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Accounting for Remote Testing in West Point's Advanced Math Program

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Abstract

When new students first arrive at the United States Military Academy (USMA), they soon find out what classes they will take during the upcoming Fall semester. Some cadets with strong mathematical backgrounds discover they have been placed into the Advanced Mathematics Program (AMP). Over the years, AMP course directors have used a variety of techniques to identify the best candidates for AMP which usually figures out to the top 30% of the incoming class. Most of these techniques considered similar criteria ranging from USMA's own college entrance examination rank (CEER) score, which factors in SAT/ACT scores among several other scores, to their Fundamental Concepts Exam (FCE) and Calculus Placement Exam (CPE) scores. Recently, the FCE and CPE have both been remotely administered during the Summer before students attend USMA to allow for expedited placement. In this paper, we use placement and post-placement scores to measure the effectiveness of AMP's current tier-based placement system. We found that the system results in few errors and can be easily optimized further through additional quality control measures.

AMP Program Overview

Each year, the Department of Mathematical Sciences at USMA selects anywhere from 250 to 300 cadets for AMP. This advanced track starts with Mathematical Modeling and Introduction to Ordinary Differential Equations (MA153) during the Fall semester and includes topics such as first order differential equations, second order differential equations, systems of first order linear differential equations, and Laplace transforms. Upon successful completion of that course, AMP cadets move on to Advanced Multivariable Calculus (MA255) which exposes them to advanced topics such as an in-depth study of vectors and geometry of space, vector functions, partial derivatives, multiple integrals, and vector calculus.[1] Since AMP is a voluntary program, we cannot force cadets to choose AMP. Despite possessing the necessary qualifications, cadets may choose to enroll in the other math tracks: the intermediate track (designed for cadets who plan to declare as a STEM Major but do not possess

[1] "Advanced Core Mathematics Program." United States Military Academy. https://www.westpoint.edu/academics/academic-departments/mathematical-sciences/about/prospective-students/advanced-core-mathematics-program

AMP qualifications), the standard track (designed for cadets who have previously taken pre-calculus but not calculus), and the pre-calculus track (designed for cadets who have not previously taken pre-calculus). Though, we can incentivize cadets to enroll in AMP by immediately offering Calculus I (MA104) validation, which would allow them added flexibility within their chosen major.

Summer Testing for Cadet Candidates

In the past, testing occurred in-person during Cadet Basic Training (CBT), otherwise known as Beast Barracks, a requirement that transforms new students into new cadets through rigorous training focused on developing future leaders of character dedicated to service in the U.S. Army.[2] During the first week of in-processing, each new cadet could choose to validate certain core courses such as English, Foreign Language and Chemistry. If these cadets performed well on their examinations, they received validation and were subsequently placed in an advanced program for the Fall semester.

Recently, USMA made significant changes to the way it conducts placement testing to determine exactly which core courses each cadet is enrolled in during the Fall Semester. When the world was impacted by COVID-19 in March 2020, USMA transitioned from in-person learning to remote learning where cadets received instruction from their college professors using the video teleconferencing platform, Microsoft Teams. With remote learning becoming the norm for the rest of the academic semester in Spring 2020, USMA adjusted how they would conduct summer placement testing for the incoming Class of 2024. Instead of the usual in-person testing completed by cadets during Beast, cadet candidates would conduct all testing remotely using the web-based learning management system, Blackboard. These cadet candidates, individuals who received and accepted a certificate of application from USMA, were given a window of about two months to complete all testing. The USMA Math Blackboard page instructed each cadet candidate to complete a Math Placement Survey and the FCE, while the CPE, a two-part exam, was considered optional.

At the conclusion of the testing period for the incoming Class of 2025, it was clear that obtaining close to a 100% completion rate would prove challenging. 1142 out of 1238 (92%) cadet candidates completed the mandatory Math Placement Survey and the FCE, which meant that course leadership would need to sort through the remaining 8% and utilize other available metrics to place them successfully. For the optional CPE, we found that 533 out of 1238 (43%) cadet candidates completed it, which served as a strong indication that AMP may easily surpass its usual enrollment of 250 – 300 members. Among the many questions we asked cadet candidates on the Math Placement Survey, we were particularly interested in the track they chose. The survey revealed that 71% of the cadet candidates preferred to be in either the standard or

[2] "Cadet Summer Training." United States Military Academy. https://www.westpoint.edu/military/department-of-military-instruction/cadet-summer-training.

intermediate tracks, while only 23% were interested in the advanced track (See Figure 1). We compiled this data along with their corresponding FCE results and proceeded to place cadets using our proprietary placement methodology.

