Confidence, Confusion, and Concerns: Perceptions of Freshmen Engineering Students

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Abstract

The Virginia Military Institute has numerically tracked the retention of incoming freshmen engineering students for years. These studies have shown that math preparedness has limited value in answering why some cadets remain in engineering and some leave. To supplement the existing data, a survey was created and given to all engineering freshmen cadets during the first two weeks of the fall 2017 semester. This paper provides the surprising results of this initial survey that had an 84% response rate and revealed confusion and misunderstanding of certain topics. Over ninety percent of the cadets felt extremely confident of their ability to succeed in their engineering courses. More than twice as many cadets were concerned with overall workload than math preparedness. Understanding these perceptions should enable the engineering departments to improve retention of engineering students by addressing concerns, misconceptions, and overconfidence.

Keywords

Perceptions, Math Preparedness, Overconfidence, Retention.

Introduction

The Virginia Military Institute's Office of Assessment and Institutional Research (OAIR) has numerically tracked incoming freshmen engineering students (called engineering cadets at VMI) for many years. For a typical four-year cadetship, over half of the students that declare engineering as their major at matriculation remain in engineering the entire four years. Slightly less than a quarter of the students transfer to non-engineering majors while the remaining students completely leave VMI.

In the past, many faculty members have felt that math preparedness was a primary indicator of success in engineering. For this study, success in engineering is defined as remaining in engineering and graduating in approximately four years. Investigations into the math preparedness of engineering cadets used average Math SAT scores and the requirement to take pre-calculus during the first semester. These investigations have shown that Math SAT scores and being prepared to take Calculus I during the first semester were both associated with graduating in engineering. However, the associations provided limited predictability and math preparedness alone was not enough to answer why some cadets remained in engineering and some left.

To supplement the numerical data that has historically been used to predict success, the OAIR produced a survey and distributed it to all engineering cadets during the first two weeks of the fall 2017 semester. Instead of focusing on numerical math preparedness, the survey focused on

their perceptions of preparedness. The survey was designed to determine how well prepared the cadets perceived they were to undertake engineering as a major. It included questions about their perception of what is required to be a professional engineer, how confident they felt in their ability to perform certain tasks, and what was their biggest academic concern or fear. This paper provides the surprising results of this initial survey which had an 84% (n=132) response rate (N=157).

Based on their own perception of their abilities, 93% of the cadets felt extremely confident of their ability to succeed in their engineering courses. The survey also revealed confusion, or misunderstanding, of certain topics. Although the authors of the survey felt that biggest academic concern or fear would be math preparedness, more than twice as many cadets were concerned with overall workload. Understanding these perceptions should enable the engineering departments to improve retention of engineering students by addressing concerns, misconceptions, and overconfidence.

Previous Numerical Studies

The OAIR investigated the retention of five engineering classes, the classes of 2013 to 2017. For each of the classes, the number of cadets that entered engineering at matriculation was determined. As shown in Table 1, 716 cadets matriculated into engineering for the five classes combined. This is an average of approximately 143 cadets per class. The first row shows the number and percentage that remained in engineering after each year. The second row shows the cumulative number and percentage that had transferred out of engineering into another major (a non-engineering major) at VMI. The third row shows the cumulative number and percentage that had left VMI entirely. Note that this table provides percentages based on the total number of cadets that originally matriculated into engineering (716 cadets). The decrease in the number that had transferred out of engineering from after year 3 to after their last year (171 down to 165) is caused by some of these cadets having left VMI entirely.

Table 1 – Retention of Engineering Cadets for Five Classes

	After 1st Year		After 2nd Year		After 3rd Year		After Last Year	
Remained in Engineering	490	68%	435	61%	419	59%	417	58%
Transferred out of Engineering	142	20%	172	24%	171	24%	165	23%
Left VMI Entirely	84	12%	109	15%	126	18%	134	19%
	Σ = 716		Σ = 716		Σ = 716		Σ = 716	

As shown in Table 1, the percentage of cadets that leave engineering during the last three years is approximately 10% (68% minus 58%). Most cadets that leave engineering leave in the first year. The numbers suggest that some cadets decide early (within their first year) that engineering is not the best major for them and switch. However, this percentage does not increase much during the next three years.

Considering only the cadets that remained in engineering, Table 2 shows the number and percentage of these cadets that were required to take Pre-Calculus and those that passed the math placement test and were allowed to enter Calculus I during their first semester. The percentage of cadets that remained in engineering and were required to take Pre-Calculus during the first semester only changes 27%, 26%, 25%, and 25% over the four years. Likewise, the percentage

of cadets that remained in engineering and were able to enter Calculus I during the first semester only changes 73%, 74%, 75%, and 75% over the four years.

