Anxiety and Personality Factors Influencing the Completion Rates of Developmental Mathematics Students

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Students lacking core mathematical skills in algebra and arithmetic are traditionally placed into developmental mathematics courses at colleges and universities. These courses attempt to bridge the gap between students' existing skill sets and mastery levels needed to be successful at the level of college algebra, precalculus and calculus. In this paper we describe the interaction of anxiety and personality traits with course content completion for 404 students enrolled in a developmental mathematics course at a large research university in the United States.

Keywords: mathematics anxiety, personality, developmental, success.

INTRODUCTION

Students in developmental mathematics courses typically have major deficits in their ability to complete foundational arithmetic and algebraic manipulations. These deficits can lead to anxiety associated with mathematics courses, mathematics exams and/or numerical operations, creating a complex set of interactions between their underlying mathematical abilities, their existing personality traits, and the levels of anxiety they experience during a course. Connections between cognitive states and mathematical performance have been studied previously (Schoenfeld, 1983), and others have identified relationships between anxiety and performance (Ma and Xu, 2004) at the secondary level. In this project we seek to understand these relationships at the undergraduate level and to develop heuristics that can be used as indicators of detrimental internal states for students with the ultimate goal of building interventions that are adapted to different combinations of student abilities, anxiety levels and personality factors. In the fall semester of 2015 a series of surveys were administered to a cohort of students enrolled in a self-paced developmental mathematics course at our institution, a large research university in the United States, in an attempt to assess their anxiety levels, personality traits and career aspirations. In addition, data representing students' patterns of task completion were collected weekly. This collection of information along with the existing demographics of the student population have been analysed in an effort to identify patterns that facilitate or inhibit success. In the current work, we present several of these analyses and attempt to find indicators in the data that would be useful for future interventions.

The ultimate goal of the larger research project is to develop profiles of students intending to major in science, technology, engineering and mathematics (STEM) fields, are underprepared in mathematics yet have the potential to be successful. We will use longitudinal data collected over two years of following a STEM-intending cohort of students who begin in a developmental mathematics course.

At our institution, students enter mathematics courses based on either existing standardized exam scores or via a locally administered placement exam. Students not meeting minimum requirements for entry to a college level algebra course must enrol in a remedial course intended to develop their arithmetic and basic algebra skills. In this course students progress at their own pace through online modules facilitated by an instructor. In a given year, approximately 30% of 5,000 incoming first-year students place into this course. Of the 823 students enrolled in the course in fall 2015, 404 consented to participate in this study and responded to the surveys administered by the research team.

INSTRUMENTS

Anxiety related to mathematics has been studied extensively due to its impact on student performance. Richardson and Suinn (1972) define mathematics anxiety as 'feelings of tension' surrounding different aspects of mathematical thought. They developed the Mathematics Anxiety Rating Scale (MARS) to measure levels of anxiety in individuals by rating 98 items that present behavioural situations. In this way, MARS can gauge the level of mathematics related anxiety present in the emotional state of a student. The items focus on a self-evaluation of respondents' relationships with mathematical content and activities such as performing basic calculations, taking exams, and using a mathematics textbook. The instrument was validated for internal consistency and for test-retest reliability (Richardson and Suinn, 1972) on a population of university students in Missouri.

We collected data during the fall 2015 semester using the Abbreviated Mathematics Anxiety Rating Scare (AMARS) instrument (Alexander & Martray, 1989). This survey is an abbreviated version of the MARS instrument and consists of 25 items split into three categories focusing on Mathematics Exam Anxiety (EA, 15 items), Numerical Task Anxiety (NTA, 5 items), and Mathematics Course Anxiety (CA, 5 items). This instrument shows high internal consistency and has been shown to reliably measure anxiety levels among students (Peterson, Casillas & Robbins, 2006).

Hembree (1990) and Ashcraft & Krause (2007) have further observed that anxiety interacts strongly with mathematics performance by inhibiting working memory and creating a cycle of difficulty for students. Such a process is particularly damaging to the capabilities of students who are weak mathematically to start with (e.g. remedial students). We seek to monitor anxiety levels in a way that provides insight into the interaction of anxiety with course completion and persistence in STEM majors, especially those who begin their study in developmental coursework.

