Success in a Statistics Course: How Important is Grit?

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Abstract

Success in a statistics course depends on many factors including student attitudes and behaviours. The aim of the present research was to examine the relationship between student success and student grit, which is defined as perseverance and passion for achieving long-term goals. In the first of two studies we had 24 students complete a self-assessment at the beginning of the semester. The responses were later evaluated using independent sample t-tests to determine what factors distinguish stronger students from weaker students. In the second study, 115 students were assessed at the end of the semester. The results of a Pearson correlation revealed that students' self-reflections were correlated with expected course grades and, as expected, stronger students reported behaviours consistent with grit. To the extent that pre-course and post-course assessments reveal student behaviours associated with academic success, the information may be useful in identifying promising students and in further developing those tendencies in all students.

Introduction

There is a rich body of literature examining approaches professors and institutions take to facilitate student learning. These including teaching learning skills (Feudel & Dietz, 2019), introducing innovative activities (Huynh & Baglin, 2017), and providing support (Dzator & Dzator, 2020; Gilbert, Hodds & Lawson, 2021; Grove, Croft, Lawson & Petrie, 2018; Mac an Bhaird, McGlinchey, Mulligan, O'Malley & O'Neill, 2021; Warwick, 2010). Each of these factors is associated with success in statistics courses. In the present paper we focus not on the actions of others, but on the attitudes and behaviours of the students themselves.

Regardless of ability level, the student who lacks confidence, has a negative attitude, or has a poor work ethic, is unlikely to succeed (Beilock & Maloney, 2015; Beilock & Willingham, 2014). Consequently, an important research goal is to determine what student behaviours are predictive of academic strength, and what course characteristics contribute to student success. With a better understanding of the relevant factors, educators can provide classroom experiences that motivate students and optimise learning (Mason & Grenier, 2005; Pan & Tang, 2004; Pan & Tang, 2005).

In previous research we have examined several factors associated with student success in statistics, including the student's ability and background, characteristics of the course, the classroom atmosphere, the student's attitude, and the student's behaviour. In a recent *Mathematics for Applications* paper (Mason & Reid, 2018), for example, we reported on research examining the relationship between course-related anxiety levels and performance in a statistics course. In a series of four studies, self-reported anxiety levels were found to negatively correlate with both expected and actual course grades (Mason & Reid, 2018). Students who were more anxious about the course tended to perform poorly. Anxiety levels

were found to drop within the first few weeks of class, and even as early as the first day of class, when course requirements were clear, the class atmosphere was relaxed, and support was readily available. Students attributed further drops in anxiety levels to frequent in-class exercises, which provided opportunities for guided practice, feedback, and confidence-building success.

Confidence is a student tendency that is associated with learning in general (Kaur & Pendergast, 2022; Stankov, Morony & Lee, 2014; Warwick 2010), and students who are successful in basic statistics courses tend to be those who have confidence in their analytical skills. Unfortunately, many students lack confidence because they fear a heavy workload, challenges beyond their perceived skill level, public embarrassment, and failing grades. The belief that they will receive poor grades may cause students to view the course as a potential barrier to graduate school, and they may fear it will limit their career options. As professors, we know the importance of background and skill level, but we also recognise the need for students to come to class with a positive attitude and a commitment to learning. The student who begins the course with a negative attitude is more likely to do poorly. As Henry Ford has been quoted as saying, "Whether you think you can, or you think you can't – you're right" (Goodreads, 2021).

Though students who are high in confidence and low in anxiety have an advantage in the classroom, success may be more directly related to another performance-related factor that has been the subject of recent research – grit (Akos & Kretchmar, 2017; Datu, 2021; Duckworth, Peterson, Matthews & Kelly, 2007; Duckworth & Quinn, 2009). When students persevere and demonstrate a passion for achieving long-term goals, even when a course is challenging for them, the students are said to have grit. Grit is envisioned as having two facets: consistency of interest and perseverance of effort. Research assessing the relationship of each facet to performance reveals that perseverance of effort is more strongly associated with successful performance (Credé, Tynan & Harms, 2017). The advantage of having the tenacity and determination to pursue a goal until you have reached a successful outcome is illustrated in the following quotation from Albert Einstein: "It's not that I'm so smart. It's just that I stay with problems longer." (Goodreads, 2024).

After completing a comprehensive review of the grit literature, Credé et al. (2017) suggested three factors that may moderate the relationship between grit and performance. One factor is individual differences such as ability and metacognition. Applying grit is more likely to lead to better performance when an individual has a greater potential for success and a greater ability to self-reflect. A second factor is the level of grit itself. Success will not come to those who fail to persist long enough to find a solution, nor will it come to those who demonstrate excessive grit by continuing too far on the wrong path. The third factor is the nature of the performance domain. Applying grit is more likely to lead to better performance when tasks are well defined.