Table 2 – Math Preparedness of Cadets that Remained in Engineering

	End of 1st Year			End of 2nd Year			End of 3rd Year			End of 4th Year		
	Total	Pre-Calc	Calc I	Total	Pre-Calc	Calc I	Total	Pre-Calc	Calc I	Total	Pre-Calc	Calc I
Remained in Egineering (numbers)	487	130	357	435	112	323	419	106	313	417	106	311
Remained in Engineering (percent)	100%	27%	73%	100%	26%	74%	100%	25%	75%	100%	25%	75%

It is clear that more cadets that are able to enter Calculus I remain in engineering by an approximately three to one ratio (75% divided by 25%). This fact that so few who take Pre-Calculus end up succeeding as engineering majors has most likely been the reason that faculty have thought that math preparedness was a primary indicator of success in engineering. However, this ratio is biased by the fact that the number who take Pre-Calculus is much smaller than the number who place into Calculus I. To correct for this bias, conditional percentages should be calculated.

Table 3 provides these conditional percentages. More specifically, it summarizes for all cadets that started in engineering, their status after last year, conditional on whether they were required to take Pre-Calculus or enter Calculus. This table provides a summary of all cadets that started in engineering and where they ended up at the end of four plus (4+) years. The plus is used because some cadets require more than four years to graduate, but are still included in the numbers. This table gives a conditional percentage of cadets that remain, transfer, or leave based on whether they were required to take Pre-Calculus or enter Calculus.

Table 3 – Summary of Math Preparedness of Cadets that Remained in Engineering

Total that took Pre-Calc	245		Total that started in Calculus	471	
Remained in Engineering	106	43%	Remained in Engineering	311	66%
Transferred out of Engineering	82	33%	Transferred out of Engineering	83	18%
Left VMI Entirely	57	23%	Left VMI Entirely	77	16%

As shown in Table 3, 66% of the cadets that started in Calculus remained in engineering, while 43% that started in Pre-Calculus remained in engineering. This 23% difference does indicate that math preparedness has some ability to predict success in engineering; however, it is not the single, largest predictor that many have believed. In fact, ignoring those who leave VMI entirely, which commonly is not related to academics, most who take Pre-Calculus end up succeeding in engineering (106 versus 82).

The situation is similar when looking at Math SAT scores. Table 4 shows mean Math SAT scores for cadets that remained in engineering, that transferred out of engineering, and that left VMI entirely. Standard deviations are also shown.

Table 4 – Math SAT Scores

	Mean SAT Score	Standard Deviation
Remained in Engineering	609	61
Trasferred out of Engineering	576	63
Left VMI Entirely	605	69

As shown, scores are higher on average for those that remain in engineering, particularly in comparison to those that transfer out of engineering. However, each difference is less than a standard deviation, indicating that the differences are not significant and that Math SAT scores will be weak predictors of success in engineering.

To further illustrate, a comparison can be made between two groups of cadets that started in engineering, those with bottom quartile Math SAT scores (below 560) and those with top quartile scores (above 647). Again ignoring those who leave VMI entirely, 84.8% of those with top quartile scores succeed in engineering while 56.5% of those with bottom quartile scores succeed. Just as with the math placement, Math SAT scores do have some ability to predict success, but this ability is limited and most of those with low scores still end up succeeding.

The data collected by the OAIR can be used to reconsider the importance of math preparedness in engineering success. Although faculty members have advised parents and incoming cadets that being prepared for math is the single most important factor in succeeding in engineering, it may be that math preparedness is actually the most important factor in just succeeding in graduating in any major. The perception that math preparedness is the most important factor has been declared for so many years that the authors decided that the perception of preparedness needed to be addressed.[1,2]

Survey to all Matriculated Cadets

In an effort to get a snapshot of the perceptions of incoming engineering cadets, the authors developed and distributed a survey to the engineering Rats during the first week of class. The survey was sent to all 157 cadets that matriculated in engineering (either Civil, Mechanical, or Electrical). A total of 132 cadets responded to the survey, an 84% response rate. Although the authors would like to take credit for producing a survey that received such an impressive response rate, it is certainly possible that many of the cadets felt that they were required to respond since they had just been through an entire week of being yelled at and ordered to do everything including how to chew their food.

