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Considering the Revision of Entrance to Major Requirements in a Mechanical Engineering Technology Program to Include Introductory Engineering Graphics Courses (WIP)

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Introduction

In previous research, overall success in the Mechanical Engineering Technology (MET) program at Penn State Behrend was assessed in relation to students' success in introductory engineering graphics courses and their visualization abilities as measured by the Purdue Spatial Visualization Test [1]. That work found a significant correlation between success in engineering graphics courses and success in the major. It also examined the relationships between the entrance to major (ETM) requirements of physics and calculus and student success, finding that success in the major had a significant correlation with success in physics courses and a statistically significant, but appreciably lower, correlation with calculus courses. This Work-In-Progress focuses on identifying and comparing individual course-level predictors of student success as an initial step toward a broader, multivariate analysis of entrance-to-major requirements

To be eligible for entrance to major, ETM, an MET student at Behrend must have a minimum of a 2.0 cumulative GPA, and a grade of C or higher in an introductory physics course and a calculus course, even though lower division major courses do not require either calculus or physics as a prerequisite. Although multiple courses in the MET major also require an earned grade of C or above to count for credit towards graduation, no departmental courses are currently used as ETM requirements. The engineering graphics courses do not require a C grade at this time, but a change to require that is currently proceeding through Penn State's curriculum change process. The physics course required for the MET curriculum has college algebra or trigonometry as a prerequisite. Some students at Behrend enroll in a different physics course that has a calculus prerequisite; those courses are included in this study and are primarily taken by students who have transferred from other majors, including mechanical engineering, or who have transferred from other institutions.

The initial study had 75 subjects, but because of the lower correlation between student success and performance in calculus, further study is being pursued on a larger group of students. Data has been collected on ten years of graduates of the bachelor's degree MET program at Behrend. This paper analyzes the relationship between success in engineering graphics, physics, and mathematics courses and overall success in the major to analyze whether calculus should be maintained as a major requirement, but considered for removal from the entrance to major requirements, and replaced with engineering graphics.

Research Hypotheses

While a student's assessed performance on any standardized measure of a topic or content may be different from their graded performance in a related course, the use of a minimum 2.0 GPA is part of the entrance to major requirements by the administration at Behrend, and departments cannot enroll or deny a student based on non-GPA data. Therefore, overall GPA is being analyzed along with earned grades in engineering graphics, calculus, and physics courses.

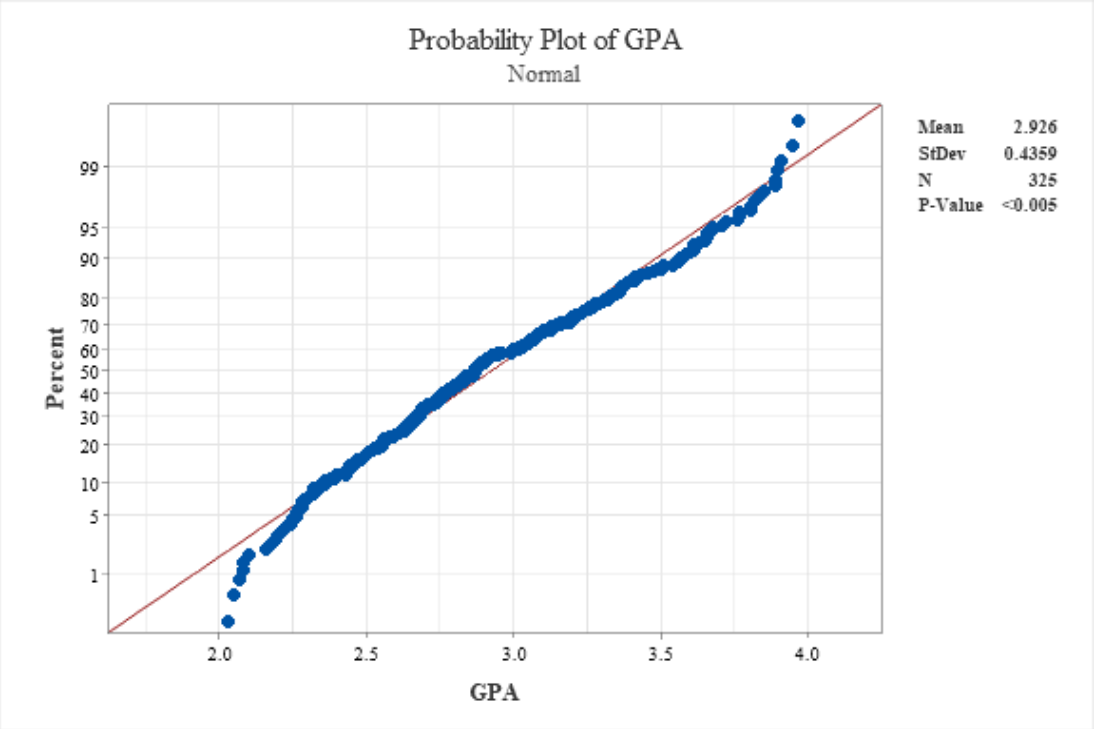
The engineering graphics (EGT) course referenced in this paper is taught by different faculty using the same course outline, topics, and similar assignments and exams. Two engineering graphics courses, EGT 120 and 121, are required for the MET major, but because the grades in the courses were highly correlated in the original study [1], a multiple regression model was run that removed EGT 120. Since the R-squared without EGT 120 was not significantly different, only the EGT 121 course grade will be used in this and future analyses. The mathematics and physics courses are taught by multiple faculty, and there are three different mathematics courses and two physics courses that meet current ETM requirements.

