Comparison of Grit Between STEM and Non-STEM College Students

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Abstract

Grit, or passion and perseverance in pursuing long-term goals, is a non-cognitive factor positively related to age and education level, and inversely related to frequent career changes (Duckworth, Peterson, Matthews, & Kelly, 2007; Duckworth & Quinn, 2009). It is less clear, however, whether undergraduate students in the midst of college study show more grit the further along they are in their program. Furthermore, for students in science, technology, engineering, and mathematics (STEM), low within-major grades, concerns over ill-preparedness after high school, and lack of confidence in laboratory skills, time management, and maintaining enthusiasm, may contribute to differences in grit between STEM and non-STEM majors during the early years of study (King, 2015; Otrel-Cass, Cowie, & Campbell, 2009; Seymour & Hewitt, 1997). With greater rates of students switching from STEM to non-STEM majors than in the opposite direction, despite little difference in grades between STEM majors who switch and those who persist, it seems that STEM majors with higher grit may remain in STEM programs, while those with lower grit may accumulate in non-STEM programs (Ackerman, Kanfer, & Calderwood, 2013; Brainard & Carlin, 1998; Kokkelenberg & Sinha, 2010; Seymour & Hewitt, 1997; Thompson & Bolin, 2011). Differences in STEM versus non-STEM grit also may depend upon whether social and behavioral science disciplines, and health science disciplines, are included in STEM (Chen & Soldner, 2013; Langdon, McKittrick, Beede, Khan, & Doms, 2011; National Science Board, 2015, 2016; U.S. Census Bureau, 2014, July 10).

The goal of this study is to test the following hypotheses: 1) undergraduates report increasing grit in going from freshman to senior level; 2) undergraduate STEM majors report lower grit than non-STEM majors early in college, but higher grit than non-STEM majors later in college; and 3) this difference is increased when social and behavioral sciences or health sciences are considered STEM, and decreased when considered non-STEM. Subjects for the study were undergraduate college students recruited through Mechanical Turk ("Amazon Mechanical Turk [Website]," 2018), as well as at a Pacific Northwest community college through posting of flyers, announcements in class, and general calls for participation via college email. Through online self-report, participants completed the eight-item Short Grit (Grit-S) Scale (Duckworth & Quinn, 2009), while also providing GPA and major field of study by self-report.

In general, this study finds that 1) four-year undergraduate subjects show higher scores in total Grit-S and the Consistency of Interest grit dimension when upper division (junior, senior) compared to lower division (freshman, sophomore), while community college students show higher Consistency of Interest when sophomore compared to freshman. Also, 2) STEM students generally show lower total Grit-S and Consistency of Interest compared to non-STEM students throughout college, but higher scores in the Perseverance of Effort grit dimension in the upper division. Additionally, 3) when considered STEM rather than non-STEM, health science students generally narrow the difference between STEM and non-STEM Grit-S and Consistency of Interest at the lower division, while social science students generally narrow that difference at the upper division.

Findings from this study will help post-secondary educators identify academic disciplines where persistence is more highly correlated to grit than other disciplines. Educators then can focus on modifying those identified programs, such as through academic and career advising, tutoring services, and teaching methods that may raise student engagement (e.g., use of internet-based components, in-class poll-taking activities, and in-class group exercises), to better address student grit levels and match students to programs of best fit (Brint, Cantwell, & Saxena, 2012; Community College Research Center & American Association of Community Colleges, n.d.; Gasiewski, Eagan, Garcia, Hartado, & Chang, 2012; Maltese & Tai, 2011).

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Chapter I

Introduction

Having the grit to complete a long-term goal is often likened to a marathon runner having the stamina, above and beyond ability, to complete a race (Duckworth et al., 2007). For instance, in a sample of psychology majors at the University of Pennsylvania, Duckworth et al. found that while grit, as measured by their Grit Scale, was positively correlated with academic performance as measured by grade point average (GPA) ($p <$ .01), the correlation was strengthened by controlling for innate intelligence as measured by SAT score ($p < .001$).

The Grit Scale is composed of self-report Likert-type items, six pertaining to consistency of interest, and six pertaining to perseverance of effort (Duckworth et al., 2007). In adult samples, Grit Scale scores increased with increasing level of education achieved ($p < .001$) (Duckworth et al., 2007). The Grit Scale subsequently was shortened to four items for both consistency of interest and perseverance of effort (Duckworth & Quinn, 2009). Using the shorter Grit-S Scale, Duckworth and Quinn found the total score to be positively correlated to GPA in a sample of middle- and high school students ($p < .001$). They also found that adult participants were 23-31% more likely to have a higher level of education compared to participants one standard deviation lower in Grit-S score. This percentage was maintained when controlled for the possible confounding factors of age and the five personality factors, often attributed to Norman (1963), of agreeableness, conscientiousness, extraversion, neuroticism, and openness (Duckworth &

Quinn, 2009; Eysenck, 1991). The Duckworth studies established correlational, rather than causal, relationships involving grit.

Besides education and GPA, the Grit and Grit-S Scales also predicted positive goal-oriented outcomes in non-academic pursuits. Both scales were significant predictors of West Point cadets completing summer training: Participants with grit scores one standard deviation above the mean were 36% (Grit) or 99% (Grit-S) more likely to complete summer training (Duckworth et al., 2007; Duckworth & Quinn, 2009). The same studies found the scales to be significant predictors of contestants advancing further in the Scripps National Spelling Bee: Participants with grit scores one standard deviation above the mean were 38% (Grit-S) or 86% (Grit) more likely to advance further in the competition. These studies suggested that grit was a characteristic demonstrated in a wide range of goal-oriented pursuits including, but not exclusive to, those in academia.

While grit levels were higher for adult participants with a college degree than those with only some or no college experience (Duckworth et al., 2007), it is less clear whether grit tends to be higher in undergraduate students farther along in their studies, or for certain academic disciplines such as those of science, technology, engineering, and mathematics (STEM). The U.S. Department of Commerce, Economics and Statistics Administration, reported that overall employment in STEM fields was expected to rise 17.0% from 2008 to 2018, compared to only 9.8% for non-STEM fields (Langdon et al., 2011). They further reported that 68% of those employed in STEM have earned at least a bachelor's degree, compared to 31% of non-STEM employees. Thus, STEM employment prospects appear healthy for the immediate future, though STEM employers seem to place particular importance on completion of STEM undergraduate programs

(Maltese & Tai, 2011). Therefore, grit and persistence to degree completion may be particularly beneficial to those pursuing STEM.

National data on undergraduate degree completion suggests that the percentage of students who initially declared a STEM major and graduated with a STEM degree, has not been consistently different than the percentages of initial non-STEM majors graduating with a non-STEM degree. From a 1988-2001 longitudinal study of college students initially recruited in eighth grade (National Center for Education Statistics, n.d.), rates of bachelor's degree recipients completing their program of original intention ranged from 41% (for social science) to 81% (for education), with STEM at 57% (King, 2015). In another study of 2003-2004 freshmen at U.S. institutions who completed bachelor's programs by 2009, initial program completion rates ranged from 48% (for education) to 66% (for social science), with STEM at 65% (Chen & Soldner, 2013). Chen and Soldner also reported that four-year program attrition was relatively stable across majors, ranging from 17% (social sciences) to 23% (humanities and business), with STEM at 20%. With substantial percentages of undergraduates not persisting to degree completion at all, let alone within their original majors, it would seem grit levels for both STEM and non-STEM majors would be higher as students progressed from freshman level to degree completion. These data also suggest that STEM students do not clearly struggle any more with degree completion than non-STEM students, so STEM students would not necessarily have a reason to show more grit than non-STEM students during this process.

Additional evidence, however, suggests that pathways to undergraduate degree completion are different for STEM and non-STEM students, and that the level of grit from year to year may be different for STEM and non-STEM students, beginning at least in secondary education. From the 1988-2001 longitudinal study of students initially recruited in eighth grade (National Center for Education Statistics, n.d.), Maltese and Tai (2011) found that participants were 44% more likely to persist to a degree in STEM if they had expressed STEM interest in eighth grade than if they had not (odds ratio = 1.44, $p < .05$). Maltese and Tai also found that taking more STEM high school classes was similarly correlated to STEM degree completion (odds ratio = 1.18, $p < .01$). Using the same dataset, King (2015) found that college students studying physical science or engineering not only had more advanced high school math preparation compared to those in other disciplines ($p < .01$), but also took more advanced English courses in high school compared to business, education, and humanities majors ($p < .01$). Thus, STEM students appeared to show signs of elevated overall perseverance of effort in high school, one of the major components of grit (Duckworth et al., 2007).

Data on Advanced Placement (AP) exams also has suggested elevated grit in pre-college STEM students. Among 26,693 students starting degree programs at the Georgia Institute of Technology (Georgia Tech) from 1999-2009, initial STEM majors took an average of 3.14 AP exams in high school, compared to 2.39 AP exams for initial non-STEM majors (Ackerman, Kanfer, & Calderwood, 2013). The same study found that initial STEM majors who eventually earned a non-STEM degree took fewer average AP exams (2.42, comparable to initial non-STEM majors) than students switching majors in the reverse direction (3.30, comparable to initial STEM majors). Data from this study also indicated that initial STEM majors received course credit from almost as many non-STEM AP exams as initial non-STEM majors (0.79 vs. 0.83 non-STEM exams per student, respectively), while also receiving course credit from far more STEM AP exams compared to initial non-STEM majors (0.84 vs. 0.24 STEM exams per student, respectively). Therefore, among students already with sufficient academic success to enter Georgia Tech, those more motivated to continue academic success, measured by number of AP exams taken, may gravitate towards STEM, even if that was not their original intent (Ackerman, Kanfer, & Calderwood, 2013). And, entering STEM students at Georgia Tech appeared to prepare better than non-STEM students for overall STEM and non-STEM college coursework, suggesting that entering STEM freshmen may show more grit through perseverance than entering non-STEM freshmen, above and beyond academic ability (Ackerman, Kanfer, & Calderwood, 2013; Duckworth et al., 2007).

However, other evidence suggests that these indicators of high school STEM preparation and achievement may have overestimated college STEM preparedness. Examining 2012 science and mathematics literacy data of 15-year-old student participants from the Program for International Student Assessment, the percentage of U.S. students scoring at the 90th percentile and above was 42% lower in the math assessment, and 23% lower in the science assessment, compared to all participating developed nations as a whole (National Science Board, 2016). Additionally, a study by Seymour and Hewitt (1997) of STEM majors at seven four-year institutions from 1990-1993, found that 24.2% of participants reported a loss of confidence in their STEM abilities after realizing that the level of performance sufficient for high grades in high school often was not enough to achieve similar success in college. Thus, U.S. high schools may not have prepared talented math and science students for college study as well as other developed nations, situating many of these students to experience feelings of academic inadequacy for the first time during the start of college, where those with lower grit may start to question their commitment to STEM (Duckworth et al., 2007; National Science Board, 2016; Seymour & Hewitt, 1997).

Data on course grades suggests that STEM courses typically do have lower mean grades than non-STEM courses. From the 1988-2001 longitudinal study of students initially recruited in eighth grade (National Center for Education Statistics, n.d.), King (2015) found that participants majoring in physical science, life science, or engineering, averaged a GPA of 2.64 to 2.68 for courses within their majors, compared to 2.92 for social science majors and 3.04 for humanities majors ($p < .01$). These findings were consistent with 1997-2007 data from a small northeastern liberal arts college, where five of the six lowest departmental GPAs came from STEM departments (2.78 for chemistry, to 3.02 for geology), while 12 of the 14 highest departmental GPAs came from non-STEM departments (3.03 for philosophy, to 3.36 for education) (Rask, 2010). King also found that physical science and engineering majors did 0.37 of a grade point better in courses that were not physical science or engineering, compared to physical science and engineering courses. Such discrepancy in major versus non-major grades may discourage STEM students from staying in their original majors (King, 2015). Rask concluded that better grade parity between STEM and non-STEM alone could result in 2-4% more students staying in college STEM departments.

Further, STEM students may be particularly apt to switch majors during the early college years (Kokkelenberg & Sinha, 2010). While 2003 data from a large Texas public institution indicated that STEM and non-STEM (specifically business and education) students all were more inclined to drop out of school during freshman year than other years (Thompson & Bolin, 2011), certain aspects of freshman and sophomore college education may impact STEM students more than non-STEM students. In Seymour and Hewitt's study (1997) of STEM majors at seven four-year institutions from 1990-1993, about 40% of participants, based on interviews and focus groups, expressed some feeling of college ill-preparedness based on high school experience, citing issues including lack of high school lab facilities, inconsistent quality of high school classes, and awarding of high grades regardless of effort. In a questionnaire study of second-year science and engineering students at a New Zealand university, 37% of respondents were concerned about confidence with lab equipment use (Otrel-Cass et al., 2009).

Otrel-Cass et al. (2009) also found almost half of the respondents to be concerned about maintaining balance between academic and non-academic life, handling school workload, and maintaining enthusiasm. Such concern about STEM workload agreed with findings of a 2008 survey of upper-division students at the University of California, with STEM participants showing the highest total weekly in-class and out-of-class study time (with engineering the very highest at 32.0 hours), and social science and humanities participants the lowest weekly study time (with humanities the very lowest at 24.4 hours) (Brint et al., 2012). Also, a longitudinal study by Brainard and Carlin (1998) of female engineering students at the University of Washington between 1991 and 1996, found that participant self-confidence in math and science, based on a five-point Likert-type scale, decreased markedly between freshman-year start (4.01 and 3.98, respectively) and end (3.37 and 3.52, respectively; $p < .001$). While issues of general time management and enthusiasm could apply to both STEM and non-STEM majors, added concerns of high-functioning quantitative skill and lab-related issues of time commitment and equipment competence, are important particularly within the STEM domain (Brainard & Carlin, 1998; Brint et al., 2012; Otrel-Cass et al., 2009).