Our goal was to assess the importance of grit in a course with well-defined tasks and expectations—statistics. We examined grit in statistics students by studying the relationships between the students' attitudes, behaviours, and grades. A major difference between the two studies is the time of measurement. We were interested in how students' grades at the end of the semester were related to their self-assessments at the start of the semester (Study 1) and to their self-assessments at the end of the semester (Study 2). In Study 1 we administered a questionnaire to new students, asking them to evaluate their own attitudes and behaviours relative to those of others taking the course. The students' responses were then correlated with their grades to determine the predictive value of self-assessments. Another approach was used

in Study 2, where we examined anonymous course evaluation forms. A series of questions on the forms asked students to reflect on their own course-related behaviours during the semester. Comparisons between the responses of more successful and less successful students were analysed to determine which behaviours were associated with success.

Study 1 and Study 2 were approved by the chair of the Institutional Review Board. The data collection was originally done to assess the course and to gather information that would help students understand what they needed to do to be successful. It was later proposed to the University Review Board that these data be further analysed and reported in a publication on statistics and grit. The chair of the Institutional Review Board determined that the research was exempt under 45 CFR 46.101 and did not require a case number. Because the data were originally collected for internal purposes, demographic information such as age, gender and race are not available. It can be noted, though, that a majority of the students who take our statistics course are 18-20 years old, Caucasian, and female.

Study 1: Pre-Assessments

Study 1 Methodology

Study 1 included all 24 students enrolled in a university statistics course that is typically taken in the student's second year. The students were from two sections taught by the same professor. The course, which is a required course for psychology majors, satisfies an analytical-skills distribution requirement for non-psychology majors. Though most of the students taking the course are psychology majors, a variety of other majors are represented as well. Based on our previous research on factors that lead to success in statistics classes, the course was designed to keep students involved and to keep anxiety levels low. For that reason, the class met in person three times each week, regular attendance and participation were expected, written homework was assigned two or three times a week, and tests were administered every two weeks. The professor and two upper-class student assistants were available in person and via email and video chat throughout the week, including weekends.

On the first day of class, students were given a 15-item questionnaire. The first 14 items described experiences, attitudes, skills, and behaviours that are related to success in a statistics course. For those items, students were asked to compare themselves to others taking the course. They were to use a seven-point Likert scale, writing "1" for an item if they thought they were far below average on that item, "4" if they thought they were similar to the average student, and "7" if they thought they were far above average on that item. Students were free to select any number from 1 to 7. The final question was an open-ended question: "What are your greatest concerns about the course?"

At the end of the semester, students were divided into two groups based on their final course grades. The 11 students who earned an "A" or a "B" were considered the stronger students and the 13 who earned a lower grade or withdrew were considered the weaker students.

Study 1 Results and Discussion

Descriptive statistics (means and standard deviations) for the responses of weaker and stronger students to each of the 14 complete, specific questionnaire items are provided in Table 1. All students responded to all questionnaire items. Responses and grades were treated as interval data and means were evaluated using IBS-SPSS independent sample t-tests, confidence intervals, and Cohen's d. Only one significant difference was revealed in comparisons of weaker and stronger students. Stronger students rated themselves higher on class attendance

($t(22) = 2.615$, p = 0.016, Cohen's d = 1.072, 95% CI [0.27, 2.33]). It should be noted that absences were rare in both groups.

There was a tendency, though not statistically significant, for stronger students to rate themselves higher for anxiety about the course, interest in statistics, and performance on homework. Surprisingly, weaker students rated themselves slightly higher on mathematical experience than stronger students did, and the standard deviation for mathematical experience was smaller for stronger students. Mathematical experience was the only item where weaker students rated themselves higher than the stronger students did. Although these results are intriguing, they are inconclusive based on the small sample size and the lack of statistical significance. We did not collect data that would allow us to assess actual differences in previous mathematical experiences.

Similarities were found in some of the ratings of weaker and stronger students. Both groups tended to rate themselves high (above 5 on the 7-point scale) on motivation to succeed in the course, comfort in working with others, class attendance, performance on homework, and grit. Grit was defined on the questionnaire as "perseverance and passion for long term goals." The finding that grit ratings were similar for weaker (M = 5.62) and stronger (M = 6.00) students is consistent with pilot work from our laboratory, where responses on the GRIT Scale (Duckworth & Quinn, 2009; Peterson, Matthews & Kelly, 2007) failed to correlate with grades in a statistics course. In both Study 1 of the present research and the pilot study, assessments of grit were made on the first day of class. It may be that, at the start of the semester, weaker and stronger students are similarly optimistic about their ability to persevere and maintain their passion for the long-term goal of success in the course. Study 2 examines self-assessments of course-related behaviours in a different sample of students at the end of the semester.