The survey included some demographic data as shown in Table 5.

Table 5 – Demographic Data

What is your Engineering Major ?	Civil - 34%	Electrical - 20%	Mechanical - 45%
Do you plan to Commission ?	Yes - 58%	No - 11%	Undecided - 31%
Are you In-state or Out-of-state ?	In-state - 63%		Out-of-state - 37%
Are you an NCAA athlete ?	Yes - 14%		No - 86%

Following the demographic questions, the survey included questions that required a response on a six-point Likert scale. These responses included: Strongly Agree, Agree, Somewhat Agree, Somewhat Disagree, Disagree, and Strongly Disagree. Some questions were asked in a slightly different format in an attempt to determine if cadets had confidence in their answers.

Confusion was noted in the response to questions related to whether or not the cadets understood what it meant to be a professional engineer. One statement provided was "I know the difference between a Licensed Professional Engineer (PE) and an unregistered engineer." Posed as a "Yes" or "No" response option, only 29% of the cadets answered "Yes" while the rest responded "No." Of the 29% that responded "Yes," 74% either Strongly Agreed, Agreed, or Somewhat Agreed to the statement, "I can explain the process required to become a Professional Engineer." The survey confirms the fact that a majority of the cadets entering engineering do not understand what is required to become a Professional Engineer. For many years, all three engineering departments have required cadets to take the Fundamentals of Engineering exam in order to graduate. Cadets are not required to pass the exam. As the engineering departments have attempted to improve performance, they have realized the need to stress the importance of passing the exam. Before the importance of passing can be emphasized, it is clear that the cadets need to have the process of becoming a professional engineer explained so that more cadets have an understanding of what is required.

Six statements were provided that addressed the cadets' perception of confidence in certain areas. For all six statements, the cadets were asked to rate their responses to the statement "I am confident in my ability to…" As shown in Table 6, the cadets responded with great confidence in their ability to perform in all six of the areas. Adding up the three Disagree categories for each of the six, only 2% to 8% disagreed with any of the statements. This indicates that between 98% and 92% of the cadets responded with some type of agreement to the statements that they felt confident in their abilities to succeed.

Performance, as measured by grades in courses taken during the first year of engineering, clearly shows that many of the cadets do not perform as well as they anticipate during the first year. Addressing this overconfidence may help to prepare cadets as they enter engineering.

Responses to several qualitative questions surprised the authors. The cadets were given the ability to respond to several open-ended questions. Many provided lengthy, detailed responses to the questions. Responses with so much detail and insight are usually not received by upper level cadets. It is possible that the timing of the survey, which was given at the end of the week-long military drill training and the beginning of the academic semester, may have inspired the cadets to refocus on the academic portion of VMI.

Table 6 – Percent Responses to Perception of Confidence

	I am confident in my ability to …					
	Strongly Agree	Agree	Somewhat Agree	Somewhat Disagree	Disagree	Strongly Disagree
Succeed at completing high level math using quantitative reasoning.	13	50	31	5	2	0
Solve open-ended problems using abstract reasoning.	13	60	24	4	0	0
Succeed in required science and lab-based courses.	24	60	14	2	0	0
Communicate effectively in writing.	27	38	28	6	1	1
Work effectively as part of a team.	54	40	4	2	0	0
Succeed in my engineering courses.	28	65	6	1	0	0

The question that provided the most surprising result was "What is your biggest academic concern or fear?" There were 125 written responses to this question, many given as a complete sentence or a paragraph. The two engineering division authors would have guessed that Math Preparedness would have been the most common answer to the question. However, over a two to one margin, the cadets responded that Managing Total Workload was their biggest concern. Approximately 61 of the responses could be categorized at Managing Total Workload while only 28 of the responses could be categorized at Math Preparedness. The remaining 36 responses were divided up among different categories including Lack of Sleep, English Classes, the Ratline, Procrastination, English as a Second Language, and Pressure to Switch Majors.

Conclusions

The numerical data provided by the OAIR in conjunction with the results of the survey have clarified some of the "legendary" beliefs that Math Preparedness is a primary indicator of success in engineering. The data show that retention as a function of Math Preparedness is complicated, and weaker than many have believed. This leads to the conclusion that Math Preparedness may not be such a good indicator of success. Also, the perceptions revealed in the survey show that many cadets are more concerned with overall workload and that many do not understand what is required to become a professional engineer. Knowing this will help the three engineering departments address the concerns in their curriculum and provide further supports for academic success.

References

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