Some have argued that lower STEM grades may be due partially to certain grading practices thought to be more prevalent in certain STEM disciplines, such as curve grading and rigid reliance on gatekeeper courses, meant purposely to deter certain students from STEM persistence (Dowd, 2000; King, 2015; Sabot & Wakeman-Linn, 1991). In a cross-sectional study of 2,750 biology, chemistry, and physics faculty participants in the 1999 National Study of Postsecondary Faculty, Goubeaud (2010) found that while over 60% of respondents in all three disciplines used short-answer exam questions for at least some of their courses, less than 53% used essay exam questions, less than 33% used writing assignments allowing students to submit multiple drafts for feedback, and though 58.9% of biology faculty respondents assigned term papers, less than 48% of chemistry and physics respondents did the same. The same study found that over 45% of chemistry and physics faculty respondents used curve grading in at least some courses, while only 27.4% of biology respondents did the same. These findings suggest that science faculty, particularly in more math-intensive disciplines, measure student success by methods that undervalue students' effort and potential for learning growth, and promote competition between students rather than collegiality (Goubeaud, 2010; Seymour & Hewitt, 1997).

Promise of good employment opportunities for STEM graduates (Langdon et al., 2011), along with the realization that non-STEM students with potentially higher GPAs likely would not vie for such jobs (Brighouse, 2008), may provide sufficient motivation for students to persist to STEM degree completion even with lower GPAs (King, 2015).

However, based on the 1988-2001 longitudinal study of students initially recruited in eighth grade (National Center for Education Statistics, n.d.), King (2015) determined that within-major GPA was the strongest predictor of persistence for physical science and engineering, compared to business, humanities, life science, and social science. Additionally, the longitudinal study of female engineering students at the University of Washington found that participants who switched out of the program had comparable GPAs, at the time of switching, compared to those who persisted, suggesting that difference in actual engineering-related ability was not a major reason for switching (Brainard & Carlin, 1998). Seymour and Hewitt's study (1997) of STEM majors at seven four-year institutions from 1990-1993, similarly found the mean GPA only to be 0.15 lower for switchers (3.0) versus persisters (3.15). Combined evidence suggests that small GPA reductions not large enough to indicate deficiencies in major discipline ability, may relate inversely to persistence more so for STEM than for other disciplines, despite motivation to persist that may come with future employment prospects (Brainard & Carlin, 1998; Brighouse, 2008; King, 2015; Langdon et al., 2011; Seymour & Hewitt, 1997).

Other studies indicate that STEM students have switched to non-STEM programs at a greater rate than non-STEM students switch into STEM programs. Of a 2003 cohort at a large Texas public institution, 27% of initial STEM majors ended up switching to a different major, compared to only 15% of initial business majors (Thompson & Bolin, 2011). Of 26,693 freshmen enrolled from 1999-2009 at Georgia Tech, an institution with a relatively high 87.8% initial STEM enrollment (Ackerman, Kanfer, & Beier, 2013; Ackerman, Kanfer, & Calderwood, 2013), of those who graduated, 15.0% of initial

STEM majors graduated with a non-STEM degree, compared to only 8.1% of initial non-STEM majors graduating with a STEM degree (Ackerman, Kanfer, & Calderwood, 2013). And, examining 1997-2007 engineering students at Binghamton University, roughly half the initial engineering majors switched to different majors, with only trace evidence of movement in the reverse direction (Kokkelenberg & Sinha, 2010). Such imbalance may be partly a logistical issue, as engineering programs are highly prescribed, requiring early program commitment by interested students should they wish to graduate on schedule (Kokkelenberg & Sinha, 2010). At the same time, non-STEM students, except for economics majors, tend to wait on committing to a major until junior year, making it difficult to switch to more sequenced and prescribed STEM programs at that stage, even for non-STEM students whose interests in STEM have grown stronger (Kokkelenberg & Sinha, 2010). Taken together, it seems that STEM programs may retain students through the later college years with higher levels of grit, as those with less perseverance and waning interest but comparable STEM ability may tend to switch majors and populate non-STEM programs already with students who may not feel as compelled to commit to a program until necessary (Brainard & Carlin, 1998; Duckworth et al., 2007; Kokkelenberg & Sinha, 2010; Seymour & Hewitt, 1997).

Complicating the question of different grit levels in STEM and non-STEM students, is a lack of consensus regarding which academic disciplines comprise STEM, and which do not, even between different agencies within the U.S. Government. While there is general agreement that traditional math, engineering, physical science, and life science college programs are considered STEM disciplines, recent reports from the National Science Board (2015, 2016) and U.S. Census Bureau (2014, July 10) included social and behavioral sciences as STEM disciplines, whereas reports from the U.S. Departments of Commerce (Langdon et al., 2011) and Education (Chen & Soldner, 2013) did not. Moreover, these recent reports also varied when considering health science disciplines (such as nursing) to be STEM, even though students in such programs often must take many introductory level math and science courses, often with laboratory components (e.g., University of Washington, 2018), thus facing issues similar to those of second-year science and engineering students (Otrel-Cass et al., 2009). And while some reports have suggested that social science majors experience GPAs and in-major degree completion levels lower than for math and science disciplines (King, 2015; Kuh & Hu, 1999), other reports have not (Chen & Soldner, 2013; Rask, 2010; Sabot & Wakeman-Linn, 1991), making it difficult to ascertain how including social and behavioral sciences in STEM might change average grit levels associated with STEM college study. However, Kuh and Hu also reported, based on mid-1980s and mid-1990s national college student samples from the College Student Experiences Questionnaire Research and Distribution Program, that social science majors showed higher grades in the last two college years compared to the first two years, while math and science grades were consistent across all four years. This could correlate to reports of higher grit in the final two years for STEM majors (Duckworth et al., 2007; Duckworth & Quinn, 2009), were social and behavioral sciences to be included.

In summary, seemingly college-ready STEM students may show signs of higher grit prior to college matriculation compared to non-STEM students, as STEM students tend to take more advanced high school classes and AP exams than non-STEM students (Ackerman, Kanfer, & Calderwood, 2013; King, 2015). However, once in college, STEM students may show signs of lower grit compared to non-STEM students, as some become overwhelmed by the high expectations prevalent in STEM programs early in college, and those accustomed to relying more on ability than stamina may question whether they should remain in STEM (Duckworth et al., 2007; Seymour & Hewitt, 1997). Further along in college, STEM students with higher grit are apt to stay in STEM, with those of lower grit populating non-STEM programs more, although students in general should show higher grit as they near degree completion (Duckworth et al., 2007).

In view of the described research, the goal of this study is to compare levels of grit in college students pursuing STEM versus non-STEM fields of study. Specifically, the proposed study aims to test the following hypotheses: 1) undergraduates report increasing grit in going from freshman to senior level; 2) undergraduate STEM majors report lower grit than non-STEM majors early in college, but higher grit than non-STEM majors later in college; and 3) this difference is increased when social and behavioral sciences or health sciences are considered STEM, and decreased when considered non-STEM.

Findings from this study will be useful in continuing development of college-level academic programs and associated support systems promoting student success, such as the guided pathways model, which aims to direct community college students through a specific plan of coursework based on aspirations, interests, and efficient program completion, and provide transparency as how content from different courses relate to each other (Community College Research Center & American Association of Community Colleges, 2015). A core component of the guided pathways model is a thorough advising plan to enhance student retention and degree completion (Community College Research

Center & American Association of Community Colleges, n.d.) . Thus, students in a STEM-related pathway may receive support that is tailored more to STEM-specific academic issues, with similar consideration for non-STEM students.

Findings on how grit may differ between STEM and non-STEM majors will help educators determine if there are specific points during the study of certain disciplines that warrant extra advising and tutoring efforts (Community College Research Center & American Association of Community Colleges, n.d.; Gasiewski et al., 2012). Studies also have suggested that certain teaching methods, such as the use of internet-based resources, in-class poll-taking activities, in-class group activities, and workshops, may help STEM students engage better with their coursework (Brint et al., 2012; Gasiewski et al., 2012; Maltese & Tai, 2011). Thus, findings from this study also may help educators identify courses tending to have students with lower grit, who may benefit greatly by having some of these methods included in course design. Additionally, any similarities or differences in grit levels between social science, health science, and science/engineering academic disciplines will provide further rationale as to which disciplines should be included in STEM, and which should not.

Chapter II

Method

Study design was approved by the Institutional Review Boards at both Harvard University and South Puget Sound Community College, Olympia, WA.

Participants

Participants for this study were college students recruited through Mechanical Turk, or MTurk ("Amazon Mechanical Turk [Website]," 2018), as well as students at a community college in the Pacific Northwest. Participants were recruited through campus posting of flyers, announcements in class, calls for participation via college email, and through a posting in MTurk using similar verbiage. The recruitment verbiage mentioned that current undergraduate college students of all different disciplines were needed for a study on important factors for college retention and completion.

Participant information was obtained via online self-report in November and December 2018. For completing the study survey, respondents were provided an opportunity to receive a $5 gift code or credit through either MTurk or Rybbon ("Rybbon [Website]," 2019). Respondents through MTurk were traceable through MTurk worker identification codes, while non-MTurk respondents seeking the gift code opportunity needed to supply an email address as their only personal identifying information, used only for the purpose of compensation. Exclusion criteria included age below 18 years old; participants unable to identify as a college freshman, sophomore, junior, or senior (based on class status or cumulative credits earned); and residents or citizens of a

European Union member, in recognition of the European Union General Data Protection Regulation (U.S. Department of Health & Human Services, 2018).

Measures

The Grit-S Scale was used to measure grit.

The Grit-S Scale

Created originally by Duckworth et al. (2007) as a 12-item online self-report characteristics inventory based upon interviews of highly successful professionals, the Grit-S Scale is an eight-item version of the original Grit Scale (Duckworth & Quinn, 2009). Using a five-point Likert-type scale for each item, four of the eight questions pertain to the dimension of consistency of interests over time, and four questions pertain to the dimension of perseverance of effort, the sum total of the responses constituting the grit score for that subject (Duckworth & Quinn, 2009). “I often set a goal but later choose to pursue a different one” is an example of a Consistency of Interest item, while “I finish whatever I begin” is an example of a Perseverance of Effort item (Duckworth & Quinn, 2009). In an adult sample, Duckworth and Quinn found strong correlation between original Grit and Grit-S scales ($r = .96$, $p < .001$), with good Grit-S internal consistency for total scale (□ = .82), consistency of interest (□ = .77), and perseverance of effort (□ = .70). A sample of Ivy League undergraduates also demonstrated good Grit-S internal consistency for total scale (□ = .83), consistency of interest (□ = .79), and perseverance of effort (□ = .78) (Duckworth & Quinn, 2009). And in an adult sample, the Grit-S Scale showed strong correlation with the conscientiousness component of the

Big Five Inventory ($r = .77$, $p < .001$) (Duckworth & Quinn, 2009; Eysenck, 1991; Norman, 1963).

The Grit-S Scale predicted that subjects one standard deviation above the mean value were 31% more likely to have achieved a higher level of education compared to the mean (Duckworth & Quinn, 2009). The Grit-S Scale also predicted that subjects one standard deviation above the mean value were 20% more likely to have made only no, one, or two career changes (Duckworth & Quinn, 2009). Ultimately, Duckworth and Quinn recommended use of the Grit-S Scale as a measure of grit, based on its strong consistency with the original Grit Scale, and for it being shorter by four items. However, the Duckworth studies established correlational, rather than causal, relationships involving grit. Additionally, the Duckworth studies did not establish score cutoffs for high and low grit, interpreting grit scores instead on a continuous scale.

For the current study, a published version of the Grit-S Scale was used where the items were distributed relatively evenly between Consistency of Interest and Perseverance of Effort items, using a five-point Likert-type scale per item (1: very much like me, to 5: not like me at all), with Perseverance of Effort items reverse-scored (Duckworth, 2007). Maximum total grit score (representing high grit) was 40: 20 for Consistency of Interest, and 20 for Perseverance of Effort (Duckworth, 2007; Duckworth & Quinn, 2009).

Procedure

Participants were directed to an online survey, to collect self-reported data. The study was administered through the SurveyMonkey website ("SurveyMonkey [Website]," 2017), with data subsequently exported and analyzed using IBM SPSS Statistics, Version 25 ("IBM SPSS Statistics Overview [Web page]," 2017).

Through the online survey, participants completed the Grit-S Scale. Participants also reported their current school type (community college, four-year undergraduate institution), age (selected categorically from 18-19, 20-21, 22-23, and 24 or above), current class status (freshman, sophomore, junior, senior) and intended academic field of study, using the categories set forth by Langdon et al. (2011) and 2012 data from the U.S. Census Bureau (2014, July 10) as guidelines. Based on those guidelines with associated examples, each participant selected one of the following categories as their intended academic field of study: computer, math, engineering, physical and life sciences, nursing and allied health (denoted hereinafter as "health science" or "health sciences"), social sciences, education (except if specific to any of the previous categories), liberal arts and history, business, literature and languages, visual and performing arts, communications, or other. For the current study, the first four field categories were considered traditional STEM, while the final seven field categories (including other) were considered non-STEM. Health sciences and social sciences initially were categorized as non-STEM, then sequentially shifted to STEM for later aspects of the study.

Participants also provided their current GPA by self-report. A study of 75 undergraduate students at a medium Midwestern university found strong correlation between self-reported and official documented cumulative GPA ($r = .97$; $p < .0001$), with average standard deviations between self-reported and actual GPA to be 0.22 GPA units at maximum (Cassady, 2001). Therefore, self-report was a reliable and convenient method for obtaining college GPA data, so long as the data was gathered in a conscientious and scholarly manner, and for informational, rather than policy-making, purposes (Cassady, 2001; Gonyea, 2005). For the current study, participants selected GPA categorically from 3.5-4.0 or A, 2.5-3.4 or B, 1.5-2.4 or C, 0.5-1.4 or D, and 0.0-0.4 or F.

Completion of the total survey typically took no longer than 20 minutes. Participants provided informed consent as the first question of the survey. Prior to providing informed consent, the survey website included information informing participants that 1) participation had no impact on course grades; 2) the survey would not be used as a clinical diagnostic tool; 3) participants could opt out of the survey at any time by closing the browser tab for the survey; 4) email addresses from non-MTurk participants would be collected from those interested in gift code compensation, and for that purpose only; 5) each participant could complete the survey only once; and 6) all questions needed to be answered in order to complete the survey.