The item on which both groups rated themselves lowest was interest in statistics. Fortunately, earlier research involving the same course with the same professor demonstrated that student interest and appreciation for the course tends to increase as the course progresses (Mason, Battaglia & Ribble, 2016).

Table 1. Mean (M) Self-Ratings (1 = far below average to 7 = far above average) and Standard Deviations (SD) of Weaker and Stronger Students.

Questionnaire Item	Weaker Students		Stronger Students	
	M	SD	M	SD
Mathematics experience	4.46	1.56	4.09	0.30
Mathematics ability	4.38	1.56	4.55	0.93
Interest in statistics	3.00	1.22	3.55	1.13
Motivation to succeed in the course	5.62	1.39	6.45	0.69
Anxiety about the course	3.38	2.40	4.18	2.04
Comfort in working with others	5.54	1.71	5.64	1.43
Comfort in asking for help	4.69	1.60	5.00	1.61
Time available to commit to the course	4.77	1.24	5.18	1.40
Time management skills	4.69	1.49	5.64	1.29
Class attendance	5.15	1.21	6.45	1.21
Participation in class	4.23	1.54	4.64	1.21
Performance on homework	5.15	1.14	5.82	1.25

Performance on tests	4.31	1.25	4.55	1.13
Grit	5.62	1.26	6.00	1.10

In response to the open-ended question "What are your greatest concerns about the course?" students replied in predictable ways. Several students questioned their math skills or their ability to keep up with the workload. Others feared that they would not demonstrate a strong work ethic and would not seek help when they needed it. Still others expressed great concern that they would do poorly on tests and would fail the course. What was not expected is that weaker and stronger students expressed similar concerns.

Study 2: Post-Assessments

Study 2 Methodology

Study 2 included all 115 students enrolled in multiple sections of a university statistics course that is usually taken in the student's second year. All the sections were taught by the same professor. The course is the same course that was described in the methodology section of Study 1. Though the course structure and the professor were the same for the two studies, the data collection for Study 2 occurred in different semesters and with different students than the data collection for Study 1.

A standard course evaluation form that is used throughout the university was administered in class. This was done at the end of the semester, but before final exams. Student names were not associated with the data. In addition to evaluating the course, the form asked students to reflect on their own effort and diligence. They were also asked to report the grade they expected to receive in the course.

The self-reflection section of the questionnaire consisted of the 12 specific items shown in Table 2. Students were instructed to rate themselves using the following five-point scale: 0 = never, 1 = almost never, 2 = sometimes, 3 = usually, and 4 = always.

Table 2. Self-Reflection Section of Course Evaluation Form.

1. Attended class
2. Arrived for class on time
3. Completed assigned readings thoroughly and on time
4. Sought out and read material related to the course even though it was not assigned
5. Participated in class discussions
6. Paid attention and took notes during lectures and presentations
7. Completed assignments as directed and submitted them on time
8. Asked for clarification of unclear material or assignments
9. Thought about how the course material applies to me
10. Did my share of the work during group activities and assignments
11. Kept a record of my scores on tests and assignments
12. Did six or more hours of homework for this course each week

Study 2 Results and Discussion

Self-reflection scores were based on the sum of the ratings for the 12 items. Our interest was not in the responses to individual items, but in the students' overall effort in the course and how that related to the grades the students anticipated earning. All students responded to all

questionnaire items. The codomain of possible self-reflection scores was zero to 48, and the range of self-reflection scores for our sample was 30 to 48. Self-reflection scores and expected grades were treated as interval data and analysed using IBB-SPSS. A Pearson correlation between self-reflection scores and expected grades revealed a positive relationship, $r(113) = 0.244$, $p = 0.009$. Students with high self-reflection scores tended to report higher grades. In other words, those students who reported having been diligent and having made a great effort in class were on track to receive high grades. Because the questionnaires were anonymous, it was not possible to verify whether the students' expectations were realised. We could not compare expected grades with final grades. It is assumed, though, that the expected grades were highly correlated with the final course grades. The students knew ninety percent of their grades at the time they completed the questionnaire. The only grade that had not yet been determined was the final test grade, and the final test was a unit test that only represented ten percent of the course grade.

