

## DEVELOPING HABITS OF MIND IN THE CORE MATHEMATICS PROGRAM

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### ABSTRACT

This study seeks to assess the development of habits of mind of students in the core mathematics program at the United States Military Academy (USMA). One of the goals of the core mathematics program is for students to display effective habits of mind in their intellectual process. This study focuses on the intended outcome that students display a sound work ethic, striving for accuracy and precision while maintaining strong resolve to complete problems in their entirety (e.g. persistence). The goal is to determine whether the daily web-based homework due dates effect the development of effective habits of mind in the core math program. Data collection efforts were completed during academic year 2015-1 (fall semester) for three sections of MA205: Integral Calculus and Differential Equations. One instructor (with 53 students) delayed the due dates on WebAssign online homework at different intervals for each section. The results show collective section and individual averages on online homework assignments, analysis of homework scores and test scores, qualitative responses to surveys about homework due dates, and analysis of the effects of due date changes against a 270-student control group. The results show some indications of effective and poor habits of mind development among individual students. However, using a Tukey test and ANOVA in R there is no statistically significant difference between the group means of student performance on the online homework and test scores after suspense dates were moved with that of the control group. This indicates that the due dates of the online homework do not affect the overall performance of students on that homework and subsequent graded exams. However, there are some individual indicators that the changes in homework due dates affect the development of habits of mind in the core mathematics program.

### INTRODUCTION

“Learning is an inherently inefficient process. Learning how to teach oneself is a skill that requires maturity, discipline, and perseverance. In studying mathematics, students learn good scholarly habits for progressive intellectual development.”<sup>ii</sup> At the United States Military Academy, the core mathematics program seeks to improve each cadet’s habits of mind in areas to include reasoning and critical thinking, creativity, work ethic, thinking interdependently, and lifelong learning and curiosity. A breadth of research exists into developing habits of mind in students at the undergraduate level. One of the significant challenges and opportunities is the inherently difficult process of quantifying whether or

not students are developing these habits of mind. During academic year 2015, the core mathematics program focused on the developing habits of mind goal. In MA205 integral calculus and differential equations, the course focused on student self-assessments via an online survey, assessing students based on their performance during the two course wide projects and assessing the effects of daily journaling on developing habits of mind. The course also focused on assessing habits of mind through data collected via daily WebAssign homework completed, and monitoring students' daily work ethic when homework suspense dates are relaxed or removed. This work focuses on the daily online homework submission submitted by students via WebAssign during one academic semester.

The math department defines the five areas it seeks to improve in its students and lists the desired outcomes for students to display effective habits of mind in their intellectual process. The areas to improve are

- **Reasoning and Critical Thinking:** Students can identify relevant information, ask questions to clarify purpose or intent, make reasonable assumptions and recognize their affects, apply induction and deduction, develop a plan, and critique their own work.
- **Creativity:** Student can extend knowledge to new situations, draw upon previous experiences, develop illustration to clarify concepts, establish connections between concepts, and take responsible risks.
- **Work Ethic:** Student strive for accuracy and precision, persist in the face of difficulty, attempt various methods without giving up, and remain focused on developing a solution strategy and implementing it.
- **Thinking Interdependently:** Student recognize potential contribution of team members, gather data from all sources, paraphrase another's ideas, understand the diverse perspectives of others and act responsibly in fulfilling group commitments.
- **Life Long Learning and Curiosity:** Student recognize the value of continuous learning, develop the ability to learn independently , learn to formulate questions to fill gaps between known and unknown, actively seek knowledge, and think about their own thing (metacognition).<sup>iii</sup>

The desired outcomes for effective habits of mind are:

Outcome 1: Demonstrate curiosity toward learning new mathematics.

Outcome 2: Reason and think critically through complex and challenging problems.

Outcome 3: Demonstrate creativity and a willingness to take risk in their approach to solving new problems.

Outcome 4: Display a sound work ethic, striving for accuracy and precision while maintaining strong resolve to complete problems in their in entirety (e.g. persistence).

Outcome 5: Think interdependently when working in groups.

Outcome 6: Demonstrate the ability and motivation to learn new material without the help of the instructor.

## DATA COLLECTION METHOD

Data collection efforts were completed during academic year 2015-1 (fall semester) for three sections of MA205: Integral Calculus and Differential Equations. One instructor delayed the due dates on WebAssign online homework at different intervals for three different sections.