Chapter III

Results

After having received 728 responses, 35 incomplete responses were excluded, while 21 responses strongly suspected to be duplicate respondents (based on identical MTurk worker identification codes or email addresses) also were excluded. Additionally, 15 responses were excluded for responding that they had begun the survey anywhere between March and August, when the correct response was either November or December. Therefore, a total of 657 responses were retained and subsequently analyzed for this study.

Of these 657 respondents, 447 identified as current students at a four-year institution, while 210 identified as current students at a community college. 101 students identified as college freshmen (57 from community college), 147 as sophomores (68 from community college), 186 as juniors (56 from community college), and 223 as seniors (29 from community college). Slightly more than half of respondents reported their current age as 22 or above, and the mean self-reported grade of respondents fell between A and B.

Stepwise multiple regression analysis was conducted on respondent data to establish predictive ability of school type (scored as 0 if community college, 1 if four-year undergraduate institution), age (1 if 18-19, 2 if 20-21, 3 if 22-23, 4 if 24 or above) and GPA (5 if A, 4 if B, 3 if C, 2 if D, 1 if F), on total Grit-S score, as well as subscores of the Grit-S dimensions of Consistency of Interest and Perseverance of Effort. Stepwise inclusion of predictor variables allowed for determination of the significance of each added variable above and beyond the previous step. Results are summarized in Table 1 (Models 1 and 2).

School type was the strongest positive predictor of total Grit-S, Consistency of Interest, and Perseverance of Effort (Model 1), for students at four-year institutions over community colleges ($F(1, 655) = 30.654$, $p < .001$; $F(1, 655) = 29.984$, $p < .001$; and $F(1, 655) = 9.268$, $p = .002$, respectively). Inclusion of GPA (Model 2) was positively correlated to Grit-S ($F(2, 654) = 17.757$, $p = .031$) and Perseverance of Effort ($F(2, 654) = 8.249$, $p = .008$) but not Consistency of Interest ($p = .264$). Age was not a significant predictor for total Grit-S ($p = .323$), Consistency of Interest ($p = .060$) or Perseverance of Effort ($p = .312$).

Hypothesis #1

To test the hypothesis that undergraduates report increasing grit in going from freshman to senior level, the stepwise multiple regression models for Grit-S, Consistency of Interest, and Perseverance of Effort, extended to include a predictor variable for class status (scored as 1 if freshman, 2 if sophomore, 3 if junior, 4 if senior), or alternatively an indicator variable for division status (0 if freshman or sophomore (lower-division), 1 if junior or senior (upper-division)). Results are summarized in Table 1 (Models 3 through 7).

While stepwise inclusion of class status (Model 3) was shown to be a positive predictor for total Grit-S, although just missing significance ($F(3, 653) = 13.151$, $p = .052$), it was a significant positive predictor for Consistency of Interest ($F(2, 654) = 18.387$, $p = .011$) with increasing class status (from freshman to senior). Class status was not a significant predictor of Perseverance of Effort ($p = .781$).

Table 1

Stepwise Multiple Regression Analyses Predicting Grit-S, Consistency of Interest, and Perseverance of Effort in College Students.

	Grit-S				Consistency of Interest				Perseverance of Effort			
Predictor	*B*	*SE B*	ΔR^2	ΔF	*B*	*SE B*	ΔR^2	ΔF	*B*	*SE B*	ΔR^2	ΔF
Model 1			.045	30.7**			.044	30.0**			.014	9.3**
Constant	25.92**	0.38			10.29**	.28			15.63**	.19		
Sch type	2.56**	0.46			1.85**	.34			0.71**	.23		
Model 2			.007	4.7*			- -	- -			.011	7.1**
Constant	23.26**	1.29			- -	- -			13.97**	.65		
Sch type	2.44**	0.46			- -	- -			0.64**	.23		
GPA	0.63*	0.29			- -	- -			0.39**	.15		
Model 3			.005	3.8†			.009	6.5*			.000	0.1
Constant	22.51**	1.34			9.38**	.45			13.92**	.68		
Sch type	2.12**	0.49			1.53**	.36			0.62*	.25		
GPA	0.59*	0.29			*ns*	- -			0.39**	.15		
Class	0.42†	0.21			0.40*	.16			0.03	.11		
Model 4			.007	4.8*			.010	7.2**			.000	0.3
Constant	23.02**	1.29			9.92**	.31			13.94**	.65		
Sch type	2.12**	0.48			1.56**	.35			0.60*	.25		
GPA	0.59*	0.29			*ns*	- -			0.39**	.15		
Up div	1.02*	0.47			0.91**	.34			0.13	.24		
Model 5			.000	0.04			.000	0.1			.000	0.0
Constant	23.09**	1.33			9.99**	.36			13.93**	.67		
Sch type	2.02**	0.70			1.42**	.51			0.62†	.35		
GPA	0.59*	0.29			*ns*	- -			0.39**	.15		
Up div	0.90	0.77			0.74	.56			0.16	.39		
UdX4y	0.19	0.97			0.27	.71			-0.04	.49		
Model 6			.007	4.8*			.010	7.2**			.000	0.3
Constant	24.04**	1.33			10.83**	.34			14.07**	.67		
Sch type	2.12**	0.48			1.56**	.35			0.60*	.25		
GPA	0.59*	0.29			*ns*	- -			0.39**	.15		
Lo div	-1.02*	.47			-0.91**	.34			-0.13	.24		
Model 7			.000	0.04			.000	0.1			.000	0.0
Constant	23.99**	1.37			10.73**	.44			14.09**	.69		
Sch type	2.21**	.67			1.68**	.49			0.58†	.34		
GPA	.59*	.29			*ns*	- -			0.39**	.15		
Lo div	-1.09†	.58			-1.01*	.43			-0.12	.30		
LdXCc	.19	.97			0.27	.71			-0.04	.49		

Note. $N = 657$. For Models 1-4, 6, tolerance ≥ .875 for all included predictor variables.
Hierarchical sequence of stepwise models: {1, 2, 3}; {1, 2, 4, 5}; {1, 2, 6, 7}.
Sch type = school type (community college, four-year institution); Class = class status (freshman, sophomore, junior, senior); GPA = grade point average; Up div = upper division (junior, senior) students; Udx4y = (upper division) x (four-year institution) interaction term; Lo div = lower division (freshman, sophomore) students; LdxCc = (lower division) x (community college) interaction term; *ns* = not significant ($p \geq .264$).
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$.

Replacement of class status with an indicator variable representing division status (Up div, coded as 0 = lower division, 1 = upper division) improved model predictive ability for total Grit-S ($F(3, 653) = 13.509$, $p = .029$), and Consistency of Interest ($F(2, 654) = 18.726$, $p = .008$) (Model 4), both with positive correlations. However, as with class status, upper division status was not a significant predictor of Perseverance of Effort ($F(3, 653) = 5.598$, $p = .576$).

Upper-division status is achieved predominately at four-year institutions rather than community colleges. Even though tolerance levels did not fall below .875 for any of the included predictor variables, suggesting lack of multicollinearity between predictors, an interaction term (UdX4y) was added to the model to assess whether the combination of four-year institution enrollment and upper-division status was a significant predictor of grit above and beyond these variables independently (Model 5). The interaction term was not a significant predictor of total Grit-S ($F(4, 652) = 10.127$, $p = .844$), Consistency of Interest ($F(3, 653) = 12.156$, $p = .703$), or Perseverance of Effort ($F(4, 652) = 4.194$, $p = .934$). Furthermore, inclusion of the interaction term resulted in upper division status being rendered non-significant for all three grit models (p = .245, .192, and .687, respectively). Switching the indicator variable to lower division status (Model 6) and the interaction term with one combining community college enrollment with lower-division status (Model 7) yielded similar findings, although lower-division status remained a significant negative predictor of Consistency of Interest even with the interaction term ($p = .018$).

Additional inspection of participant data broken down by class status and analyzed by independent samples *t*-tests, revealed that participants from four-year institutions generally had higher mean scores for Grit-S, Consistency of Interest, and Perseverance of Effort, compared to community college participants of the same class status. Results are summarized in Table 2.

Table 2

Grit-S, Consistency of Interest, and Perseverance of Effort scores, based on school type and class status.

			Grit-S			Consistency of Interest			Perseverance of Effort		
School type	Class status	*n*	*M*	*SD*	*t*	*M*	*SD*	*t*	*M*	*SD*	*t*
Com col	Fr	57	25.26	5.09		9.11	4.02		16.16	3.05	
	So	68	25.81	5.08	-0.60	10.74	3.46	-2.44*	15.07	3.11	1.96†
	Jr	56	27.30	5.52	-1.57	11.57	3.67	-1.30	15.73	2.82	-1.22
	Sr	29	24.79	3.65	2.51*	9.10	3.17	3.07**	15.69	2.49	0.07
4-yr inst	Fr	44	27.19	6.24		11.05	4.65		16.14	2.98	
	So	79	27.85	4.87	-0.66	11.61	3.84	-0.72	16.24	2.35	-0.21
	Jr	130	28.62	6.10	-1.01	12.40	4.39	-1.33	16.22	2.74	0.05
	Sr	194	28.92	5.60	-0.46	12.42	3.95	-0.05	16.50	2.76	-0.89

Note. Com col = community college; 4-yr inst = four-year institution; Fr = freshman; So = sophomore; Jr = junior; Sr = senior.
†$p < .10$ compared to previous class. *$p < .05$ compared to previous class. **$p < .01$ compared to previous class.

Mean scores for four-year institution participants generally increased with increasing class status, although differences in values between adjoining years were not statistically significant. For community college participants, mean Grit-S score decreased significantly for seniors compared to juniors ($\Delta M = 2.51047$, $t(77.933) = 2.507$, $p = .014$, 95% CI [0.51709, 4.50385]), while mean Consistency of Interest score increased significantly for sophomores compared to freshmen ($\Delta M = -1.63003$, $t(123) = -2.435$, $p = .016$, 95% CI [-2.95490, -0.30516]) but decreased significantly for seniors compared to juniors ($\Delta M = -2.46798$, $t(83) = 3.074$, $p = .003$, 95% CI [0.87094, 4.06502]). Mean Perseverance of Effort score decreased for community college sophomores compared to freshmen, but the difference barely failed to reach significance (ΔM = 1.08437, $t(123)$ = 1.959, p = .052, 95% CI [-0.01114, 2.17987]).

Student participants then were grouped according to school type (community college, four-year institution) and lower division (freshman, sophomore) or upper division (junior, senior), and analyzed groupwise by independent samples *t*-tests. Results are summarized in Table 3.

Table 3

Grit-S, Consistency of Interest, and Perseverance of Effort scores, based on school type and lower or upper division.

			Grit-S			Consistency of Interest			Perseverance of Effort		
Group 1	Group 2	*n*	*M*	*SD*	*t*	*M*	*SD*	*t*	*M*	*SD*	*t*
Com col	Lo div	125	25.56	5.07	-1.24	9.99	3.80	-1.40	15.57	3.12	-0.36
	Up div	85	26.45	5.08		10.73	3.68		15.72	2.70	
4-yr inst	Lo div	123	27.61	5.39	-1.98*	11.41	4.14	-2.30*	16.20	2.58	-0.65
	Up div	324	28.80	5.80		12.41	4.13		16.39	2.75	
Lo div	Com col	125	25.56	5.07	-3.09**	9.99	3.80	-2.80**	15.57	3.12	-1.75†
	4-yr inst	123	27.61	5.39		11.41	4.14		16.20	2.58	
Up div	Com col	85	26.45	5.08	-3.42**	10.73	3.68	-3.42**	15.72	2.70	-2.01*
	4-yr inst	324	28.80	5.80		12.41	4.13		16.39	2.75	

Note. Com col = community college; 4-yr inst = four-year institution; Lo div = lower-division student (freshman or sophomore); Up div = upper-division student (junior or senior).
†$p < .10$. *$p < .05$. **$p < .01$.

Community college students did not exhibit any significant difference in mean Grit-S, Consistency of Interest, or Perseverance of Effort, between lower- and upper-division students. However, upper-division students at four-year institutions showed significant increases compared to lower-division students in mean Grit-S (ΔM = -1.19271, $t(445)$ = -1.979, p = .048, 95% CI [-2.37701, -0.00842]) and mean

Consistency of Interest (ΔM = -1.00708, $t(445)$ = -2.303, p = .022, 95% CI [-1.86659, -0.14757]), but not mean Perseverance of Effort (ΔM = -0.18564, $t(445)$ = -0.648, p = .518, 95% CI [-0.74891, 0.37763]).

Among participants reporting as lower-division students, those at four-year institutions reported significantly greater scores than those at community college, for mean Grit-S (ΔM = -2.04976, $t(246)$ = -3.085, p = .002, 95% CI [-3.35857, -0.74094]) and mean Consistency of Interest (ΔM = -1.41450, $t(246)$ = -2.804, p =.005, 95% CI [-2.40806, -0.42094]), but not mean Perseverance of Effort (ΔM = -0.63525, $t(239.105)$ = -1.749, p =.082, 95% CI [-1.35086, 0.08035]). Among participants reporting as upper-division students, those at four-year institutions reported significantly greater scores than those at community college, not only for mean Grit-S (ΔM = -2.35541, $t(407)$ = -3.416, p = .001, 95% CI [-3.71102, -0.99980]) and mean Consistency of Interest (ΔM = -1.68417, $t(407)$ = -3.422, p =.001, 95% CI [-2.65160, -0.71673]), but also mean Perseverance of Effort (ΔM = -0.67124, $t(407)$ = -2.010, p =.045, 95% CI [-1.32771, -0.01477]).

Hypothesis #2

To test the hypothesis that undergraduate STEM majors report lower grit than non-STEM majors early in college, but higher grit than non-STEM majors later in college, the earlier stepwise multiple regressions for Grit-S, Consistency of Interest, and Perseverance of Effort, were modified to include four indicator variables as predictors: lower-division non-STEM students, lower-division STEM students, upper-division non-STEM students, and upper-division STEM students (in each case coded as 0 if no, 1 if yes). Criteria for fields of study considered STEM was based on the U.S. Department of

Commerce definition that excludes social, behavioral, and health sciences (Langdon et al., 2011). Results are summarized in Table 4.