Only earned grades were included in the analyses; transfer credit and pass/no pass grades that were in effect during COVID-19-impacted semesters were omitted. With IRB approval, data was collected from a total of 325 graduating students over ten years at Behrend. During that time, there were minor changes in the curriculum, but the requirement of passing a calculus course and a physics course for ETM did not change. The program maintained continuous accreditation by ABET during that time.

- Hypothesis 1 – there is no significant relationship between performance in ETM required calculus courses and overall GPA
- Hypothesis 2 – there is no significant relationship between performance in ETM required physics courses and overall GPA
- Hypothesis 3 – there is no significant relationship between performance in an introductory engineering graphics course and overall GPA

Results

The demographics of the study subjects were 304 males and 21 females earning a 130 credit-hour bachelor's degree in Mechanical Engineering Technology. The median time to graduation for students who maintained full-time enrollment was 9 semesters, and the mean was 9.38 semesters. The subjects' median GPA was 2.87, and the mean was 2.93 with a standard deviation of 0.44. The GPAs were nearly normally distributed, as indicated by the probability plot.



Hypothesis 1, there was a significant relationship between performance in ETM required calculus courses and overall GPA at P 0.00, and the hypothesis was rejected.

ANOVA ETM Math Grades vs Overall GPA

Source	DF	SS	MS	F	P
Regression	1	14.85	14.85	106.88	0.00
Error	289	40.15	0.14		
Total	290	55.00			

Hypothesis 2, there was a significant relationship between performance in ETM required physics courses and overall GPA at P 0.00, and the hypothesis was rejected.

ANOVA ETM Physics Grades vs Overall GPA

Source	DF	SS	MS	F	P
Regression	1	24.16	24.16	236.79	0.00
Error	297	30.31	0.10		
Total	298	54.47			

Hypothesis 3, there was a significant relationship between performance in an introductory engineering graphics course and overall GPA at P 0.00, and the hypothesis was rejected.

ANOVA Appl Solid Model Grade vs Overall GPA

Source	DF	SS	MS	F	P
Regression	1	20.93	20.93	180.39	0.00
Error	310	35.97	0.12		
Total	311	56.90			

Discussion

There were significant relationships between the grades in the courses analyzed and the overall GPAs of subjects who had completed the MET bachelor's degree program at Behrend. That was not unexpected because students must be successful in major courses to complete the program. Since all the relationships were significant, the strength of the relationship was analyzed by calculating the R-squared values to determine the proportion of variance in GPAs that could be predicted from individual courses, revealing notable differences.

The adjusted R-squared value of Overall GPA vs ETM Math was only 26.74%, which was substantially lower than that for the ETM physics courses at 44.17% and engineering graphics at 36.58%.

Overall GPA vs ETM Math

S	R-sq	R-sq(adj)
0.37	27.00%	26.74%

Overall GPA vs ETM Physics

S	R-sq	R-sq(adj)
0.32	44.36%	44.17%

Overall GPA vs App Solid Model

S	R-sq	R-sq(adj)
0.34	36.78%	36.58%

The topics covered in EGT 121 include working drawings, ANSI standards, geometric dimensioning and tolerancing, sectioned assemblies, fasteners, weld and finish symbols, advanced layouts, and bill of materials. Work is done with hand sketching and CAD using Creo, both of which require 3D visualization. There have been multiple studies indicating a positive relationship between visualization abilities, such as those required to be successful in an engineering graphics course, and success across courses in the STEM fields [2], [3], [4].

Many of the courses in the MET major at Behrend, outside of the engineering graphics courses referenced in this study, require the use of 3D visualization skills, including an advanced CAD course, two FEA courses, a production design lab that requires the creation of technical drawings and the machining of parts, and a technical elective in rapid prototyping that incorporates surface modeling and the building of physical models for data acquisition. The significant positive relationship between the grades in engineering graphics and the overall student success in the major indicates we should look further than just math and physics for ETM requirements to assess if there are better ways to ensure that students who are accepted in the major are not only adequately prepared, but that those who may initially struggle with their mathematics are not unnecessarily excluded from attempting the major of their choice.

The findings are being discussed at the departmental level as the program considers revising its entrance to major requirements. Specifically, the program is considering optimizing its ETM requirements to more closely align them with predictors that have been demonstrated to be statistically significant indicators of student success. These findings reflect the structure and sequencing of the MET curriculum at this institution and may not directly generalize to other programs with different prerequisite models.

References

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