Students in MA205 are required to complete daily Web-based homework assignment prior to coming to class. The Web-based homework assignments cover material from the previous lesson and material from the upcoming the lesson. The goal is to reinforce students learning in the classroom from the previous day by requiring them to revisit the topics. The next goal is to encourage student self-learning by requiring students to complete problems on the next lesson's topic(s) prior to the class period. The homework is electronically graded and instructors have access to the time each student spent on the lesson, number of attempts made, and what the students entered as responses for each attempt. The course is split into four blocks of instruction. For each block of instruction, WebAssign grades account for 75 points towards the overall 2000 points in the course. This means WebAssign homework totals 300 points for the semester or 15% of each cadet's overall grade.

This study focuses on three sections of students taught by a single instructor. Section B27 (B hour) had 18 students, section C27 (C Hour) had 17 students and section D27 (D hour) had 18 students, for 53 students total. Additionally, there were 725 students enrolled in the course during the same period that were not involved in the study.

Phase one, Baseline period: During block one of instruction (18AUG14-11SEP14) the students are required to submit web-based homework for 12 lessons. Here a baseline can be established as to amount of time, number of submissions, and overall scores. The goal is for students to begin developing effective habits of mind techniques and that they complete the daily homework in a timely and accurate manner.

Phase two, delay submission for B hour until end of block: During block two (15SEP14-7OCT14), the B Hour student's submission deadlines for the web-based homework will be moved to the end of the block. This means that the 12 web-based assignments will not be due until 7OCT14. The deadlines for C and D Hours will remain the same.

Phase three, delay submissions for C hour until end of block. During block three (9OCT14-12NOV14), the C Hour student's submission deadlines for the web-based homework will be moved to the end of the block. This means that the eight web-based assignments will not be due until 12NOV14. B hour will continue to have the extended deadlines until the end of the block. The deadlines for D hour will remain the same.

Phase four, delay submissions for D hour until end of block. During block four (14OCT14-12DEC14), the D Hour student's submission deadlines for the web-based homework will be moved to the end of the block. This means that the eight web-based assignments will

not be due until 12DEC14. B hour and C hour will continue to have the extended deadlines until the end of the block.

The data was then collected via WebAssign online grading tools and were compiled as percentages in an excel spreadsheet. The data shows scores per individual assignment, individual and class average block scores, and number of lessons with scores below 65% and below 10%. Additionally, student filled out online surveys to provide qualitative comments on WebAssign submission deadlines.

## ANALYSIS AND RESULTS

The goal is to determine whether the daily web-based homework is helping students in the core math program in developing habits of mind. An indicator of effective habits of mind and work ethic would be for students to continue completing the assignments daily and maintain their scores after the submission requirements are removed. An indicator of poor habits of mind and work ethic would be to observe a decline in WebAssign grades and assignment completion rates after the homework suspense dates are moved to the end of the block.

Figure 1 and Table 1 present the results by block of average assignment scores for the students in each hour. For block 1 of instruction, all three sections had the assignment due at the beginning of each lesson. At the start of block 2, the homework suspense dates for section B27 were moved to the end of the block. The results of block 1 show that section B27 scores fall 1.5% below the other sections. However, in the ensuing blocks section B27's average scores fall between 2-10% below the other sections' scores. This suggests that having the due dates of the assignments moved so early in the course had a negative impact on section B27 developing the outcomes of effective habits of mind.