In order to understand the way that anxiety interacts with underlying student predispositions, we collected data to measure baseline personality traits in this population. To do this we utilized the Integrative Big-Five Trait Taxonomy and the corresponding Big Five Inventory survey (BFI) developed by John and Srivastava (1999). This instrument and its underlying framework identify five core groups of personality traits as a way of characterizing individual behaviour. This work is

founded on the notion that personality traits manifest as verbalizations, and that the five core groups identified in their work can be measured by a collection of test items that identify the levels of these traits present in a person's behaviour by their response to linguistic prompts. Survey respondents rate items using a five-point Likert scale from 'Disagree Strongly' to 'Agree Strongly' over a range of 44 statements such as 'I am someone who is talkative' or 'I am someone who tends to be lazy.' The responses are averaged across a defined group of questions to give a composite score in one of five personality areas including Extraversion (EV), Agreeability (AG), Conscientiousness (CS), Neuroticism (NR) and Openness (OP). This instrument has been validated on multiple populations (John, Naumann & Soto, 2008; John and Srivastava, 1999; Fossati, Borroni, Marchione & Maffei, 2011) and has high reliability for reporting these underlying personality trait levels (John and Srivastava, 1999)

SURVEY AND DEMOGRAPHIC DATA AND RESULTS

The values shown in the second column of Table 1 indicate the average levels of anxiety found in an average student in our population. These anxiety measures provide a way to compare the level of apprehension a student possesses to the average score found in a given group, and to look at the way anxiety levels compare to student performance. Personality trait measures given by the BFI for our cohort are given in the fourth column. For comparison, we note the values for a population of 468 college students surveyed in Peterson, Casillas & Robbins (2006) at other colleges and universities in the last column of Table 1. As noted in John, Naumann & Soto (2008) these values represent the relative level of these personality traits in our population. Several studies have compiled data related to the personality traits found in other populations but this group of students at a university are relevant to the current work.

We examined the breakdown of all these scores along a number of demographic categories including gender, ethnicity, high school grade point average (GPA) and major. Majors of students in the study were designated as STEM or non-STEM using the list of STEM fields maintained by the National Science Foundation cross-listed with major codes at the university and developed from student records. These data are presented in Tables 2 - 4.

The outputs from these analyses indicate that female students exhibit higher levels of Exam Anxiety. In addition, non-STEM intending students tended to maintain higher levels of anxiety. Neither of these was found to differ significantly between populations, however. It was observed and noted below that anxiety and Conscientiousness interact significantly with student success.

Anxiety levels and personality traits showed no discernable association to GPA and also did not differ between racial groups except those for Native American and

Pacific Islander groups. Further analysis is needed to see how these demographic factors interact with anxiety and personality traits.

Anxiety Factor	Average Anxiety N=404	Personality Trait	Average Score	2006 Study Average Score
Exam	52.11	EV	3.35	3.50
Task	10.41	AG	3.93	4.10
Course	11.44	CS	3.64	3.92
		NR	3.09	2.81
		OP	3.43	3.68

Table 1: Averages for anxiety levels and personality traits

	EA	NTA	CA	EV	AG	CS	NR	OP
Total (N = 404)	52.11	10.41	11.44	3.35	3.93	3.64	3.09	3.43
Non-STEM (N = 320)	52.55	10.32	11.60	3.39	3.93	3.65	3.10	3.43
STEM (N = 84)	50.44	10.74	10.83	3.20	3.93	3.61	2.04	3.43
F (N = 253)	54.18	10.34	11.36	3.37	4.01	3.70	3.27	3.40
M (N = 151)	48.64	10.53	11.56	3.33	3.80	3.54	2.78	3.48

Table 2: Average anxiety levels and personality traits for total respondent population, by major and gender

COURSE COMPLETION DATA AND RESULTS

Students complete this course by passing online exams administered in the Pearson MyMathLab system. They must demonstrate 80% mastery on each of seven chapter

exams, and then 70% mastery on a comprehensive final in order to pass the course. The number of students of the 404 survey respondents who had completed each of the seven exams and the final at the beginning of weeks five, six, eleven and twelve are shown in Table 5. Week five was the earliest available data. We chose week six to provide a one-week snapshot of student behaviour, and this observed the data again five weeks later for another set of indicators. Finally, we observed student performance again in week twelve to capture the same one-week change. In subsequent work the rate of progress over one week will be compared at the two different times to develop a 'rate of completion' model for the students. In the current work we focus on correlations with anxiety and personality traits.