For total Grit-S, stepwise inclusion of an indicator variable representing lower-division students with STEM academic focus (L St) resulted in significant negative correlation with total Grit-S above and beyond school type and GPA ($F(3, 653) = 15.567$, $p = .001$). Subsequent stepwise inclusion of an indicator variable representing upper-division students with non-STEM academic focus (U NSt) resulted in further significant correlation, this time positive, with total Grit-S ($F(4, 652) = 13.050$, $p = .023$). Indicator variables for lower-division non-STEM students (L NSt; $p = .363$) and upper-division STEM students (U St; $p = .363$) were not significant predictors of total Grit-S.

For Consistency of Interest, stepwise inclusion of indicator variables yielded significant positive correlation above and beyond school type and GPA for upper-division non-STEM ($F(2, 654) = 30.464$, $p < .001$), significant negative correlation for lower-division STEM ($F(3, 653) = 23.588$, $p = .003$), and significant positive correlation for lower-division non-STEM ($F(4, 652) = 18.843$, $p = .04$). For Perseverance of Effort, none of the indicator variables were significant predictors, although upper-division STEM was positively-correlated but not quite to a significant level ($F(3, 653) = 6.748$, $p = .056$). When the indicator variable showing the next strongest correlation above and beyond school type and GPA, upper-division non-STEM ($p = .116$), was included in the model, it rendered both variables not significant ($p = .185$ for upper-division STEM, .452 for upper-division non-STEM).

Table 4

Stepwise Multiple Regression Analyses Predicting Grit-S, Consistency of Interest, and Perseverance of Effort in STEM and non-STEM College Students.

	Grit-S				Consistency of Interest				Perseverance of Effort			
Predictor	*B*	*SE B*	ΔR^2	ΔF	*B*	*SE B*	ΔR^2	ΔF	*B*	*SE B*	ΔR^2	ΔF
Model 1			.045	30.7**			.044	30.0**			.- -	- -
Constant	25.92**	0.38			10.29**	.28			- -	- -		
Sch type	2.56**	0.46			1.85**	.34			- -	- -		
Model 2			.007	4.7*			- -	- -			.025	8.2**
Constant	23.26**	1.29			- -	- -			13.97**	.65		
Sch type	2.44**	0.46			- -	- -			0.64**	.23		
GPA	0.63*	0.29			- -	- -			0.39**	.15		
Model 3			.015	10.7**			.041	29.6**			.005	3.7†
Constant	24.05**	1.30			9.98**	.28			13.94**	.65		
Sch type	2.09**	0.47			1.64**	.33			0.55*	.24		
GPA	0.60*	0.29			*ns*	- -			0.38*	.15		
L NSt	- -	- -			- -	- -			- -	- -		
L St	-1.66**	0.51			- -	- -			- -	- -		
U NSt	- -	- -			2.01**	.37			- -	- -		
U St	- -	- -			- -	- -			0.43†	.23		
Model 4			.007	5.2*			.013	9.1**			.001	0.6
Constant	23.71**	1.31			10.48**	.32			13.98**	.65		
Sch type	2.04**	0.47			1.43**	.34			0.59*	.24		
GPA	0.60*	0.29			*ns*	- -			0.38*	.15		
L NSt	- -	- -			- -	- -			- -	- -		
L St	-1.31*	0.53			-1.15**	.38			- -	- -		
U NSt	1.22*	0.53			1.67**	.38			-0.22	.30		
U St	- -	- -			- -	- -			0.34	.26		
Model 5			- -	- -			.006	4.3*			- -	- -
Constant	- -	- -			10.12**	.37			- -	- -		
Sch type	- -	- -			1.57**	.34			- -	- -		
GPA	- -	- -			*ns*	- -			- -	- -		
L NSt	- -	- -			1.02*	.50			- -	- -		
L St	- -	- -			-0.86*	.41			- -	- -		
U NSt	- -	- -			1.92**	.40			- -	- -		
U St	- -	- -			††	- -			- -	- -		

Note. $N = 657$. Tolerance ≥ .902, .761, and .948, for all included predictor variables for Grit-S, Consistency of Interest, and Perseverance of Effort through Model 3, respectively.
Sch type = school type (community college, four-year institution); GPA = grade point average; L = lower division (freshman, sophomore) students; U = upper division (junior, senior) students; St = STEM (science, technology, engineering, math) academic focus (excluding health and social sciences); NSt = non-STEM academic focus; *ns* = not significant ($p > .25$).
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$. ††.000 minimum tolerance.

Because MTurk is a computer-based work platform, it was possible that MTurk workers identifying as STEM students may have been skewed more towards computer-based STEM disciplines compared to non-computer STEM disciplines, posing a potential bias in STEM grit scores. Therefore, a comparison of grit scores for non-STEM, computer-based STEM (identifying "computer" as intended academic field of study), and non-computer STEM students was conducted. Results are presented in Table 5.

Table 5

Grit-S, Consistency of Interest, and Perseverance of Effort scores for lower- and upper-division college students, comparing non-STEM, computer-based STEM, non-computer STEM areas of discipline.

			Grit-S			Consistency of Interest			Perseverance of Effort		
Group 1	Group 2	*n*	*M*	*SD*	t^{a}	*M*	*SD*	t^{a}	*M*	*SD*	t^{a}
Lo div	NC Stem	93	25.84	4.69	-0.36	10.09	3.65	0.23	15.75	2.75	-0.94
	C Stem	68	26.12	5.09		9.94	4.16		16.18	2.90	
	Non-Stem	87	27.72	5.95	$1.77^{\dagger}$	11.93	4.06	3.00^{**}	15.79	3.00	-0.80
Up div	NC Stem	139	26.71	5.20	-3.52^{**}	10.78	3.91	-2.53^{*}	15.94	2.62	-3.45^{**}
	C Stem	120	29.14	5.82		12.06	4.23		17.08	2.73	
	Non-Stem	150	29.13	5.85	-0.01	13.26	3.79	2.46^{*}	15.87	2.76	-3.60^{**}

Note. Lo div = lower-division student (freshman or sophomore); Up div = upper-division student (junior or senior); NC Stem = non-computer-based STEM (science, technology, engineering, math) academic focus (excluding health and social sciences); C Stem = computer-based STEM academic focus; Non-Stem = non-STEM academic focus.
[a]Compared to C Stem.
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$.

With lower-division participants, computer-based STEM students had an intermediate mean Grit-S score compared to non-computer STEM students (ΔM = -0.27894, $t(159)$ = -0.359, p = 0.720, 95% CI [-1.81251, 1.25463]) and non-STEM students (ΔM = 1.60649, $t(153)$ = 1.774, p = .078, 95% CI [-0.18247, 3.39545]), barely missing significance to the non-STEM mean. In contrast, with upper-division participants, computer-based STEM students had a mean Grit-S score slightly above that for non-STEM students (ΔM = -0.00833, $t(268)$ = -0.012, p = .991, 95% CI [-1.41576, 1.39909]), and significantly greater than that for non-computer STEM students (ΔM = -2.42944, $t(240.963)$ = -3.517, p = .001, 95% CI [-3.78999, -1.06889]).

Regarding Consistency of Interest, among lower-division participants, computer-based STEM students had a slightly lower mean score compared to non-computer STEM students (ΔM = 0.14485, $t(159)$ = 0.234, p = .815, 95% CI [-1.07514, 1.36483]), and a significantly lower score compared to non-STEM students (ΔM = 1.98986, $t(153)$ = 2.996, p = .003, 95% CI [0.67790, 3.30182]). For upper-division participants, computer-based STEM students had an intermediate mean score significantly greater than non-computer STEM students (ΔM = -1.28135, $t(257)$ = -2.531, p = .012, 95% CI [-2.27837, -0.28434]), and significantly less than non-STEM students (ΔM = 1.20167, $t(268)$ = 2.458, p = .015, 95% CI [0.23899, 2.16434]).

With Perseverance of Effort, for lower-division participants, computer-based STEM students had a greater mean value than both non-computer STEM students (ΔM = -0.42378, $t(159)$ = -0.944, p = .347, 95% CI [-1.31059, 0.46303]) and non-STEM students (ΔM = -0.38337, $t(153)$ = -.800, p = .425, 95% CI [-1.32978, 0.56305]), though neither difference was statistically significant. However, for upper-division participants, computer-based STEM students had a significantly greater mean value compared to both non-computer STEM students (ΔM = -1.14808, $t(257)$ = -3.447, p = .001, 95% CI [-1.80388, -0.49228]) and non-STEM students (ΔM = -1.21000, $t(268)$ = -3.601, $p < .001$, 95% CI [-1.87165, -0.54835]).

Student participants divided into lower-division non-STEM, lower-division STEM, upper-division non-STEM, and upper-division STEM groups, subsequently were compared groupwise by independent samples *t*-tests, for total Grit-S, Consistency of Interest, and Perseverance of Effort. Results are summarized in Table 6 for students at four-year institutions, and Table 7 for students at community college.

Table 6

Grit-S, Consistency of Interest, and Perseverance of Effort scores for lower- and upper-division college students at four-year institutions, comparing STEM and non-STEM areas of discipline.

			Grit-S			Consistency of Interest			Perseverance of Effort		
Group 1	Group 2	*n*	*M*	*SD*	*t*	*M*	*SD*	*t*	*M*	*SD*	*t*
Lo div	Non-Stem	44	28.52	5.49	1.41	12.45	4.12	2.13^{*}	16.07	2.56	-0.43
	Stem	79	27.10	5.30		10.82	4.06		16.28	2.61	
Up div	Non-Stem	117	29.51	6.08	$1.66^{\dagger}$	13.64	3.82	4.12^{**}	15.87	2.84	-2.57^{*}
	Stem	207	28.40	5.61		11.72	4.14		16.68	2.66	
Non-Stem	Lo div	44	28.52	5.49	-0.95	12.45	4.12	$-1.72^{\dagger}$	16.07	2.56	0.40
	Up div	117	29.51	6.08		13.64	3.82		15.87	2.84	
Stem	Lo div	79	27.10	5.30	$-1.78^{\dagger}$	10.82	4.06	-1.65	16.28	2.61	-1.15
	Up div	207	28.40	5.61		11.72	4.14		16.68	2.66	

Note. Lo div = lower-division student (freshman or sophomore); Up div = upper-division student (junior or senior); Stem = STEM (science, technology, engineering, math) academic focus (excluding health and social sciences); Non-Stem = non-STEM academic focus.
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$.

At four-year institutions, mean Grit-S was greater for upper-division non-STEM students compared to upper-division STEM students ($\Delta M = 1.11185$, $t(322) = 1.662$, $p = .097$, 95% CI [-0.20433, 2.42804]) and for upper-division STEM students compared to lower-division STEM students ($\Delta M = -1.29970$, $t(284) = -1.778$, $p = .076$, 95% CI [-2.73820, 0.13880]), though neither difference reached a significant level. For

Consistency of Interest, mean score was significantly greater for lower-division non-STEM students compared to lower-division STEM students (ΔM = 1.63176, $t(121)$ = 2.126, p = .036, 95% CI [0.11223, 3.15129]), as well as for upper-division non-STEM students compared to upper-division STEM students (ΔM = 1.92122, $t(322)$ = 4.124, p < .001, 95% CI [1.00480, 2.83764]). Additionally, the mean score was greater for upper-division versus lower-division for both non-STEM students (ΔM = -1.18648, $t(159)$ = -1.718, p = .088, 95% CI [-2.55016, 0.17720]) and STEM students (ΔM = -0.89702, $t(284)$ = -1.648, p = .101, 95% CI [-1.96866, 0.17462]), though just failing to reach significance in both cases. For Perseverance of Effort, mean score was significantly greater for upper-division STEM compared to upper-division non-STEM students (ΔM = -0.80936, $t(322)$ = -2.565, p = .011, 95% CI [-1.43009, -0.18864]).

Table 7

Grit-S, Consistency of Interest, and Perseverance of Effort scores for lower- and upper-division college students at community college, comparing STEM and non-STEM areas of discipline.

			Grit-S			Consistency of Interest			Perseverance of Effort		
Group 1	Group 2	*n*	*M*	*SD*	*t*	*M*	*SD*	*t*	*M*	*SD*	*t*
Lo div	Non-Stem	43	26.91	6.36	$1.92^{\dagger}$	11.40	3.97	3.09^{**}	15.51	3.40	-0.15
	Stem	82	24.85	4.12		9.26	3.51		15.60	2.98	
Up div	Non-Stem	33	27.79	4.79	$1.97^{\dagger}$	11.91	3.39	2.42^{*}	15.88	2.47	0.44
	Stem	52	25.60	5.12		9.98	3.69		15.62	2.85	
Non-Stem	Lo div	43	26.91	6.36	-0.66	11.40	3.97	-0.60	15.51	3.40	-0.52
	Up div	33	27.79	4.79		11.91	3.39		15.88	2.47	
Stem	Lo div	82	24.85	4.12	-0.88	9.26	3.51	-1.14	15.60	2.98	-0.03
	Up div	52	25.60	5.12		9.98	3.69		15.62	2.85	

Note. Lo div = lower-division student (freshman or sophomore); Up div = upper-division student (junior or senior); Stem = STEM (science, technology, engineering, math) academic focus (excluding health and social sciences); Non-Stem = non-STEM academic focus.
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$.

Regarding community college students, mean Grit-S score was greater for lower-division non-STEM compared to lower-division STEM (ΔM = 2.05332, t(61.020) = 1.917, p = .060, 95% CI [-0.08841, 4.19505]) and upper-division non-STEM compared to upper-division STEM (ΔM = 2.19172, t(83) = 1.972, p = .052, 95% CI [-0.01896, 4.40241]), with neither difference reaching a significant level. For Consistency of Interest, as with four-year institutions, mean score for community college was significantly greater for lower-division non-STEM students compared to lower-division STEM students (ΔM = 2.13925, t(123) = 3.091, p = .002, 95% CI [0.76930, 3.50921]), as well as for upper-division non-STEM students compared to upper-division STEM students (ΔM = 1.92832, t(83) = 2.420, p = .018, 95% CI [0.34361, 3.51303]). For Perseverance of Effort, groupwise comparison did not reveal any discernible difference within the community college sample.