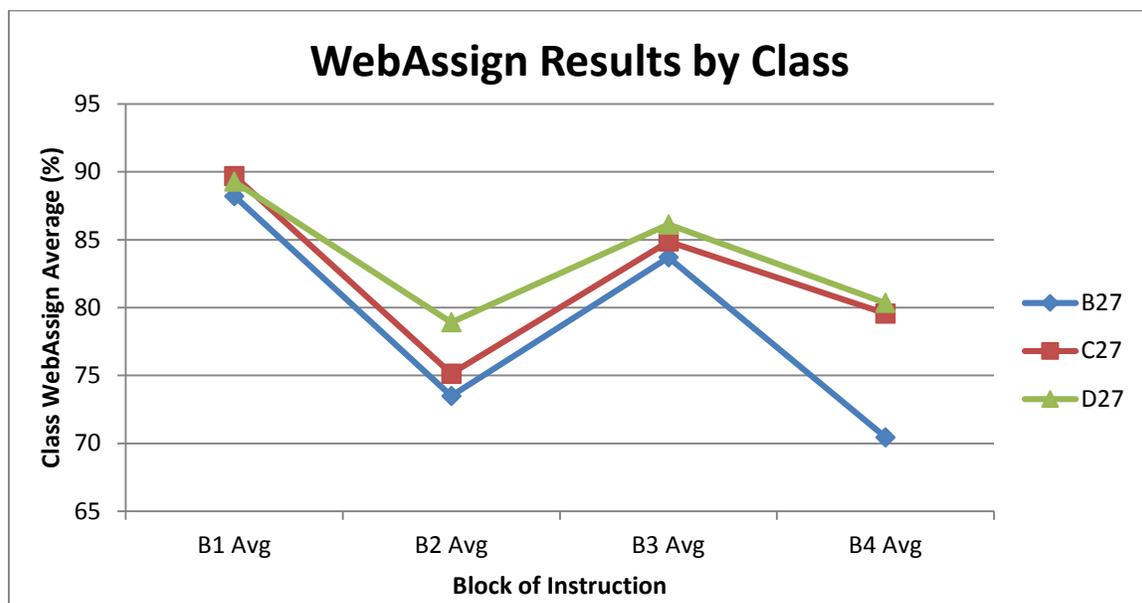


Figure 1: Block Average WebAssign scores for each class hour.

In block three, the suspense dates were delayed for section C27. However, there was not a significant drop in scores relative to the scores in section D27. In fact, during difference in average assignment scores between C27 and D27 was 3.7% in favor of D27. During block three, section C27 closed that gap to about 1.3%. This suggests that C27 developed good work ethics and habits of mind during blocks one and two that carried over into block three and four. During block four, the assignment due dates were shifted for section D27. However, this section maintained the highest average scores on the daily homework. This indicates that the work ethic and habits of mind developed in the first three blocks continued during the last block.

	Block 1 Average	Block 2 Average	Block 3 Average	Block 4 Average
B27	88.2063	73.49375	83.69903	70.44979
C27	89.6774	75.12632	84.86763	79.56162
D27	89.26634	78.91685	86.11535	80.34882

Table 1: Block Average WebAssign scores for each class hour corresponding to Figure 1.

Another way to analyze the data is to look at how many assignments scored less than 65% (or an F grade) and less than 10% (little to no effort). The specific breakdown of letter grade with respect to assignment score is in Appendix 1. The numbers of each of categories are totaled by block of instruction by section in Figure 2 and Table 2. Here the effects on section B27 having the suspense dates moved first are shown. Section B27 went from being just three F scores (less than 65%) above the average in block one to 10 F scores above the average (62) in block two. Additionally, section B27 consistently had the most F scores throughout the semester. This significant spike in F grades on individual assignments and consistently performing below the other sections shows that delaying the due date so early in the semester was detrimental to the development of a good work ethic.

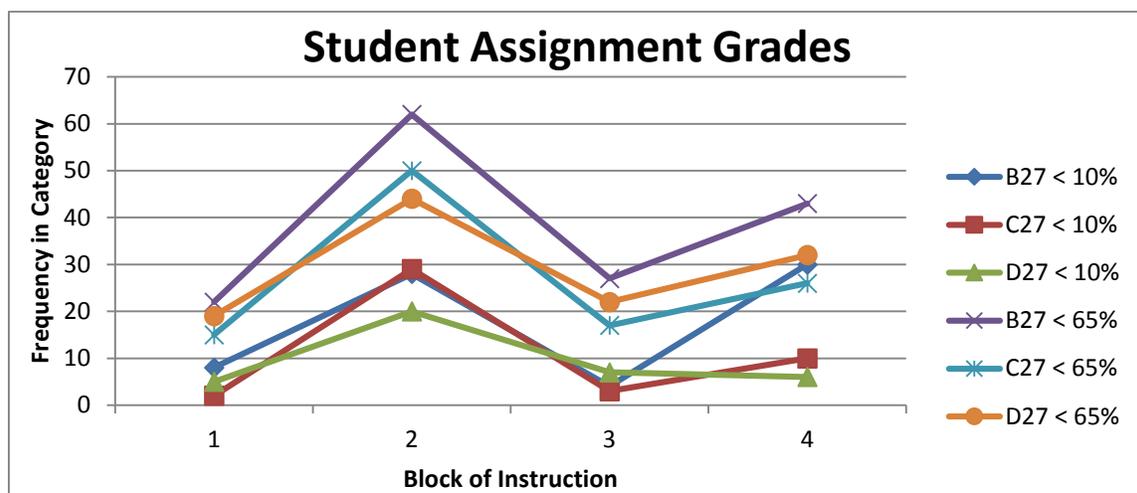


Figure 2: Number of individual assignment scores falling below 10% and 65% each block by class hour.