High School GPA	EA	NA	CA	Total Anxiety	EV	AG	CS	NR	OP
<2.0	32.67	5.67	8.00	46.33	3.17	3.96	4.22	2.54	3.77
2.0-2.49	51.94	11.00	11.59	74.53	3.20	3.72	3.36	2.91	3.29
2.5-2.99	50.58	10.54	11.33	72.45	3.38	3.83	3.53	3.02	3.45
3.0-3.49	54.13	10.75	12.03	76.91	3.38	3.99	3.69	3.12	3.40
3.5-3.79	52.11	10.68	11.58	74.38	3.45	3.87	3.64	3.10	3.43
>3.8	51.64	9.56	10.39	71.58	3.14	4.15	3.81	3.18	3.36
No data	49.94	10.44	11.25	71.63	3.21	4.14	3.86	2.98	3.76

Table 3: Average anxiety levels and personality traits by high school GPA

Race	EA	NA	CA	Total Anxiety	EV	AG	CS	NV	OP
African American	51.42	12.09	13.42	76.94	3.20	3.85	3.73	2.90	3.46
Native American	58.88	12.75	13.88	85.50	3.23	3.60	3.41	3.45	3.26
Asian	52.45	13.27	13.82	79.55	3.25	3.88	3.44	3.07	3.53
Pacific Islander	48.00	9.50	16.00	73.50	3.88	3.44	3.33	3.75	3.90
Hispanic	54.54	11.54	12.46	78.54	3.57	4.01	3.68	2.84	3.58
No data	49.33	14.50	12.00	75.83	2.85	4.18	3.38	3.03	3.28
White	52.01	10.15	11.15	73.31	3.38	3.94	3.65	3.10	3.42

Table 4: Average anxiety levels and personality traits by ethnicity

Week	Exam							
	1	2	3	4	5	6	7	Final
Five	250	89	57	24	7	1	1	0
Six	288	140	89	36	12	2	1	0
Eleven	343	316	292	149	59	21	12	10
Twelve	346	330	325	265	160	68	33	23

Table 5: Number of students in completing exams by weeks

A graphic representation of these data shows that the overall trend of the population is a logistic response in the sense that over time, a small fraction of the students will complete the later exams followed slowly by the main bulk of the population. Some students will remain 'stuck' on earlier exams.

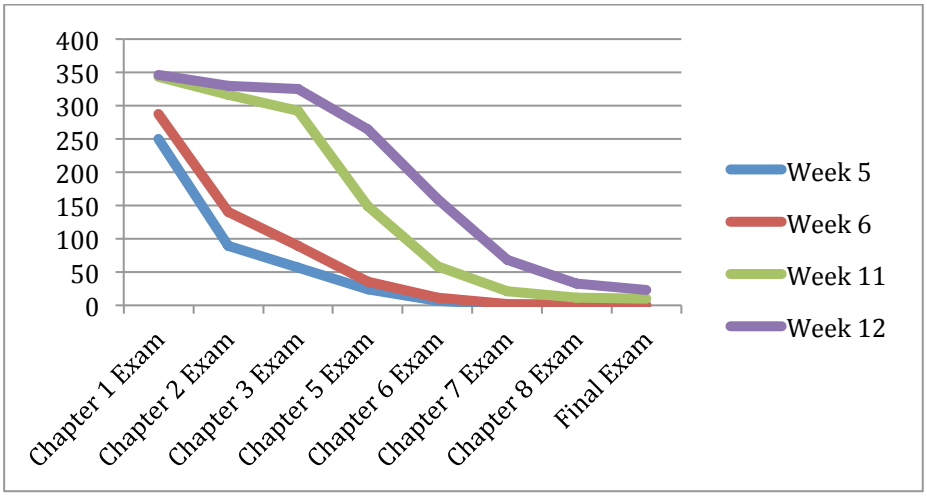

Figure 1: Number of exams completed by students at beginning and end of semester

Anxiety levels, personality traits and other demographic variables provide a method for analysing progress through these exams. First, we give the average number of exams completed at four points for the respondent student population and then for gender and STEM major subsets. In week 5, *N*=390 students were observed to be active in the course. By week 12, this number had dropped to *N*=382.