General Discussion and Conclusions

In summary, our research examined the relationship between student factors, such as course-related behaviours, and success in a statistics class. Study 1 included a pre-course assessment, where students evaluated themselves relative to others in the class. The responses of weaker and stronger students were compared on 14 questionnaire items. The greatest response difference between the two groups was on an item dealing with class attendance. At the start of the semester stronger students were more confident that they would attend class regularly. As previous research has shown, regular attendance in a statistics class is predictive of better performance (Khan, 2022). Though the stronger students expected to have stronger attendance, the actual attendance rates for weaker and stronger students were similar, with very few absences occurring in either group. Perhaps the structure of the course, which included daily homework assignments and biweekly tests, encouraged regular attendance in students who at the onset expected less of themselves.

Grit was addressed directly in Study 1, as one item asked students to rate their own grit relative to the grit of other statistics students. Grit was defined as "perseverance and passion for long-term goals." Both the weaker and the stronger students tended to rate their grit as high, with the stronger students considering themselves only slightly grittier than the weaker students. The fact that the weaker students rated themselves high on grit but were not able to perform at a high level, supports Credé et al.'s (2017) contention that the relationship between grit and performance may be moderated by domain-specific ability (in this case, statistics ability) and metacognition (in this case, the ability to assess oneself). In other words, though the weaker students believed they had a passion for long-term goals and would persevere, they may have been limited by their cognitive ability level and they may have overestimated the strength of their work ethic.

It is interesting to relate two of the questionnaire items in Study 1 with the two facets of grit. Grit is said to be composed of consistency of interest and perseverance of effort, and perseverance has been shown to be a stronger factor than interest in determining performance. Two relevant questionnaire items are interest in statistics and motivation to succeed in the course. Interest in statistics was given the lowest rating by both the weaker and the stronger students, while motivation to succeed in the course had one of the highest ratings for both groups. Students, regardless of which group they were in, showed relatively low interest, but high motivation and high grit.

In the second study, students were asked at the end of the semester to evaluate their own course-related behaviour throughout the semester. Students who reported having engaged in the most positive course-related behaviours were on track to receive high grades. Those who reported they had failed to engage in positive course-related behaviours expected lower grades. While Study 1 showed that some students who have the best of intentions at the beginning of the semester fail to achieve success, Study 2 showed that poorer students can retrospectively recognise that they did not put forth their best effort. This finding supports the idea that perseverance of effort is a critical aspect of grit when it comes to successful performance. Of course, we tend to put effort into the tasks that interest us, but interest alone is not sufficient, and a lack of interest need not lead to poor performance. If one has a low level of interest but is otherwise motivated (for example, by grades), then they may find success. Also, if effort leads to success, then success may lead to greater interest.

One limitation of both Study 1 and Study 2 is that they rely on self-report data. In Study 1 we collected pre-assessments, where students compared themselves to others taking the course. To the extent that students can accurately make such judgements, the data provide information about a student's relative strengths at the beginning of a class. Whether or not students are skilled at self-assessment, the data represent the students' perceptions of their strengths, which may still have value as a predictor of success.

In Study 2 we collected post-assessments, where students reflected on the semester and reported how diligent they had been. It is understood that students' memories are fallible, and they may overestimate or underestimate the time and effort they put into the course. Nevertheless, students' perceptions of their own efforts are interesting data to examine, especially as they relate to course outcomes.

Another limitation of Study 2 is that due to the anonymous nature of course evaluation forms and the fact that the evaluation was administered before the final test was taken, responses could not be matched with actual course grades. As was stated earlier, though, students knew 90% of their course grade at the time the questionnaire was administered. The correlation of self-reflections with course grades could be validated in a future study where all grades were determined before course evaluations were completed.

Our research was limited to statistics classes. Future research could determine the generalisability of our findings by replicating the studies in other areas. For example, the methodologies of the present studies could be used to examine student behaviours associated with success in a variety of mathematics courses. To the extent that pre-course assessment and post-course assessments help to identify student behaviours associated with academic success, the information could be used to identify promising students and to further develop those tendencies in all students.

The present research was exploratory in nature. Our findings should be assessed in future studies with larger samples. It would be of value, for example, to examine the factor structure of questionnaire data from a large sample. In addition, with a large sample, qualitative data could be collected using structured or open-ended questions and then coded for content analysis. Such studies would deepen our understanding of the relationship between student grit and academic success.

Finally, at the individual course level, we recommend that educators use pre-assessments of relevant course attitudes, skills, and behaviours. The assessments could be used to draw

students' attention to the critical factors associated with success. Furthermore, the information gathered could be used to identify those students who may need additional guidance and support.

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