Analyzing the assignments that had scores of 10% or less provide some insight to the habits of mind development. Section B27 was consistently at or above the average with a significant spike in block 4 of instruction. However, sections C27 and D27 decreased relative to the average in this category once their suspense dates were changed. This is another indicator that C27 and D27 students had developed effective habits of mind by the time their suspense dates were changed.

	B27 < 10%	C27 < 10%	D27 < 10%	Average		B27 < 65%	C27 < 65%	D27 < 65%	Average
Block 1	8	2	5	5.0		22	15	19	18.7
Block 2	28	29	20	25.7		62	50	44	52.0
Block 3	4	3	7	4.7		27	17	22	22.0
Block 4	30	10	6	15.3		43	26	32	33.7

Table 2: Number of individual assignment scores falling below 10% and 65% each block by class hour.

Table 3 shows individual scores by block, focusing on when the due date of assignment changed (blue rectangle). The red ovals highlight the students that had a significant drop in score immediately following the change in assignment due dates. Section B27 had six students immediately and significantly lower their homework averages. While sections C27 and D27 only had one and two students, respectively, with the same results. Another indicator of effective habits of mind across the board was that only three students total completely blew off the homework (16% or less) immediately after the due dates were changed. On a positive note, those scores circled in blue indicate that high achieving students continued to do well even after the deadline for assignments was changed. Qualitative comments from these students specifically are discussed at the end of this section.

	Block 1	Block 2	Block 3	Block 4		Block 1	Block 2	Block 3	Block 4		Block 1	Block 2	Block 3	Block 4
B27 Student 1	83.5	35.8	76.7	31.8	C27 Student 1	91.1	24.4	85.3	75.3	D27 Student 1	90.6	96.5	99.6	99.7
B27 Student 2	90.6	56.2	71.4	55.2	C27 Student 2	96.9	96.4	87.0	89.5	D27 Student 2	94.9	94.1	92.8	92.1
B27 Student 3	94.5	97.4	94.9	99.7	C27 Student 3	86.1	56.9	78.6	50.9	D27 Student 3	95.2	93.8	92.9	82.8
B27 Student 4	88.8	93.0	86.5	63.6	C27 Student 4	85.8	55.8	90.8	83.0	D27 Student 4	97.1	77.9	93.6	49.1
B27 Student 5	91.8	93.8	97.4	98.1	C27 Student 5	80.3	83.2	90.4	82.9	D27 Student 5	100.0	100.0	100.0	100.0
B27 Student 6	96.9	89.0	87.1	91.9	C27 Student 6	88.7	75.2	76.9	82.3	D27 Student 6	70.3	70.0	64.2	57.4
B27 Student 7	50.2	6.6	50.4	0.0	C27 Student 7	86.9	89.9	91.2	85.5	D27 Student 7	81.9	82.2	71.5	85.8
B27 Student 8	93.8	50.7	63.3	46.3	C27 Student 8	90.6	92.0	90.4	82.1	D27 Student 8	75.7	52.5	67.0	74.4
B27 Student 9	97.5	94.4	95.3	86.3	C27 Student 9	100.0	99.7	100.0	92.5	D27 Student 9	82.6	69.6	76.2	77.8
B27 Student 10	100.0	97.4	100.0	100.0	C27 Student 10	97.8	88.4	96.4	99.7	D27 Student 10	85.7	51.8	62.8	0.0
B27 Student 11	100.0	95.5	95.1	96.4	C27 Student 11	95.6	97.7	88.8	91.1	D27 Student 11	100.0	100.0	100.0	99.7
B27 Student 12	92.0	51.5	81.3	71.9	C27 Student 12	97.9	99.2	99.0	95.3	D27 Student 12	97.8	94.8	93.5	85.0
B27 Student 13	65.3	55.6	82.7	26.5	C27 Student 13	89.9	82.5	86.1	78.4	D27 Student 13	100.0	96.9	100.0	100.0
B27 Student 14	67.3	65.1	71.0	50.6	C27 Student 14	84.0	39.0	89.6	47.6	D27 Student 14	92.0	75.1	60.7	79.6
B27 Student 15	99.8	95.2	97.4	97.7	C27 Student 15	91.0	60.3	79.5	45.2	D27 Student 15	72.9	19.9	92.0	94.1
B27 Student 16	94.1	90.9	87.9	76.0	C27 Student 16	96.6	99.5	97.7	93.6	D27 Student 16	94.5	90.7	94.9	100.0
B27 Student 17	100.0	100.0	100.0	99.7	C27 Student 17	65.3	37.1	15.1	77.7	D27 Student 17	97.9	85.9	96.8	87.9
B27 Student 18	81.5	54.6	73.1	76.4						D27 Student 18	77.7	68.9	91.7	75.9

Block WebAssign Due Date Changed

Table 3: Block Average WebAssign Scores by Individual.