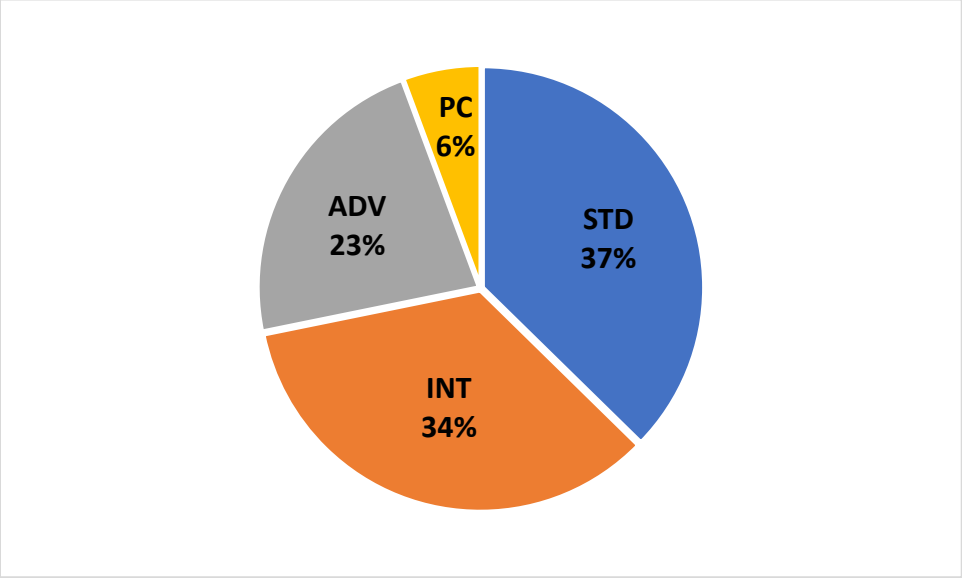

Figure 1: Math Placement Survey Track Results (Class of 2025)

Tier-Based Placement System

AMP utilizes tier placement based on the use of both longitudinal and episodic datasets. The longitudinal data comes from a candidate's CEER score which is derived from Scholastic Aptitude Test (SAT) or ACT scores, high school rank convert score (HSRCS), candidate fitness assessment (CFA), faculty appraisal score (FAS), athletic activities score (AAS), and extracurricular activities score (EAS).[3] The intent of the CEER score is to mimic how cadets are evaluated while at USMA which is based upon performance in four different programs: academic, physical, military and character. This contrasts with normal colleges where High School grade point average (GPA) is the absolute best predictor of student success according to Barnett et al.[4] RAND Corporation determined the CEER score to be a reliable metric that is proven to accurately predict successful cadet performance.[5] After being provided with CEER

[3] Lawrence Hanser and Mustafa Oguz. *United States Service Academy Admissions: Selecting for Success at the Military Academy/West Point and as an Officer*. (RAND National Defense Research Institute, Santa Monica, CA, 2015), ix.

[4] Barnett, Elisabeth, Peter Bergman, Elizabeth Mary Kopko, Vikash T. Reddy, Clive Belfield, and Susha Roy. "Multiple measures placement using data analytics: An implementation and early impacts report." (2018), 1.

[5] Hanser and Oguz, 22.

score data from USMA Admissions, we used the following formula to compute a longitudinal score, LS:

$$LS = \left(\frac{CEER - CEER_{min}}{CEER_{max} - CEER_{min}}\right)$$

This formula normalized CEER scores to result in an output where $0 \leq LS \leq 1$, allowing for the tiered system to work properly.