Hypothesis #3

To test the hypothesis that difference between STEM and non-STEM grit is increased when social and behavioral sciences or health sciences are considered STEM, and decreased when considered non-STEM, the earlier stepwise multiple regression models for Grit-S, Consistency of Interest, and Perseverance of Effort, were modified so that health science participants originally classified in the predictor variables for upper-division or lower-division non-STEM, now were classified as STEM. Social science participants subsequently were included in STEM as well. Results are summarized in Table 8 for health science as STEM, and Table 9 for health and social science as STEM.

Table 8

Stepwise Multiple Regression Analyses Predicting Grit-S, Consistency of Interest, and Perseverance of Effort in STEM (Including Health Science) and non-STEM College Students.

Predictor	Grit-S				Consistency of Interest				Perseverance of Effort			
	B	*SE B*	ΔR^2	ΔF	*B*	*SE B*	ΔR^2	ΔF	*B*	*SE B*	ΔR^2	ΔF
Model 1			.045	30.7**			.044	30.0**			.- -	- -
Constant	25.92**	0.38			10.29**	.28			- -	- -		
Sch type	2.56**	0.46			1.85**	.34			- -	- -		
Model 2			.007	4.7*			- -	- -			.025	8.2**
Constant	23.26**	1.29			- -	- -			13.97**	.65		
Sch type	2.44**	0.46			- -	- -			0.64**	.23		
GPA	0.63*	0.29			- -	- -			0.39**	.15		
Model 3			.011	7.66**			.038	26.8**			.007	4.6*
Constant	23.06**	1.28			10.02**	.28			13.93**	.65		
Sch type	2.29**	0.46			1.65**	.33			0.54*	.24		
GPA	0.63*	0.29			*ns*	- -			0.38*	.15		
L NSth	- -	- -			- -	- -			- -	- -		
L Sth	- -	- -			- -	- -			- -	- -		
U NSth	1.47**	0.53			1.98**	.38			- -	- -		
U Sth	- -	- -			- -	- -			.48*	.22		
Model 4			- -	- -			.006	4.5*			.002	1.1
Constant	- -	- -			10.42**	.34			13.98**	.65		
Sch type	- -	- -			1.46**	.34			0.59*	.24		
GPA	- -	- -			*ns*	- -			0.38*	.15		
L NSth	- -	- -			- -	- -			- -	- -		
L Sth	- -	- -			-0.79*	.37			- -	- -		
U NSth	- -	- -			1.73**	.40			-0.31	.30		
U Sth	- -	- -			- -	- -			0.36	.25		

Note. $N = 657$. Tolerance ≥ .974, .837, and .948, for all included predictor variables for Grit-S, Consistency of Interest, and Perseverance of Effort through Model 3, respectively.
Sch type = school type (community college, four-year institution); GPA = grade point average; L = lower division (freshman, sophomore) students; U = upper division (junior, senior) students; Sth = STEM academic focus (including health science); NSth = non-Sth academic focus; *ns* = not significant ($p > .25$).
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$.

With the shift of 24 lower-division and 14 upper-division health science students to STEM, identification as upper-division non-STEM (Table 8, Model 3) gained significance as a positive predictor of total Grit-S above and beyond school type and GPA ($F(3, 653) = 14.514$, $p = .006$), versus prior to the shift (Table 4, Model 4). Lower-division STEM, a significant negative predictor of total Grit-S prior to the shift, no longer was a significant predictor upon health science inclusion ($p = .075$).

For the Consistency of Interest subscore (Table 8, Model 3), upper-division non-STEM remained a significant positive predictor above and beyond school type, upon health science removal ($F(2, 654) = 28.972$, $p < .001$). However, in Model 4, lower-division non-STEM was no longer significantly positively-correlated upon health science removal ($p = .210$), while lower-division STEM remained significantly negatively-correlated upon health science inclusion ($F(3, 653) = 20.918$, $p = .034$).

For the Perseverance of Effort subscore, upper-division STEM became a significant positive predictor upon inclusion of health science above and beyond school type and GPA ($F(3, 653) = 7.052$, $p = .033$), where it was a non-significant positive predictor when health science was excluded (Table 4, Model 3). When the indicator variable showing the next strongest correlation above and beyond school type and GPA, upper-division non-STEM ($p = .056$), was included in the model, it rendered both variables not significant ($p = .161$ for upper-division STEM, .302 for upper-division non-STEM).

In examining correlational differences in Grit-S for STEM upon inclusion of both health and social science disciplines (Table 9, Model 3), 10 lower-division and 34 upper-division social science students also were shifted to STEM. Under these conditions, upper-division non-STEM, a positive predictor of Grit-S both before and after shifting health science to STEM, was rendered not significant upon also shifting social science to STEM ($p = .196$). In the same model, lower-division STEM, rendered not significant upon health science inclusion, returned to being a significant negative predictor of Grit-S above and beyond school type and GPA, when social science also was included in STEM ($F(3, 653) = 14.729$, $p = .004$).

Table 9

Stepwise Multiple Regression Analyses Predicting Grit-S, Consistency of Interest, and Perseverance of Effort in STEM (Including Health and Social Science) and non-STEM College Students.

	Grit-S				Consistency of Interest				Perseverance of Effort			
Predictor	*B*	*SE B*	ΔR^2	ΔF	*B*	*SE B*	ΔR^2	ΔF	*B*	*SE B*	ΔR^2	ΔF
Model 1			.045	30.7**			.044	30.0**			.- -	- -
Constant	25.92**	0.38			10.29**	.28			- -	- -		
Sch type	2.56**	0.46			1.85**	.34			- -	- -		
Model 2			.007	4.7*			- -	- -			.025	8.2**
Constant	23.26**	1.29			- -	- -			13.97**	.65		
Sch type	2.44**	0.46			- -	- -			0.64**	.23		
GPA	0.63*	0.29			- -	- -			0.39**	.15		
Model 3			.012	8.28**			.023	16.3**			.005	3.6†
Constant	24.11**	1.31			10.10**	.28			13.93**	.65		
Sch type	2.04**	0.48			1.73**	.34			0.53*	.24		
GPA	0.60*	0.29			*ns*	- -			0.38*	.15		
L NSths	- -	- -			- -	- -			- -	- -		
L Sths	-1.41**	0.49			- -	- -			- -	- -		
U NSths	- -	- -			1.74**	.43			- -	- -		
U Sths	- -	- -			- -	- -			0.42†	.22		
Model 4			- -	- -			.012	8.6**			.002	1.2
Constant	- -	- -			10.67**	.34			13.98**	.65		
Sch type	- -	- -			1.44**	.35			0.59*	.24		
GPA	- -	- -			*ns*	- -			0.38*	.15		
L NSths	- -	- -			- -	- -			- -	- -		
L Sths	- -	- -			-1.08**	.37			- -	- -		
U NSths	- -	- -			1.39**	.44			-0.37	.33		
U Sths	- -	- -			- -	- -			0.30	.25		

Note. $N = 657$. Tolerance ≥ .910, .847, and .936, for all included predictor variables for Grit-S, Consistency of Interest, and Perseverance of Effort through Model 3, respectively.
Sch type = school type (community college, four-year institution); GPA = grade point average; L = lower division (freshman, sophomore) students; U = upper division (junior, senior) students; Sths = STEM academic focus (including health and social science); NSths = non-Sths academic focus; *ns* = not significant ($p > .25$).
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$.

For the Consistency of Interest subscore (Table 9, Model 3), upper-division non-STEM remained a significant positive predictor with the removal of both health and social science disciplines from non-STEM ($F(2, 654) = 23.470$, $p < .001$). In Model 4, lower-division STEM remained a significant negative predictor of Consistency of Interest with inclusion of both health and social sciences in STEM ($F(3, 653) = 18.682$, $p = .004$).

For the Perseverance of Effort subscore (Table 9, Model 3), upper-division STEM, a significant positive predictor upon health science inclusion, returned to being not significant when social science disciplines also were included in STEM ($F(3, 653) = 6.726$, $p = .058$). When the indicator variable showing the next strongest correlation above and beyond school type and GPA, upper-division non-STEM ($p = .067$), was included in the model (Model 4), it rendered both variables not significant ($p = .222$ for upper-division STEM, .265 for upper-division non-STEM).

Groupwise grit component comparisons by independent samples *t*-tests of lower-division non-STEM, lower-division STEM (including health science but not social science), upper-division non-STEM, and upper-division STEM (including health science but not social science), are summarized in Table 10 for students at four-year institutions, and Table 11 for students at community college. At four-year institutions, the non-significant increase in mean Grit-S observed in upper-division non-STEM compared to STEM students, in Table 6, diminished further in Table 10 when health science was shifted from non-STEM to STEM ($\Delta M = 0.83914$, $t(322) = 1.226$, $p = .221$, 95% CI [-0.50770, 2.18599]). However, the non-significant increase observed in upper-division compared to lower-division STEM students, in Table 6, was maintained in Table 10 when health science was shifted from non-STEM to STEM (ΔM = -1.24948, $t(302)$ = -1.797, p = .073, 95% CI [-2.61808, 0.11911]).

Table 10

Grit-S, Consistency of Interest, and Perseverance of Effort scores for lower- and upper-division college students at four-year institutions, comparing STEM (including health science) and non-STEM areas of discipline.

			Grit-S			Consistency of Interest			Perseverance of Effort		
Group 1	Group 2	*n*	*M*	*SD*	*t*	*M*	*SD*	*t*	*M*	*SD*	*t*
Lo div	Non-Stem	36	28.42	5.89	1.07	12.44	4.38	1.81†	15.97	2.62	-0.64
	Stem	87	27.28	5.17		10.98	3.98		16.30	2.57	
Up div	Non-Stem	107	29.36	6.17	1.23	13.58	3.86	3.64**	15.79	2.87	-2.80**
	Stem	217	28.52	5.60		11.84	4.14		16.69	2.65	
Non-Stem	Lo div	36	28.42	5.89	-0.81	12.44	4.38	-1.47	15.97	2.62	0.35
	Up div	107	29.36	6.17		13.58	3.86		15.79	2.87	
Stem	Lo div	87	27.28	5.17	-1.80†	10.98	3.98	-1.66†	16.30	2.57	-1.16
	Up div	217	28.52	5.60		11.84	4.14		16.69	2.65	

Note. Lo div = lower-division student (freshman or sophomore); Up div = upper-division student (junior or senior); Stem = STEM (science, technology, engineering, math) academic focus (including health science); Non-Stem = non-STEM academic focus.
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$.

For Consistency of Interest, the significantly greater mean for lower-division non-STEM compared to STEM students, in Table 6, diminished to non-significant levels in Table 10 upon shifting health science to STEM (ΔM = 1.46743, $t(121)$ = 1.806, p = .073, 95% CI [-0.14146, 3.07633]). However, the significantly greater mean for upper-division non-STEM compared to STEM students, in Table 6, was maintained in Table 10 after shifting health science to STEM (ΔM = 1.74073, $t(322)$ = 3.639, $p < .001$, 95% CI [0.79953, 2.68193]). The non-significant increase in mean Consistency of Interest observed in upper-division compared to lower-division non-STEM students, in Table 6, diminished further in Table 10 upon shifting health science to STEM (ΔM = -1.13499, t(141) = -1.474, p = .143, 95% CI [-2.65691, 0.38692]). Meanwhile, the non-significant increase in mean value for upper-division compared to lower-division STEM students, in Table 6, widened in Table 10 upon shifting health science to STEM, though still not reaching significant levels (ΔM = -0.86170, t(302) = -1.658, p = .098, 95% CI [-1.88438, 0.16098]).

For Perseverance of Effort, the significant increase in mean value for upper-division STEM compared to non-STEM students observed in Table 6, widened in Table 10 upon shifting health science to STEM (ΔM = -0.90159, t(322) = -2.803, p = .005, 95% CI [-1.53431, -0.26887]). All other comparisons showing no significant difference in Perseverance of Effort, in Table 6, remained essentially unchanged in Table 10 upon shifting health science to STEM.

Regarding community college students, the non-significant increase in mean Grit-S for lower-division non-STEM compared to STEM students, in Table 7, diminished in Table 11 upon shifting health science to STEM (ΔM = 0.84467, t(123) = 0.765, p = .446, 95% CI [-1.34211, 3.03145]). By contrast, the non-significant increase for upper-division non-STEM compared to STEM students, in Table 7, widened in Table 11 to significant levels upon shifting health science to STEM (ΔM = 2.40948, t(83) = 2.116, p = .037, 95% CI [0.14471, 4.67425]).

For Consistency of Interest, significant mean score increase in Table 7 for lower-division non-STEM compared to STEM community college students, diminished to non-significant levels in Table 11 upon shifting health science to STEM (ΔM = 1.23847, t(123) = 1.507, p = .134, 95% CI [-0.38829, 2.86523]). However, the significant increase in Table 7 for upper-division non-STEM compared to STEM students, widened in Table 11 upon shifting health science to STEM (ΔM = 2.29495, $t(83) = 2.836$, $p = .006$, 95% CI [0.68566, 3.90424]). For Perseverance of Effort among the community college sample, groupwise comparison did not reveal any discernible difference within the community college sample, even after shifting health science to STEM.

Table 11

Grit-S, Consistency of Interest, and Perseverance of Effort scores for lower- and upper-division college students at community college, comparing STEM (including health science) and non-STEM areas of discipline.