The next series of tables (Tables 4-6) show the block average homework score compared to the block assessment exam for each individual. The WPR or Written Partial Review is an exam given at the end of the block to assess the students understanding of that block’s learning objectives. The TEE or Term End Exam is a final test given that assesses the students understanding of the entire course material. Correlations between block homework scores and the WPRs are traditionally stronger than the final block homework score and the TEE. The columns boxed in red indicate the block where the daily homework suspenses were initially moved to the end of the block.

Some interesting results on individual effects of the due date change can be reported from each of these tables. Table 4 shows that B27 Student 1 had a significant drop in WA grade that reflected on WPR 2. This student scored an 86.2% on the block one homework and earned a 91.6% (A-) on the block one assessment. However, when the suspense on daily homework was removed, he or she only scored 35.8% on the homework and this reflected in a 66% (D) on the block two assessments. Conversely, B27 Student 4 increased his or her WebAssign average between block one and block two and his WPR test score went up by 12%. B27 Student 7 illustrates a correlation between low daily homework scores and low test scores on all the assessments. Meanwhile students 15-17 of section B27 maintained high daily homework averages and high scores on the assessments in both blocks one and two.

	Block 1	WPR 1	Block 2	WPR 2	Block 3	WPR 3	Block 4	TEE
B27 Student 1	86.2	91.60%	35.8	66.00%	76.7	62.00%	31.8	81.00%
B27 Student 2	89.2	99.20%	56.2	92.00%	71.4	80.00%	55.2	72.33%
B27 Student 3	96.3	87.60%	97.4	91.20%	94.9	88.00%	99.7	88.67%
B27 Student 4	89.9	80.00%	93.0	92.00%	86.5	70.00%	63.6	75.17%
B27 Student 5	92.1	98.00%	93.8	84.40%	97.4	80.00%	98.1	93.83%
B27 Student 6	96.3	96.40%	89.0	81.60%	87.1	76.40%	91.9	81.50%
B27 Student 7	59.3	67.60%	6.6	75.20%	50.4	42.40%	0.0	69.50%
B27 Student 8	92.6	87.60%	50.7	78.80%	63.3	56.80%	46.3	74.50%
B27 Student 9	99.0	73.60%	94.3	73.60%	95.3	62.40%	86.3	72.17%
B27 Student 10	100.0	95.60%	97.4	90.40%	100.0	94.00%	100.0	94.50%
B27 Student 11	100.0	91.60%	95.5	98.00%	95.1	88.00%	96.4	92.17%
B27 Student 12	94.9	88.40%	51.5	87.60%	81.3	78.80%	71.9	79.33%
B27 Student 13	67.2	82.00%	55.6	80.40%	82.7	66.40%	26.5	67.17%
B27 Student 14	79.6	89.60%	65.1	78.40%	71.0	71.60%	50.6	67.17%
B27 Student 15	99.8	98.40%	95.2	93.20%	97.4	89.60%	97.7	90.33%
B27 Student 16	93.4	90.40%	90.9	98.00%	82.9	82.00%	76.0	89.33%
B27 Student 17	100.0	92.40%	100.0	98.00%	100.0	86.00%	99.7	93.17%
B27 Student 18	84.1	82.80%	54.6	88.00%	73.1	75.20%	76.4	76.33%

Table 4: Block Average WebAssign Scores and Test Scores by Individual for B Hour.

For section C27 the initial change of assignment due dates did not occur until block three of instruction. Therefore, for the first 2 blocks and 24 assignments the homework was due at the beginning of class. Observed is that C27 Student 9 maintained good WebAssign grades and good scores on the WPR assessments even after the due date change. Student 11’s daily homework grades dropped only slightly and then he or she failed the WPR. For this treatment group, most students did not see a significant drop in WA scores or WPR

scores after homework due dates were moved in block three. This seems to correlate the hypothesis that the later the deadline for daily homework is removed, the better the students will perform. This is an indication of good work ethic developed in the first two blocks of instruction.