Next, we computed the episodic score based on the CPE and FCE scores gathered from Blackboard during the Summer Placement testing. Instead of normalizing the data like we did for the longitudinal score, we instead divided each respective score by their total number of points. Then, with normalized CPE and FCE scores, we take the average of these two values to find each candidate's episodic score. The formula for episodic score, ES, is as follows:

$$ES = Average\left(\frac{Calc}{43}, \frac{FCE}{50}\right)$$

Once both the longitudinal and episodic scores are calculated, candidates are ready to be placed into their appropriate tier (Table 1).

Tier		LS	ES
1.1	≥	0.8	0.8
1.2	≥	0.7	0.7
1.3	≥	0.7	0.6
1.4	≥	0.6	0.6
1.5	≥	0.5	0.5
1.6	NEED MORE INFO		

Table 1: AMP Tiers based on LS and ES

After each candidate is sorted into tiers from Tier 1.1 (highest) to Tier 1.6 (lowest), we then use a pairwise comparison to match up cadets from each of the six tiers with their track preference from the Math Placement survey. In Table 2, the groups highlighted in green were each selected for inclusion into AMP, while those highlighted in orange were selected for a follow-up interview to be conducted during CBT. This occurred due to

course leadership's decision to ramp up program numbers. Those not selected were highlighted in red. In total, 294 candidates were initially placed into AMP, while an additional 59 were conditionally placed.

				Track Preference			
Tier		**LS**	**ES**	**ADV**	**INT**	**STD**	**PC**
1.1	≥	0.8	0.8	115	28	2	0
1.2	≥	0.7	0.7	64	53	9	2
1.3	≥	0.7	0.6	12	13	20	0
1.4	≥	0.6	0.6	20	28	7	0
1.5	≥	0.5	0.5	15	32	12	2
1.6	NEED MORE INFO			20	210	381	76
				246	154	50	80

Table 2: AMP Tiers vs. Track Preference

We found that most of the selected cadets originated from Tiers 1.1/1.2 and had self-selected as either advanced or intermediate track. Those that chose the advanced track but were identified as Tier 1.3 and Tier 1.4 were allowed entrance into the program despite having mediocre longitudinal and episodic scores. We were also pleasantly surprised to find that only two candidates pegged as Tier 1.1 had preferred to be in the standard track as some may gravitate towards choosing an easier math course where top marks can be had with much less work, and others with little interest in choosing a STEM major might not see the appeal of undergoing the rigors of AMP. As for the interview process, we talked to each cadet and asked them about their mathematical background to determine whether they would be a good fit for the program. Due to time constraints, interviews were rushed, and most cadets were admitted into the program. Thus, AMP entered the academic year with its largest enrollment ever at 349 cadets.

Post-Placement Testing

During the first year after USMA converted to remote testing, AMP leadership encountered some troubling issues regarding the cadets enrolled in the program. Several cadets, having earned placement into AMP through their test scores and CEER score, lacked the required calculus skills to be successful in MA153. These cadets were required to take the FCE again during the first week of school, but successful performance on the FCE did not indicate mastery of calculus since the exam only measured aptitude in algebra, geometry, and trigonometry. This placed a heavy burden on faculty to either conduct additional instruction (AI) with struggling cadets or substitute valuable lecture time to review necessary math fundamentals. To prevent this situation

from ever happening again, we introduced a one-week block of instruction on calculus review and tested their knowledge with a new assessment called WRIT 0 which served as a Calculus Placement Exam Part III with the only difference from the other two being that it was administered inside the classroom. Since it was given the first day of the second week of the semester, there was also enough time to recommend cadets who did not meet certain standards ($\geq 80\%$ on the FCE and $\geq 66\%$ on WRIT 0) to drop-down to the standard track and take Mathematical Modeling & Introduction to Calculus (MA103). For the Class of 2025, AMP leadership recommended 19 cadets move down to MA103 from MA153. We now further analyze the test scores from these two in-person assessments.