			Grit-S			Consistency of Interest			Perseverance of Effort		
Group 1	Group 2	*n*	*M*	*SD*	*t*	*M*	*SD*	*t*	*M*	*SD*	*t*
Lo div	Non-Stem	27	26.22	5.89	0.77	10.96	3.95	1.51	15.26	3.48	-0.58
	Stem	98	25.38	4.84		9.72	3.74		15.65	3.02	
Up div	Non-Stem	29	28.03	4.81	2.12*	12.24	3.23	2.84**	15.79	2.50	0.19
	Stem	56	25.63	5.06		9.95	3.68		15.68	2.82	
Non-Stem	Lo div	27	26.22	5.89	-1.27	10.96	3.95	-1.33	15.26	3.48	-0.66
	Up div	29	28.03	4.81		12.24	3.23		15.79	2.50	
Stem	Lo div	98	25.38	4.84	-0.30	9.72	3.74	-0.36	15.65	3.02	-0.05
	Up div	56	25.63	5.06		9.95	3.68		15.68	2.82	

Note. Lo div = lower-division student (freshman or sophomore); Up div = upper-division student (junior or senior); Stem = STEM (science, technology, engineering, math) academic focus (including health science); Non-Stem = non-STEM academic focus.
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$.

Independent samples *t*-tests again were used to compare the grit components, this time for lower-division non-STEM, lower-division STEM (including health and social science), upper-division non-STEM, and upper-division STEM (including health and social science) groups. Results are summarized in Table 12 for students at four-year institutions, and Table 13 for students at community college.

Table 12

Grit-S, Consistency of Interest, and Perseverance of Effort scores for lower- and upper-division college students at four-year institutions, comparing STEM (including health and social sciences) and non-STEM areas of discipline.

			Grit-S			Consistency of Interest			Perseverance of Effort		
Group 1	Group 2	*n*	*M*	*SD*	*t*	*M*	*SD*	*t*	*M*	*SD*	*t*
Lo div	Non-Stem	32	28.88	5.63	1.55	12.91	4.15	2.43*	15.97	2.63	-0.60
	Stem	91	27.16	5.26		10.88	4.02		16.29	2.57	
Up div	Non-Stem	79	29.33	6.44	0.93	13.56	4.03	2.86**	15.77	2.89	-2.31*
	Stem	245	28.63	5.58		12.04	4.10		16.59	2.68	
Non-Stem	Lo div	32	28.88	5.63	-0.35	12.91	4.15	-0.76	15.97	2.63	0.33
	Up div	79	29.33	6.44		13.56	4.03		15.77	2.89	
Stem	Lo div	91	27.16	5.26	-2.18*	10.88	4.02	-2.33*	16.29	2.57	-0.93
	Up div	245	28.63	5.58		12.04	4.10		16.59	2.68	

Note. Lo div = lower-division student (freshman or sophomore); Up div = upper-division student (junior or senior); Stem = STEM (science, technology, engineering, math) academic focus (including health and social sciences); Non-Stem = non-STEM academic focus.
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$.

At four-year institutions, the non-significant increase in mean Grit-S observed in upper-division non-STEM compared to STEM students, in Table 6, that diminished further in Table 10 when health science was shifted from non-STEM to STEM, maintained a diminished difference in Table 12 when social science also was shifted from non-STEM to STEM ($\Delta M = 0.69646$, $t(322) = 0.928$, $p = .354$, 95% CI [-0.78018, 2.17310]). By contrast, the non-significant increase observed in upper-division compared to lower-division STEM students, in Table 6, and maintained in Table 10 when health science shifted to STEM, increased to a significant level in Table 12 when social science also shifted to STEM ($\Delta M = -1.46782$, $t(334) = -2.175$, $p = .030$, 95% CI [-2.79506, -0.14057]).

For Consistency of Interest, the significantly greater mean for lower-division non-STEM compared to STEM students, in Table 6, where the difference diminished to non-significant levels in Table 10 upon shifting health science from non-STEM to STEM, increased back to significant levels in Table 12 when social science also shifted from non-STEM to STEM ($\Delta M = 2.02713$, $t(121) = 2.431$, $p = .017$, 95% CI [0.37606, 3.67820]). Moreover, the significantly greater mean for upper-division non-STEM compared to STEM students, in Table 6, where the significant difference was maintained in Table 10 after shifting health science to STEM, maintained significance in Table 12 upon also shifting social science to STEM ($\Delta M = 1.51206$, $t(322) = 2.864$, $p = .004$, 95% CI [0.47335, 2.55078]). The non-significant increase in mean Consistency of Interest observed in upper-division compared to lower-division non-STEM students, in Table 6, that diminished further in Table 10 upon shifting health science to STEM, maintained diminishment in Table 12 upon also shifting social science to STEM ($\Delta M = -0.65071$, $t(109) = -0.763$, $p = .447$, 95% CI [-2.34037, 1.03895]). Finally, the non-significant increase in mean value for upper-division compared to lower-division STEM students, in Table 6, where the difference widened in Table 10 upon shifting health science to STEM, though still not reaching significant levels, widened to significant levels in Table 12 upon also shifting social science to STEM ($\Delta M = -1.16578$, $t(334) = -2.330$, $p = .020$, 95% CI [-2.15018, -0.18138]).

For Perseverance of Effort, the significant increase in mean value for upper-division STEM compared to non-STEM students observed in Table 6, where the difference widened in Table 10 upon shifting health science from non-STEM to STEM, narrowed but maintained significance in Table 12 upon also shifting social science from non-STEM to STEM (ΔM = -0.81560, $t(322)$ = -2.306, p = .022, 95% CI [-1.51129, -0.11992]). All other comparisons showing no significant difference in Perseverance of Effort, in Tables 6 and 10, remained essentially unchanged in Table 12 upon also shifting health science to STEM.

Regarding community college students, the non-significant increase in mean Grit-S for lower-division non-STEM compared to STEM students in Table 7, that diminished in Table 11 upon shifting health science to from non-STEM to STEM, remained diminished in Table 13 upon also shifting social science from non-STEM to STEM (ΔM = 1.44460, $t(123)$ = 1.192, p = .236, 95% CI [-0.95429, 3.84349]). However, the non-significant increase for upper-division non-STEM compared to STEM students in Table 7, where the difference widened in Table 11 to significant levels upon shifting health science to STEM, retreated in Table 13 to non-significant levels (ΔM = 1.29453, $t(83)$ = 1.044, p = .299, 95% CI [-1.17055, 3.75961]).

For Consistency of Interest, the significant mean score increase in Table 7 for lower-division non-STEM compared to STEM community college students, that diminished to non-significant levels in Table 11 upon shifting health science to STEM, widened slightly in Table 13 upon also shifting social science to STEM, although the difference remained not significant (ΔM = 1.55495, $t(123)$ = 1.724, p = .087, 95% CI [-0.23064, 3.34053]). However, the significant increase in Table 7 for upper-division non-STEM compared to STEM students, where the difference widened in Table 11 upon shifting health science to STEM, diminished to non-significant levels in Table 13 upon also shifting social science to STEM (ΔM = 1.56311, $t(83)$ = 1.760, p = .082, 95% CI [-0.20291, 3.32913]). For Perseverance of Effort among the community college participants, groupwise comparison did not reveal any discernible difference within the community college sample group, even after shifting both health and social science to STEM.

Table 13

Grit-S, Consistency of Interest, and Perseverance of Effort scores for lower- and upper-division college students at community colleges, comparing STEM (including health and social sciences) and non-STEM areas of discipline.

			Grit-S			Consistency of Interest			Perseverance of Effort		
Group 1	Group 2	*n*	*M*	*SD*	*t*	*M*	*SD*	*t*	*M*	*SD*	*t*
Lo div	Non-Stem	21	26.76	5.90	1.19	11.29	4.21	$1.72^{\dagger}$	15.48	3.52	-0.15
	Stem	104	25.32	4.89		9.73	3.68		15.59	3.05	
Up div	Non-Stem	23	27.39	4.68	1.04	11.87	3.18	$1.76^{\dagger}$	15.52	2.50	-0.41
	Stem	62	26.10	5.21		10.31	3.79		15.79	2.78	
Non-Stem	Lo div	21	26.76	5.90	-0.39	11.29	4.21	-0.52	15.48	3.52	-0.05
	Up div	23	27.39	4.68		11.87	3.18		15.52	2.50	
Stem	Lo div	104	25.32	4.89	-0.97	9.73	3.68	-0.96	15.59	3.05	-0.43
	Up div	62	26.10	5.21		10.31	3.79		15.79	2.78	

Note. Lo div = lower-division student (freshman or sophomore); Up div = upper-division student (junior or senior); Stem = STEM (science, technology, engineering, math) academic focus (including health and social sciences); Non-Stem = non-STEM academic focus.
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$.

Chapter IV

Discussion

This study compares levels of grit in college students pursuing STEM versus non-STEM fields of study. Specifically, the study tests the following hypotheses: 1) undergraduates report increasing grit in going from freshman to senior level; 2) undergraduate STEM majors report lower grit than non-STEM majors early in college, but higher grit than non-STEM majors later in college; and 3) this difference is increased when social and behavioral sciences or health sciences are considered STEM, and decreased when considered non-STEM.

Regarding general relationships between grit and college status, age, and GPA, multiple linear regression analysis in the current study (Table 1, Model 2) finds that GPA is a significant predictor of total Grit-S ($p = .031$), consistent with the findings of Duckworth et al. (2007). However, age, which Duckworth et al. found a significant predictor of grit, is not a significant predictor in the current study. The mean age for participants in the Duckworth et al. study was 45 years, while for the current study, almost half of the respondents report their age as between 18 and 21. It may be that the limited age distribution in the current study does not provide enough difference in time for the older respondents to develop the life experience that Duckworth et al. suspected was important in fostering grit.

The current study also finds school type to be a significant predictor of total Grit-S, Consistency of Interest, and Perseverance of Effort (Table 1, Model 1); namely, respondents at four-year institutions have significantly higher scores compared to community college respondents ($p < .001$, $p < .001$, and $p = .002$, respectively). This trend is echoed in comparing four-year and community college students between corresponding class years, except for freshman Perseverance of Effort, which is comparable for both school types (Table 2). Importantly, this general correlation is significantly evident (Table 3) when comparing mean grit values of four-year lower-division students to community college lower-division students, and similarly with upper-division students (except for lower-division Perseverance of Effort). Four-year students show significantly higher levels of total Grit-S ($p \leq .002$) and Consistency of Interest ($p \leq .005$) for both upper division and lower division. Because four-year institutions offer upper-division coursework with greater depth than what typically is available at community colleges, and the more selective four-year admission process essentially requires students to show some demonstration of pre-college interest and accomplishment at the outset, there is greater opportunity at four-year institutions to take students' pre-existing interests and develop their consistency.

Examining Perseverance of Effort (Table 3), students at four-year institutions report higher mean values, compared to community college students for both upper ($p = .045$) and lower divisions ($p = .082$). However, these correlations are weaker than for total Grit-S or Consistency of Interest ($p < .01$ throughout). Thus, findings suggest that the significant increase in grit observed with four-year students compared to community college student is due predominantly to Consistency of Interest, and less so from Perseverance of Effort.

It may be that the cafeteria-style of course selection common at community colleges enables students to spend more time taking courses from different academic disciplines, at the expense of taking a series of courses from a single discipline and maintaining consistency (Community College Research Center & American Association of Community Colleges, 2015). This finding may not be consistent with the finding from Duckworth et al. (2007) that study participants with at least a bachelor's degree have mean grit scores no greater than for associate's degree holders. However, participants in the current study responded to the survey in the midst of attending college, while the Duckworth study participants responded post-degree. Thus, it may be that the educational correlation to grit observed by Duckworth et al. also was informed by experiences gained after the college experience.

Hypothesis #1

Regarding the first hypothesis, that undergraduates report increasing grit in going from freshman to senior level, the findings of the current study partially confirm the hypothesis. Multiple linear regression analysis in the current study (Table 1, Model 3) finds that total Grit-S correlates positively with college class status, but not quite to a significant level ($p = .052$). However, the Consistency of Interest subscale of total Grit-S does show a significant positive correlation to college class status ($p = .011$), while the Perseverance of Effort subscale of total Grit-S shows no significant correlation to class status. Furthermore, replacing class status with an indicator variable representing division status improves the positive predictive ability of total Grit-S ($p = .029$) and Consistency of Interest ($p = .008$), while differences in Perseverance of Effort remain not significant. Thus, it seems that while college students may not have significant gains in grit from one year to the next, they do appear generally to remain more committed to their interests as they advance through undergraduate study.

This is consistent particularly with the current findings for study participants at four-year institutions. For four-year institutions, although respondents do not show significant differences in mean grit scores and subscores from one year to the next (Table 2), upper-division four-year respondents do show significantly greater mean total Grit-S (p =.048) and Consistency of Interest (p = .022) compared to lower-division respondents, with no significant difference in Perseverance of Effort between the two groups (Table 3).

However, the trends observed with four-year student participants do not align completely with community college participants. In contrast to four-year students, community college students do see more significant year-to-year changes in Consistency of Interest, but not Grit-S or Perseverance of Effort (Table 2). Specifically, community college freshmen in the study show particularly low Consistency of Interest scores, with sophomores showing significant gains (p = .016), and interestingly, community college students identifying as seniors showing significantly less Consistency of Interest and total Grit-S compared to community college juniors (p = .003 and .014, respectively). Regarding the sophomore-level finding, the admission process for community college typically is less rigorous than for four-year institutions. As a result, the backgrounds of students entering community college may be rather heterogeneous. Thus, the increase in Consistency of Interest observed between freshman and sophomore year may be indicative of such students having greater variety of pre-college interests and backgrounds (and thus, lower Consistency of Interest at the outset of college) compared to four-year students. Lower-division coursework therefore might have a more direct relationship to developing Consistency of Interest during the first year of community college than to four-year institutions.

The significant grit factor decreases for community college seniors may take into account community college students having earned enough cumulative college credit for senior status, remaining at the community college, and taking extended time to explore various academic interests rather than concentrating further in a specific discipline. On the other hand, community college seniors may lose Consistency of Interest due to lack of depth in available coursework at the community college rather than their own loss of interest. Economic, family, or timing factors may prevent upper-division community college students from transferring to a four-year institution to continue pursuing their interests at a deeper level, even though they very well may wish to do so.

These differences in Consistency of Interest, however, are not evident in community college students when generally comparing lower-division to upper-division respondents, in contrast to four-year students (Table 3). Also not evident are significant differences in Perseverance of Effort among community college students, either by class or division status.