	Block 1	WPR 1	Block 2	WPR 2	Block 3	WPR 3	Block 4	TEE
C27 Student 1	98.1	73.60%	24.4	60.80%	85.3	66.00%	75.3	64.50%
C27 Student 2	96.3	80.80%	96.4	84.80%	87.0	71.20%	89.5	77.83%
C27 Student 3	92.1	85.20%	56.9	80.40%	78.6	85.60%	50.9	71.00%
C27 Student 4	93.0	88.80%	55.8	89.20%	90.8	71.60%	83.0	72.50%
C27 Student 5	81.2	91.20%	83.2	85.20%	90.4	88.80%	82.9	73.83%
C27 Student 6	88.4	87.20%	75.2	88.40%	76.9	90.00%	82.3	94.17%
C27 Student 7	86.8	83.20%	89.9	82.40%	91.2	66.00%	85.5	82.83%
C27 Student 8	90.7	57.60%	92.0	82.80%	90.4	74.80%	82.1	63.33%
C27 Student 9	100.0	98.40%	99.7	96.80%	100.0	90.00%	92.5	99.67%
C27 Student 10	97.4	92.40%	88.4	76.00%	96.4	82.40%	99.7	83.33%
C27 Student 11	98.8	72.80%	97.7	75.60%	88.8	45.20%	91.1	77.83%
C27 Student 12	98.0	90.00%	99.2	67.20%	99.0	89.60%	95.3	90.83%
C27 Student 13	91.6	80.40%	82.5	68.80%	86.1	58.80%	78.4	67.33%
C27 Student 14	86.6	69.20%	39.0	75.20%	89.6	71.60%	47.6	79.17%
C27 Student 15	92.3	74.80%	60.3	61.20%	79.5	78.40%	45.2	84.17%
C27 Student 16	97.9	87.20%	99.5	89.60%	97.7	81.20%	93.6	88.17%
C27 Student 17	68.3	74.80%	37.1	78.80%	15.1	82.80%	77.7	72.83%

Table 5: Block Average WebAssign Scores and Test Scores by Individual for C Hour.

Section D27 was the last section to have WebAssign due dates pushed to the end of the block, occurring during block four of instruction. The correlation between block four homework scores and scores on the comprehensive final exam is harder to make as only four of the 15 questions on the final were from block four material. However, some observations on student individual performance can still be made. D27 Student 4 saw a drop in block four WebAssign, but then pulled off a B+ on TEE. D27 Student 10 did no homework in block 4 and resulted in a low C- on the TEE. D27 Student 13 maintained a high WebAssign score and did well on the TEE. Only two of 18 students WebAssign scores dropped significantly in block four, which is an indicator good work ethic.

	Block 1	WPR 1	Block 2	WPR 2	Block 3	WPR 3	Block4	TEE
D27 Student 1	98.8	92.40%	96.5	78.80%	99.6	64.40%	99.7	70.33%
D27 Student 2	94.8	96.80%	94.1	97.20%	92.8	82.40%	92.1	86.83%
D27 Student 3	97.8	68.40%	93.8	59.60%	92.9	53.20%	87.8	65.50%
D27 Student 4	96.5	95.60%	77.9	90.00%	93.6	74.00%	49.1	88.00%
D27 Student 5	100.0	92.40%	100.0	64.40%	100.0	83.20%	100.0	93.17%
D27 Student 6	71.6	66.40%	70.0	60.00%	64.2	80.00%	57.4	68.33%
D27 Student 7	89.1	91.20%	82.2	88.40%	71.5	92.40%	85.8	87.67%
D27 Student 8	71.4	80.40%	52.5	68.40%	67.0	76.00%	74.4	80.00%
D27 Student 9	86.5	86.80%	69.6	81.20%	76.2	63.60%	77.8	77.50%
D27 Student 10	85.9	90.40%	51.8	75.60%	72.8	66.00%	0.0	71.50%
D27 Student 11	100.0	98.00%	100.0	98.00%	100.0	86.00%	99.7	93.33%
D27 Student 12	97.8	83.60%	94.8	85.60%	93.5	73.20%	85.0	76.83%
D27 Student 13	100.0	97.60%	96.9	89.60%	100.0	94.00%	100.0	93.83%
D27 Student 14	91.9	85.20%	75.1	82.40%	60.7	71.20%	79.6	71.67%
D27 Student 15	78.6	66.00%	19.9	67.60%	92.0	48.00%	94.1	64.83%
D27 Student 16	99.8	90.80%	90.7	86.40%	94.9	79.20%	100.0	84.50%
D27 Student 17	98.0	83.20%	85.9	82.40%	96.8	81.60%	87.9	85.00%
D27 Student 18	80.0	78.00%	68.9	82.80%	91.7	83.20%	75.9	78.17%

Table 6: Block Average WebAssign Scores and Test Scores by Individual for D Hour.