Results & Analysis

When comparing the results of the FCE conducted during Summer Placement to the FCE administered during Week 1 of the Fall Semester, we noticed a marked improvement in FCE scores. The average score increased 6% and there were several more perfect scores on the second attempt (see Table 3). One reason that FCE scores improved could be due to instructor assistance as some instructors may have given supplementary resources for the cadets to study or discussed potential FCE questions in class. When taking a closer look at the scores, we noticed a small handful of cadets that performed much worse when taking the exam in-person. There were a total of 14 cadets who missed 4+ more questions (16% decrease or more) than they did when they took it the first time. This result begs the question: did these cadets use unauthorized references when they first took the FCE during the Summer? If so, then we must further question this small group of cadets to identify if there exists a significant problem with their integrity and their overall character which is something that USMA does not take lightly.

Test	Placement	Post-Placement
FCE 1	91%	
FCE 2		97%
CPE	79%	
WRIT 0		85%

Table 3: Placement Scores vs. Post-Placement Scores

When comparing CPE scores to WRIT 0 scores, we found the same exact average score increase of 6% that we saw with FCE scores. By looking at the box plot in Figure 2, we notice a clear-cut improvement in the median score and a higher, tighter interquartile range on WRIT 0 versus the CPE. This was a highly expected outcome since cadets were given an extra block of instruction during Week 1 which covered both differential and integral calculus in detail. Unfortunately, we found almost double the number of cadets (total of 26) scored 16% worse or more on the in-person WRIT 0. The cadet who achieved the minimum score of 34% originally received a 98% on the CPE, resulting in an extremely high delta of -64%. These cadets must be labeled as high-risk and require immediate attention to prevent similar circumstances from happening again in the future.

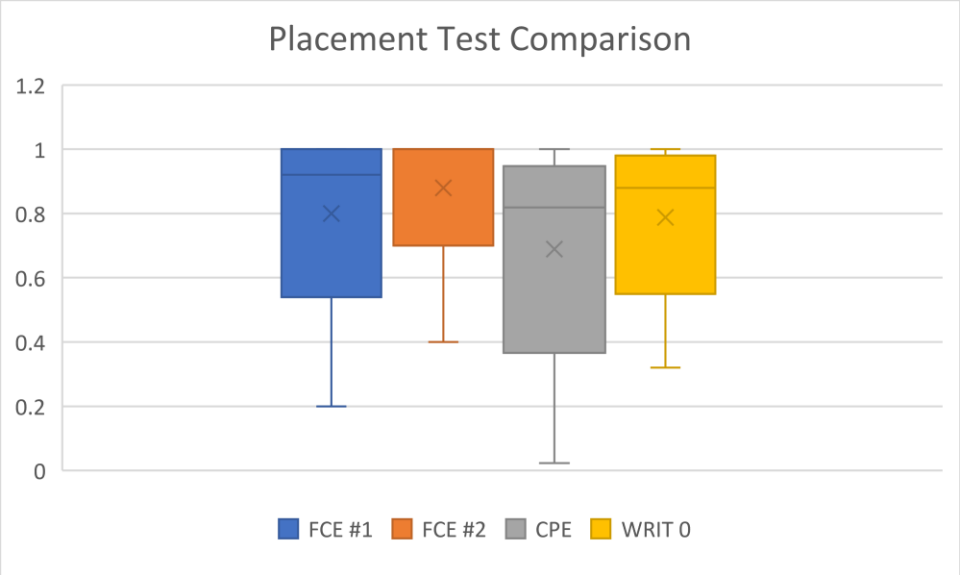

Figure 2: Box Plot of Placement and Post-Placement Score Data

Recommendations

Our findings reveal that the current tier-based placement system performs incredibly well for the most part but there is still some room for improvement. We gain much from sustaining the current post-placement system of conducting another in-person FCE and a WRIT 0. This has proven to be an excellent solution that addresses the issues experienced in the previous year with cadets not comprehending the material in MA153 due to insufficient calculus skills. However, we propose the inclusion of an additional mini-WRIT to be conducted during CBT interviews which tests cadets on easily recognizable concepts that they had to have encountered while taking single-variable calculus. It would ensure we are placing cadets correctly the first time and avoiding the stress of restructuring cadets' schedules during the 2nd week of the

semester. Also, we must target high-risk cadets and deal with them swiftly and accordingly, so we are able to meet USMA's mission of producing leaders of character.

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