce F. Carroll

Dr. Bruce Carroll is an Associate Professor and the Undergraduate Coordinator in Mechanical and Aerospace Engineering at the University of Florida.