Upon completion of the course, students from sections B27, C27, and D27 were asked to participate in an online survey to provide qualitative feedback on the administering of WebAssign during the course. Only 28 of 53 students responded to this survey and provided additional insight into the assignment due date process. The specific questions asked of students can be found in Appendix 2. Of the students that participated, 86% agreed that WebAssign problems helped them prepare for class each day. However, only 64% agreed that changing the due date of WebAssign to the end of the block helped them to manage their time better. Twenty five percent disagreed with that comment while 10% felt neutral about it. After the assignment due dates were moved only 25% of the students reported to have continued to do all the lessons daily. Finally, 64% said that in reflection, the changing of the due dates for WebAssign assignments in MA205 was helpful to them. Twenty two percent admitted it was counterproductive, while 14% said it did not make a difference.

Students were then asked to provide positive and negative feedback on the WebAssign due date changes. This provides some insight into whether or not the changing of due dates of WebAssign caused a significant difference in students' homework and test scores. It also provides insight into whether or not effective habits of mind are being developed because of the daily online homework. A selection of the feedback is as follows:

#### Positive Feedback from Students on WebAssign due date Changes:

- The change allowed me to allocate valuable time to other classes that I did not need to spend on math.
- It allowed us to attempt the web assign after we covered the material [in class].
- Takes stress off sacrificing a grade in math for a grade in another class. I can always come back [to do math work later].

- This allows someone to put an assignment off if other graded assignments are more of a priority.
- [I was able to complete] my assignments in class when I did not understand the problem. I did not lose any points [and it] helped give me the opportunity to complete the WebAssign without any penalties.
- Allowed me more time to study and complete other work for math and other classes.
- I was able to push back the assignments to make room for more immediate graded events.
- [Gave me] more flexibility.
- It allowed students extra time on assignments that are more difficult.
- I liked being able to use what we learned from class that day in order to go back and work through problems from the previous night that I did not understand.

**Negative Feedback from Students on WebAssign due date changes:**

- I got complacent and stopped doing WebAssign entirely, yet still took the time to understand the concepts.
- Changing the due date can let the assignments get away from the cadets.
- Did give me quite a workload the night before [the assignments were due], but I still felt confident going into the WPR (B+).
- The change in due date allows people to blow off the assignments but with a little discipline, that problem can be fixed personally.
- Changing the due date caused me to sometimes do my WebAssign assignments later or in class.
- I had no motivation to complete the assignments daily.
- If you do not have the discipline to keep up on it, you hurt yourself by falling behind.
- Some students take it for granted and leave all the work for the end of the block, which is not a good idea.

This study then solicited feedback from the students that achieved an over 95% average on all the WebAssign assignments. This survey focused on student motivation, how and when the students completed the daily homework, and the level of effort they put into the assignments. The specific questions asked in this survey are available in Appendix 3. The comments here can be linked directly to math department's desired outcomes for effective habits of mind.

**Qualitative Feedback from students that scored 95% or better on WebAssign assignments:**

- I typically would complete my WebAssign for a whole week, the weekend before that week. [Outcome 4]
- Every Saturday, I sat down for a couple hours to complete the lessons for the upcoming week. [Outcomes 4 and 6].
- I personally aimed to achieve 100% in all the lessons. [Outcomes 4 and 6]
- I like that WebAssign forces cadets to actually work through problems, which to me is the best way to learn this type of material. [Outcomes 2, 3, 4, and 6]

- I always tried to successfully complete every assignment with a 100% so I felt confident about the material in class. [Outcomes 2, 3, 4, and 6]
- Pattern matching does occur sometimes but gaining the knowledge of the process is very important to me. [Outcomes 2 and 3]
- I recognized that I could get all of the WebAssign points if I just put the effort in. [Outcome 4]
- It was more of a personal motivation to prove that I can solve the problems given by WebAssign. [Outcomes 4 and 6]

## CONCLUSIONS

The results show some indications of effective and poor habits of mind development among individual students. However, the data requires further analysis of the effects of due date changes against a control group. For this, a 270-student control group was selected at random from the remaining 723 students in the course. The students in the control group were assessed on the identical online homework and graded tests, as were the students in the study. The homework and test scores of the students in the study are then compared to the scores from the 270-student control group. To determine if due date significantly affected the scores a four sample Tukey test (t-test) was performed, assuming equal variances between scores for the homework grades by block and the end of block assessments (WPRs and TEE). Figure 3 shows a boxplot of block three homework scores for each of the sections in the study compared with the scores of the control group. The black horizontal line represents the median, the star represents the mean, the dashed line shows the range of scores, and the hollow circles indicate any outliers to the data.