In summary, for community college students it is Consistency of Interest, not total Grit-S, where the most significant increase emerges, and greatest within the lower division. By contrast, while four-year students show significant increases in both total Grit-S and Consistency of Interest throughout college, the correlations are not evident from year to year, but rather over the longer term, in comparing the last two college years collectively to the first two years. And, of the two components of total grit, the strongest correlations occur with Consistency of Interest, not Perseverance of Effort.

Hypothesis #2

The second hypothesis of the current study is that undergraduate STEM majors report lower grit than non-STEM majors early in college, but higher grit than non-STEM majors later in college. The rationale behind the hypothesis was that lower-division STEM students lower in grit would tend to switch to non-STEM majors when transitioning to the upper division, leading to a self-selection of upper-division students remaining in STEM who are higher in grit than upper-division non-STEM students.

The findings from the current study partially confirm this hypothesis at the lower-division level, but not the upper-division level. Multiple linear regression analysis finds a significantly negative correlation between both total Grit-S and Consistency of Interest with the group identifying as lower-division STEM (p = .001 and .003, respectively), consistent with the hypothesis (Table 4, Model 4). Also consistent is a significant positive correlation between Consistency of Interest and lower-division non-STEM (p = .04). However, contrary to the hypothesis, both total Grit-S and Consistency of Interest show a significantly positive correlation with the population identifying as upper-division non-STEM (p = .023 and < .001, respectively), rather than the anticipated upper-division STEM. Absent significant correlations in these regression models is Perseverance of Effort, suggesting again the predominance of Consistency of Interest over Perseverance of Effort as a grit factor in this college sample. Thus, while these findings do indicate that lower-division STEM students have lower mean Grit-S and Consistency of Interest compared to the other students, upper-division STEM students do not rise above the level of other students in any of the grit components.

Since most respondents for this study came from an internet-based workforce (Mechanical Turk), there was concern that the STEM-based findings may be skewed towards a student subset with particular computer-based interests. Although computer-based STEM respondents are not the majority of the STEM sample pool in the current study, they do make up 44.8% (n = 188) of the total STEM pool. Therefore, STEM students were divided into non-computer and computer-based STEM groups, and analyzed by independent samples t-test for mean differences (Table 5). As it turns out, there are no significant mean differences in Grit-S, Consistency of Interest, and Perseverance of Effort between non-computer and computer-based STEM groups at the lower-division level, but significant increases in all grit scores and subscores for computer-based STEM compared to non-computer STEM for the upper division (p = .001, .012, and .001, respectively). Thus, the significant negative correlations between lower-division STEM students and both Grit-S and Consistency of Interest (Table 4) result mainly from non-computer students, not computer-based students (Table 5). Interestingly, for mean Perseverance of Effort at the upper-division level, the score for computer-based STEM students is significantly higher than both non-computer STEM and non-STEM students. Therefore, for all three grit scores, inclusion of computer-based STEM does not overestimate the negative correlations observed with STEM students.

The hypothesis-contradicting findings at the upper division suggest possibly that lower-division STEM students with waning interest in their major very well may switch majors, but to other STEM disciplines rather than non-STEM, keeping Consistency of Interest scores comparatively low for upper-division STEM. Previous studies on switching STEM majors have focused mainly on switch rates either to non-STEM majors, or any major other than initial (Ackerman, Kanfer, & Calderwood, 2013; Kokkelenberg & Sinha, 2010; Thompson & Bolin, 2011), without particular consideration to the switch rates of STEM majors to other STEM majors. However, a recent transcript study of 1690 STEM students at a New York community college between 2011 and 2014, examined rates of STEM majors switching to non-STEM versus a different STEM major, predicted by chemistry course enrollment (Cohen & Kelly, 2019). Cohen and Kelly found that, of the 151 STEM majors who both earned a grade of C or better in an introductory chemistry course and switched to a different major, 35.1% switched to a different STEM degree program, while 64.9% switched to a non-STEM degree program. However, Cohen and Kelly also found that STEM majors taking introductory chemistry were significantly more likely to be switching to a non-STEM major (odds ratio 2.313; $p < .001$) compared to taking introductory physics, biology, or anatomy/physiology (odds ratio 1.230, 0.698, and 0.371, respectively). Thus, the findings of Cohen and Kelly suggest that while switching chemistry-based majors may be more likely to switch to a non-STEM degree program, switching non-chemistry STEM majors may be more apt to remain in STEM.

Focusing on four-year institutions, where mean Grit-S and Consistency of Interest both are significantly higher for upper-division compared to lower-division students (Table 3), those differences are no longer significant when examining just STEM or just non-STEM students (Table 6). However, STEM students show significantly lower Consistency of Interest than non-STEM students, both at the upper ($p < .001$) and lower ($p = .036$) divisions. Similar trends also emerge for Grit-S, though not to a significant level. Very similar results occur also with community college students, with significantly lower Consistency of Interest for STEM compared to non-STEM at both the lower division (p = .002) and upper division (p = .018), with similar non-significant Grit-S trending as with four-year students (Table 7). Thus, consistent with the general findings for all students in the sample, four-year and community college STEM students appear to struggle more with maintaining interest in their initial STEM disciplines of focus. However, if they switch majors, it is possible they switch preferably to other STEM majors rather than non-STEM majors, thereby retaining lower-division STEM students with lower Consistency of Interest scores in STEM as they transition to upper division.

Whereas total Grit-S and Consistency of Interest findings for four-year students do not agree with the hypothesis at the upper division, Perseverance of Effort is significantly higher for upper-division STEM compared to non-STEM students at four-year institutions (p = .011), in agreement with the hypothesis, though a similar significant finding is not seen with community college students. Thus, while Consistency of Interest is consistently lower for four-year STEM students compared to four-year non-STEM students for both upper and lower divisions, perhaps upper-division STEM students tend to combat waning interest with increased perseverance, possibly with the understanding that degree completion would not be far off (Brainard & Carlin, 1998). Even so, the increased perseverance is not enough to offset waning interest completely.

In summary, for the lower division, STEM students are predicted to have lower Grit-S compared to non-STEM students, in agreement with the hypothesis. Of the two grit components, it is Consistency of Interest that shows significant negative correlations for both four-year and community college STEM students at the lower division. By contrast and in conflict with the hypothesis, upper-division non-STEM students are predicted to have higher Grit-S than upper-division STEM students. While Consistency of Interest once again shows significant negative correlations for both four-year and community college STEM students at the upper division, the significant positive correlation of Perseverance of Effort for upper-division STEM over non-STEM may counteract some of the negative grit correlations seen with upper-division STEM, but not enough to bring upper-division STEM grit to parity with upper-division non-STEM grit.

Hypothesis #3: Switching health science into STEM

Regarding the third hypothesis of the study, that differences in grit increase when social and behavioral sciences or health sciences are considered STEM, and decrease when considered non-STEM, the approach of the current study was to re-classify respondents identifying as health science students from non-STEM to STEM, and examine the impact of the re-classification on the earlier models. This was followed by further re-classifying social science students as STEM, and examining this impact on previous models. The rationale behind the hypothesis was that health science majors, like many STEM majors, do laboratory coursework as part of their degree program requirements, with such coursework being highlighted by STEM students as a major stressor (Otrel-Cass et al., 2009). However, it perhaps may be that the laboratory coursework required for health science either is less rigorous, or less plentiful, than for other STEM disciplines. Alternatively, perhaps health science majors have an easier time than other STEM majors of visualizing the application of their studies towards their ultimate career and academic goals (Cohen & Kelly, 2019).

Focusing just on moving health science into STEM, the findings of the current study generally are inconsistent with the hypothesis for both lower division and upper division. Multiple linear regression analysis in the current study finds when 24 lower-division (eight at four-year institutions) and 14 upper-division (ten at four-year institutions) health science respondents are re-classified as STEM (Table 8, Models 3 and 4), a significantly negative correlation between lower-division STEM and Consistency of Interest in the later model (p = .034). This aspect is consistent with the earlier regression model (Table 4). However, the negative correlation between lower-division STEM with Grit-S, as well as the positive correlation between lower-division non-STEM with Consistency of Interest observed in the earlier model, are not significant in the later model when health science students are re-classified as STEM. Since lower-division STEM Grit-S appears to increase as health science is included, while lower-division non-STEM Consistency of Interest appears to decrease as health science is excluded, these results indicate a reduction, not a widening, in grit differences between lower-division STEM and non-STEM after shifting health science to STEM, thereby contradicting the hypothesis. This suggests that lower-division health science majors tend to be better than other lower-division students at maintaining interest in their disciplines of study.

For the upper division, there is a significantly positive correlation between upper-division non-STEM with both Grit-S (p = .006) and Consistency of Interest (p < .001). These correlations are as strong or stronger compared to the significant positive correlations from the earlier regression model with health science students as non-STEM (Table 4, Models 4 and 5). These findings also contradict the hypothesis, since the hypothesis proposes that upper-division STEM, not non-STEM, is strengthened when health science is considered STEM.

With the shift of health science to STEM, the current study also reveals a widening positive correlation between upper-division STEM and Perseverance of Effort in the overall multiple linear regression model above and beyond school type and GPA ($p = .033$) that was not significant prior to the shift. Since upper-division non-STEM remains significantly and positively correlated to Grit-S and Consistency of Interest after the shift, while upper-division STEM continues to see no significant corresponding correlations, there is no positive enhancement of STEM Grit-S or Consistency of Interest at the upper-division level after including health science, in opposition to the hypothesis. However, positive enhancement for upper-division STEM does appear to occur with Perseverance of Effort when including health science, consistent with the hypothesis at least in regard to that grit dimension. Although increased Perseverance of Effort for upper-division STEM is not enough to compensate fully for the negative contributions of Consistency of Interest towards overall Grit-S for that group, it does seem that health science majors are strong in Consistency of Interest as lower-division students, but strong in Perseverance of Effort as upper-division students.

In examining data for four-year students only, as was the case in the earlier assessment (Table 6), there is no significant difference in lower-division or upper-division Grit-S between STEM and non-STEM students, even after switching health science to STEM (Table 10). Moreover, the difference in lower-division Consistency of Interest, significantly greater for non-STEM students compared to STEM students in the earlier assessment (Table 6), does not appear significant after switching health science to STEM (Table 10). By contrast, for upper division, the significant increase in Consistency of Interest for non-STEM over STEM ($p < .001$) is maintained upon switching health science to STEM ($p < .001$), while the significant increase in Perseverance of Effort for STEM over non-STEM ($p = .011$) is strengthened after the switch ($p = .005$). Although these four-year findings incorporate data from only eight lower-division and ten upper-division health science students, the findings do align with the general model: health science students are high in Consistency of Interest at the lower division level, but high in Perseverance of Effort at the upper division level. In contrast, while other four-year STEM students also may be strong in Perseverance of Effort as upper-division students, they are weak in Consistency of Interest throughout college.

For the community college sample prior to switching health science to STEM, there was no significant difference in total Grit-S between STEM and non-STEM for either lower or upper division (Table 7). While this lack of significance occurs again at the lower division when health science switches to STEM, for the upper division there now appears a significant increase in non-STEM Grit-S ($p = .037$) that does not appear with four-year students (Table 11). It is noted, though, that the shift of community college health science to STEM comprises 16 lower-division students and only 4 upper-division students.

Before the switch, community college Consistency of Interest was significantly higher for non-STEM compared to STEM students, both for lower and upper divisions (Table 7). After the switch, the difference between community college lower-division STEM and non-STEM Consistency of Interest is no longer significant (Table 11), agreeing with the finding for four-year students. Perseverance of Effort for community college, not significantly different between STEM and non-STEM for both lower and upper division, remains so after switching health science to STEM. Thus, while upper-division Perseverance of Effort (significantly higher for STEM in four-year students) was the only major difference observed between four-year and community college students in the earlier assessment, after switching health science to STEM, upper division Grit-S (significantly higher for non-STEM in community college students) also appears to differ between four-year and community college students. The small upper-division sample size certainly may have skewed these findings. However, it also may be that both of these differences may be a function of the lack of available upper-division coursework (particularly in STEM where mandatory sequential coursework is prevalent) where perseverance and consistent interest could be tested.

In summary, when health science is considered STEM, lower-division STEM Grit-S appears significantly less negative, while lower-division non-STEM Consistency of Interest appears significantly less positive, narrowing the difference between STEM and non-STEM grit factors at the lower division, contradicting the hypothesis. For the upper division, while Perseverance of Effort appears significantly higher for STEM compared to non-STEM four-year students, Consistency of Interest and overall Grit-S appear significantly higher for non-STEM compared to STEM for college students in general, thereby contradicting the hypothesis again.

Hypothesis #3, continued: Switching health and social science into STEM

The next iteration testing this hypothesis keeps the health science student sample in STEM, and additionally switches ten lower-division (four at four-year institutions) and 34 upper-division (28 at four-year institutions) social science students into STEM. While the initial hypothesis was the same between switching health science and social science to STEM, the rationale was not. For social science, it was reasoned that lower-division social science as STEM would lower STEM grit, since students thought of as non-STEM seem to wait longer than STEM students to declare their major (Kokkelenberg & Sinha, 2010), suggesting possible reduction in Consistency of Interest. As to upper-division social science, based on a report suggesting that social science grades were higher in the upper division compared to lower division, while math and science grades were stable throughout college (Kuh & Hu, 1999), it was thought perhaps that upper-division social science as STEM would raise STEM grit, since GPA was positively correlated to grit (Duckworth et al., 2007).

The findings after switching social science into STEM generally are consistent with the hypothesis for both lower division and upper division, in contrast to the findings for health science; however, when considering the findings of health and social science as a collective group, total movement of that group into STEM renders net findings inconsistent with the hypothesis. Examining multiple linear regression at the lower division (Table 9, Models 3 and 4), the negative correlation between lower-division STEM and Consistency of Interest after switching health science to STEM (Table 8) remains significant yet again with inclusion of both health and social sciences as STEM ($p = .004$, Table 9, Model 4). Moreover, the negative correlation between lower-division STEM with Grit-S, not significant after health science inclusion, returned to significance with further social science inclusion ($p = .004$, Table 9, Model 3). Consistent with earlier models, lower division status continues not to be a significant predictor of Perseverance of Effort when social science shifts to STEM. Whereas health science inclusion seems to reduce the negative general grit correlation with lower-division STEM, the inclusion of social science appears to strengthen that negative correlation, agreeing with the hypothesis. However, as a collective group, health and social science inclusion in STEM transforms the grit regression models of lower-division traditional STEM (Table 4), by reversing the significant positive predictive ability of lower-division non-STEM on Consistency of Interest (Table 9), thereby narrowing the difference between STEM and non-STEM levels for that grit component, in opposition to the hypothesis.