	Week 5	Week 6	Week 11	Week 12
Total (N=390)	1.09	1.44	3.06	3.97
Non-STEM (N=307)	1.09	1.44	2.99	3.87
STEM (N=83)	1.06	1.47	3.32	4.31
Female (N=244)	1.09	1.43	3.11	4.01
Male (N=146)	1.09	1.46	2.96	3.89

Table 6: Average number of completed exams by major and gender

Splitting the same data for STEM vs. non-STEM majors shows that as expected, STEM intending students are more motivated and attentive to the completion of course requirements. Interestingly, however, this distinction does not become apparent until week 11.

PERSONALITY, ANXIETY AND COMPLETION RATES

Completion rates can also be compared to anxiety levels. We first observe that average anxiety levels correlate negatively with completion. Specifically, for the *N=382* students who remained active in the course in week twelve, we present data relating anxiety measures and exam completion for each of the eight exams in the semester as noted in Table 7.

Exams Completed	EA	NA	CA
0	54.71	11.47	12.95
1	55.14	11.77	13.17
2	49.93	10.2	11.13
3	51.85	9.77	10.71
4	50.74	11.16	11.28
5	52.46	9.95	11.41
6	51.29	6.43	10.43
7	34	8	7
8	48.56	9.22	12
Total (N=382)	51.96	10.42	11.41

Table 7: Average anxiety levels by number of exams completed in week 12

Bivariate Pearson correlations measures were computed for all anxiety measures and personality trait levels against completion rates in weeks 5, 6, 11, and 12. Table 8 shows significant correlations of Conscientiousness with week eleven and week twelve completion rates, as well as between week twelve completion and both exam and course anxiety.

Linear regression models were constructed for exam completion in the twelfth week (EC_{12}) against both Conscientiousness (CS) and Exam Anxiety (EA). The functions representing these models were

$$EC_{12} = 2.605 + .374CS$$

$$EC_{12} = 4.812 - .016EA$$

Using these functions and hypothesizing that a student would need to have completed four out of eight exams by week twelve we see that students below CS=3.73 and above EA=50.75 are at risk of not completing the course. These values are close to

the population averages of EA=52.12 and CS=3.62 and provide guidance for identifying students at risk for failure.

		EA	CA	Total Anxiety	CS
Week 11	Pearson Correlation	-0.098	-0.093	-.112*	.106*
	Sig. (2-tailed)	0.056	0.069	0.029	0.038
Week 12	Pearson Correlation	-.103*	-.122*	-.121*	.111*
	Sig. (2-tailed)	0.044	0.017	0.018	0.03
** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).					

Table 8: Completion correlations with anxiety and personality factors

CONCLUSIONS AND DISCUSSION

As a first step to try to predict who will be successful in the self-paced Developmental Mathematics Course, we have analysed two possible contributing factors from the AMARS and the BFI measures. We see that anxiety, especially exam anxiety, seems to be a contributing factor to explain why students do not successfully complete the course requirements. It seems that students with higher exam anxiety may be avoiding taking exams and may run out of time at the end of the semester. It is also no real surprise that conscientiousness plays an important role in successful completion of the requirements for the course. We see that students need a higher than average conscientiousness score to be able to successfully complete the course requirements. These two factors will be further examined to determine if it is possible to provide interventions at the beginning of the semester to effect changes for students who indicate on these two measures that they are below cut-off values. Approximate cut values can be obtained using either t-test analyses or stronger correlation matrices for both anxiety levels and personality trait scores. These cut values will be the focus of future work and interventions. In particular, an analysis of these same data within the STEM intending subgroup would allow for interventions that may support the persistence of STEM identifying students.

Although, the self-paced course structure fits this type of Developmental Mathematics Course very well because students come in with such varied backgrounds, it is clear that the lack of deadlines and lack of strict oversight may be a problem with students who have higher exam anxiety or who have a lower conscientiousness score. In order to ensure success of students that exhibit these indicators, we need to provide interventions (e.g. peer coaches, suggested completion schedules) from the beginning that assist them in overcoming these barriers to success.

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