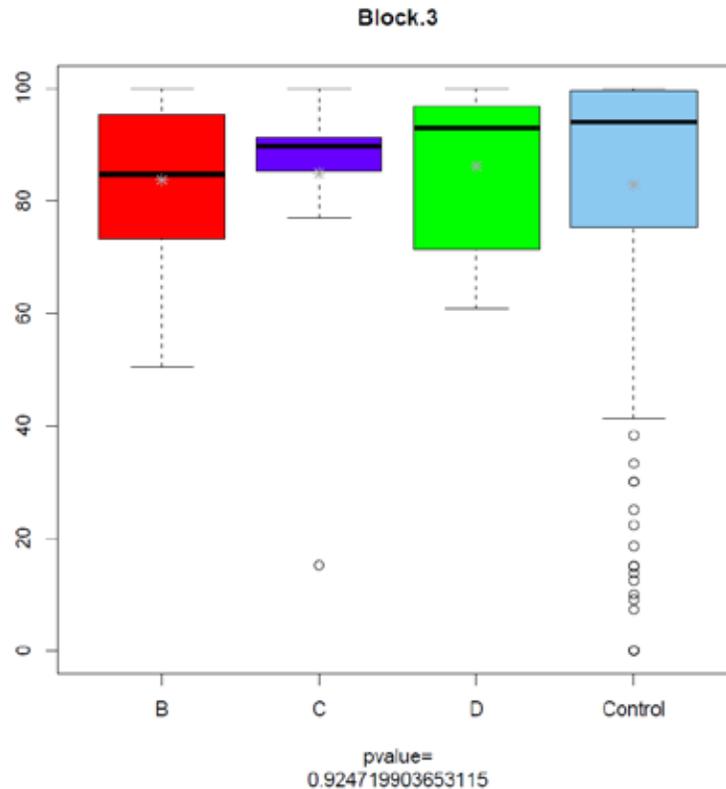


Figure 3: Boxplot for the Tukey-Test of WebAssign Homework grades for block.<sup>iv</sup>

To achieve significant findings from the treatment groups versus a control group, a p-value of 0.05 or lower must be obtained. Appendix 4 provides additional boxplots and p-values for each block of homework and for all four graded exams. For all of these boxplots the P-value was 0.288 or greater. Therefore, using a Tukey test and ANOVA in R there is no statistically significant difference between the group means of student performance on the online homework and test scores after suspense dates were moved with that of the control group. This indicates that the due dates of the online homework do not affect the overall performance of students on that homework and subsequent graded exams. However, homework and test scores are not necessarily indicative of effective habits of mind.

There are some individual indicators that the changes in homework due dates affect the development of habits of mind in the core mathematics program. Only nine of 53 students homework grades significantly dropped after the homework deadlines were moved. Six of those nine were in the section that had the suspense moved earliest. Therefore, effective habits of mind were being learned and maintained with the sections that had the due dates moved later. Section B27 started the semester with homework grades within 1.5% (block 1) of the other sections and finished the semester 9-10% below the other sections. This showed that the earlier the submission deadlines were moved resulted in a worse overall performance. Section C27 had the suspensions moved during block three and continued to perform well on daily homework. This showed that, collectively, effective habits of

mind were developed in the first two blocks of instruction. Section D27 maintained highest average even after deadlines were moved for block four. Finally, individuals with high WebAssign scores tended to maintain high scores, even after homework due dates were moved. These individuals, as reported in the results section, have already met many of the desired outcomes for effective habits of mind. The goal moving forward is to see if more students could achieve these outcomes during their time at USMA.

### **FUTURE WORK**

There are some good indicators that the daily web-based homework is helping students in the core math program in developing effective habits of mind. However, the due dates of assignment were not the only factor that contributed to students' assignment scores and completion rates. The study could not control for external factors such as workloads from other courses, extracurricular requirements, military duties and obligations, and additional constraints on students' time. In addition, each section was populated with students at random from the 800 students in the course. Therefore, each section did not contain the same number of students with previous calculus experience or identical past performance in related math courses. Future studies should be conducted to control for more of these variables to verify the results indicated in this work.

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<sup>i</sup> The views expressed in this article are those of the authors and do not reflect the official policy or position of the U.S. Military Academy, the Department of the Army, the Department of Defense, or the U.S. Government.

<sup>ii</sup> Department of Mathematical Sciences, USMA, Core Mathematics, Academic Year 2014-2015.

<sup>iii</sup> Ibid.

<sup>iv</sup> The analysis of the data with the Tukey-test and ANOVA in R was performed by Jarrod Shingleton. He also produced the boxplots in Figure 3 and Appendix 4 and provided them to the author.