In the upper division, of the significantly positive correlations between upper-division non-STEM with Grit-S and Consistency of Interest that were maintained after switching health science to STEM (Table 8, Models 3 and 4), the correlation with Grit-S is not significant after also switching social science to STEM, while the positive correlation with Consistency of Interest remains significant ($p < .001$) (Table 9, Models 3 and 4). Perseverance of Effort, originally not significantly correlated to upper-division STEM but positively correlated after switching health science to STEM, fails barely to reach significance when social science also switches to STEM ($p = .058$). Thus, switching social sciences to STEM appears to work towards decreasing reported Grit-S values for upper-division non-STEM (consistent with the hypothesis), while also slightly decreasing reported Perseverance of Effort values for upper-division STEM. As a collective group, health and social science inclusion in STEM transforms the grit regression models of upper-division traditional STEM (Table 4) by removing the significant positive predictive ability of upper-division non-STEM on Grit-S (Table 9). While this net transformation does not suggest that upper-division STEM grit could significantly exceed upper-division non-STEM grit, it would appear to trend in the same direction as the hypothesis.

Therefore, social science students generally appear to be relatively low in Grit-S in the lower division, but relatively high in Grit-S in the upper division, with greater influence of Consistency of Interest compared to Perseverance of Effort for the lower division. It also is apparent that the behavior of data in this study from social science students does not converge with health science students, making combined data from the collective group difficult to interpret. Additionally, health and social science sample group sizes are relatively small, with only ten students identifying as lower-division social science students. This increases the possibility that these findings may not be generally representative of these groups.

Focusing just on four-year institutions (Table 12), consistent with previous assessments, there is no significant difference in lower-division or upper-division Grit-S between STEM and non-STEM students, even after switching both health and social science to STEM. However, a finding not observed previously in the current study's assessments is a significant increase in total Grit-S for upper-division STEM compared to lower-division STEM (p = .030), after switching health and social science to STEM. It should be noted that mean lower-division STEM Grit-S scores remain relatively stable with each shift of students from non-STEM to STEM (from 27.10 to 27.28 to 27.16), however these values come about from a shift of only eight health science followed by four social science students into STEM. Meanwhile, mean upper-division STEM Grit-S scores continually increase (from 28.40 to 28.52 to 28.63), from a shift of ten health science followed by 28 social science students into STEM. Thus, of these observed trend lines, the low number of lower-division participants moved into STEM probably makes that particular trend line generally less representative. Nevertheless, it appears, at least for four-year students, that the social science subgroup, more so than then rest of STEM, exhibits large positive impact on Grit-S values for upper-division STEM, consistent with the hypothesis for the upper division.

As to four-year Consistency of Interest (Table 12), significantly greater for lower-division non-STEM students compared to STEM students prior to shifting health science to STEM (Table 6), but not significant after switching health science to STEM (Table 10), it re-gains significance after also switching social science to STEM ($p = .017$), though through inclusion of only four students. Moreover, for upper division, the significant increase in Consistency of Interest for non-STEM over STEM ($p < .001$), maintained upon switching health science to STEM ($p < .001$), is maintained still when social science also is switched to STEM, though slightly reduced in significance ($p = .004$). Additionally, as with Grit-S, Consistency of Interest now is significantly greater for upper-division STEM compared to lower division STEM ($p = .020$).

Regarding four-year Perseverance of Effort, lower-division differences in Perseverance of Effort between STEM and non-STEM remain not significant across all iterations of STEM classification assignment. Meanwhile, the significant increase in upper-division Perseverance of Effort for STEM over non-STEM ($p = .011$), still present after switching health science to STEM ($p = .005$), remains, though slightly reduced in significance, after switching both health and social science to STEM ($p = .022$). Thus, the increase in upper-division over lower-division STEM Grit-S with social science seems due to increased Consistency of Interest. These four-year findings are in alignment with the overall findings from general linear regression model, when focusing just on transformations to the regression model from moving social science to STEM.

For the community college sample, following a move of only six lower-division and six upper-division social science students to STEM already including health science (Table 13), the significant increase in upper-division Grit-S for non-STEM compared to STEM, observed only upon switching health science to STEM, once again reverts to not significant upon switching health and social science to STEM, and returning to alignment with four-year students. With Consistency of Interest, originally significantly higher for non-STEM compared to STEM students regardless of division (Table 7), with lower division differences no longer significant after switching health science to STEM (Table 10), differences now are no longer significant either for upper or lower division after shifting both health and social science to STEM (Table 13). This is in direct contrast to four-year students, where Consistency of Interest is significantly higher for non-STEM compared to STEM students regardless of division (Table 12). Perseverance of Effort, not significantly different between STEM and non-STEM for both lower and upper division, remains so throughout all switches of health and social science to STEM. Finally, the significant increases observed in four-year upper-division STEM compared to lower-division STEM for Grit-S and Consistency of Interest, are not seen for community college students.

While upper-division Perseverance of Effort (significantly higher for STEM in four-year students) was the only major difference observed between four-year and community college students in the earliest assessment (Tables 6 and 7), after switching health science to STEM, upper division Grit-S (significantly higher for non-STEM in community college students) also appeared to differ between four-year and community college students (Tables 10 and 11). Now, after switching both health and social science to STEM, Perseverance of Effort continues to be a significant factor for upper-division four-year students but not community college students, while upper-division Grit-S is no longer a significantly positive factor for non-STEM compared to STEM community college students. Consistency of Interest now emerges as a significant factor between STEM and non-STEM four-year students, but not community college students. Grit-S and Consistency of Interest also emerge as significant factors between upper-division and lower-division four-year STEM students, but not community college STEM students. These findings suggest switching social science to STEM seems to polarize the values for Consistency of Interest (and Grit-S to a lesser extent) between these various four-year student groups, while providing more balance in values between the community college student groups. However, it is possible that non-representative small sample size is factor here, particularly as to why the community college values here appear more balanced: In this study, only 12 of the 44 social science students in the study are community college students.

Summarizing the social science findings, lower-division social science student participants seem to show lower Grit-S and Consistency of Interest on par with lower-division traditional STEM, but not health science, students, consistent with the hypothesis. Moreover, reclassification of four-year social science participants from non-STEM to STEM precipitates an increase in both upper-division STEM Grit-S and Consistency of Interest, also consistent with the hypothesis. However, health science STEM inclusion seems more to narrow the gap between STEM and non-STEM grit component levels at the lower division, while social science STEM inclusion does so at the upper division, thereby confounding grit component analysis if grouped together in STEM.

General Discussion

Regarding the findings gathered for testing Hypothesis #1, that undergraduates report increasing grit in going from freshman to senior level, the main finding is that Grit-S and Consistency of Interest are positively correlated to upper-division status, while Perseverance of Effort is not significantly correlated to division status, above and beyond GPA and whether the school type attended is community college or four-year institution. These correlations hold true when examining data from students from four-institutions only, and indicate that Consistency of Interest predominates over Perseverance of Effort in informing the total Grit-S of college students. Thus, it seems that college instructors should consider modifying instructional methodology, or otherwise offering more student support, in lower-division coursework to promote more Consistency of Interest during the first half of college. For example, writing or science courses could include more assignments directing students to write about specific aspects of their intended field of study, experts in their intended field of study coming from a similar background (Schinske, Perkins, Snyder, & Wyer, 2016), or a collection of various topics with subsequent self-reflection (Kuh, 2008; Liberal Education and America's Promise, 2018). Instructors also should encourage students to think more actively early on about post-undergraduate career and academic possibilities (Community College Research Center & American Association of Community Colleges, n.d.). By implementing these sorts of strategies often and early in college, not only may they help students maintain interest, but it also may alert students earlier on if in truth their efforts may be better used exploring other fields of interest more seriously instead.

Study survey data from community college students differ from four-year students, indicating that significant differences in Consistency of Interest for community college students occur within, not between, lower and upper divisions: a significant increase for sophomore compared to freshman students, and a significant decrease for senior compared to junior students. Thus, more so for community college than four-year institutions is the importance of building freshman-specific instructional and support strategies for maintaining interest within one's discipline of focus. Replacing the traditional cafeteria-style of community college course offerings with a Pathways (or guided pathways) model where recommended courses for specific disciplines of interest are sequentially and strategically mapped for students at the start of college, with strong advising and student support networks also in place to help keep students on track towards program completion (Community College Research Center & American Association of Community Colleges, 2015, n.d.), would be an example of such a strategy. To address waning interest for senior community college students, instructors may consider strategies such as offering more independent study, undergraduate research, or service-focused opportunities (Kuh, 2008; Liberal Education and America's Promise, 2018), and informing students vigilantly about current scholarship and academic transfer options to four-year institutions.

Regarding the findings gathered for testing Hypothesis #2, that undergraduate STEM majors report lower grit than non-STEM majors early in college, but higher grit than non-STEM majors later in college, this study finds that total Grit-S is negatively correlated to lower-division STEM, agreeing with the hypothesis, but positively correlated to upper-division non-STEM, in conflict with the hypothesis. Again, Consistency of Interest is the predominate factor informing total Grit-S, with Consistency of Interest positively correlated to non-STEM regardless of division status, and negatively correlated to lower-division STEM. Examining data for four-year and community college students separately, Consistency of Interest scores follow the same significant trends observed generally, while Perseverance of Effort is significantly greater, but only for four-year upper-division STEM compared to non-STEM. Community college students express the same significant correlations as four-year students, except for Perseverance of Effort, which is not significantly different between upper-division STEM and non-STEM.

These results suggest that STEM students find it more difficult to maintain interest in their intended field of study compared to non-STEM students of similar division status. Upper-division four-year STEM students partly may compensate for this through increased perseverance, although their overall mean grit still falls short of upper-division four-year non-STEM students. Thus, while the findings surrounding Hypothesis #1 indicate the overall importance of promoting Consistency of Interest for all college students, the findings for Hypothesis #2 suggest that it is particularly important in the case of STEM to explore STEM-focused strategies to help students maintain their interest throughout college. Also given that the GPA of students who switch out of STEM majors tends to be comparable to non-switching STEM students, the switchers appear largely to do so for reasons other than lack of ability (Brainard & Carlin, 1998; Seymour & Hewitt, 1997). Support strategies may, for instance, take the form of time management support, given that STEM coursework is particularly time-consuming, partly due to laboratory courses that students in non-STEM disciplines do not take to the same extent (Brint et al., 2012; Otrel-Cass et al., 2009). Previous reports also have suggested that STEM students exhibit better engagement with coursework when instructors demonstrate accessibility, personability, respect for students, enthusiasm for the subject matter, and willingness to offer tips and anecdotes regarding the subject matter (Micari & Pazos, 2012; Otrel-Cass et al., 2009; Vogt, 2008).

Regarding the findings gathered for testing Hypothesis #3, that differences in grit increase when social and behavioral sciences or health sciences are considered STEM, and decrease when considered non-STEM, a qualitative summary of correlational trends based on data analysis (*p*-values not included, and not established in all cases) observed with the various grit dimensions (Grit-S, Consistency of Interest, Perseverance of Effort) for the various college groups examined in the current study (upper-division versus lower-division; four-year institution versus community college; STEM, health science, social science, non-STEM), is shown in Table 14.

There is some ambiguity concerning exactly which fields of study should be included in STEM. Specifically, some may contend that while health science is not always thought of as a STEM area (Chen & Soldner, 2013), it should be considered so (National Science Board, 2015, 2016), particularly given the large commitment for such students to take science-based laboratory courses. On the other hand, certain organizations include social sciences in STEM, including the National Science Board (2015, 2016) and U.S. Census Bureau (2014, July 10), even though the type of experimental academic work associated with social science is different both qualitatively and quantitatively, than for disciplines traditionally accepted as STEM. By investigating this hypothesis, one hope was that analysis of grit-based scores between students from health science, social science, and traditional STEM, would provide an additional basis to justify the categorization of health and social science as STEM or non-STEM at the college level. Proper alignment and universal acceptance of disciplines that are STEM and those that are non-STEM, would facilitate the interpretation of future academic and career research data based on STEM.

Table 14

Qualitative summary of Grit-S, Consistency of Interest, and Perseverance of Effort general trends for lower- and upper-division college students, based on school type and general area of discipline.

			Grit-S			Consistency of Interest			Perseverance of Effort		
Group 1	Group 2	*n*	Cc	4y	Total	Cc	4y	Total	Cc	4y	Total
Lo div	Non-Stem	53					+				
	Stem	161			–	–	–	–			
	Health sci	24			+	+	+				
	Soc sci	10		–	–		–	–			
Up div	Non-Stem	102					+	+		–	
	Stem	259				–	–			+	
	Health sci	14	–			–				+	+
	Soc sci	34	+	+	+	+	+				–

Note. Cc = community college; 4y = four-year institution; Lo div = lower-division student (freshman or sophomore); Up div = upper-division student (junior or senior); Stem = STEM (science, technology, engineering, math) academic focus (excluding health and social sciences); Non-Stem = non-STEM academic focus (excluding health and social sciences); Health sci = health science academic focus; Soc sci = social science academic focus; (+) = positive qualitative correlation (though not necessarily significant); (–) = negative qualitative correlation (though not necessarily significant).

By sequentially re-classifying health science and social science from non-STEM to STEM, and subsequently analyzing differences in non-STEM and STEM grit scores and subscores, the results suggest that these discipline groups correlate to grit in distinctly different manners compared to traditional STEM. In comparison to traditional STEM, lower-division health science study participants tend to show higher Grit-S and Consistency of Interest compared to lower-division traditional STEM participants, with both groups tending towards high Perseverance of Effort at the upper division (Table 14). Thus, these lower-division findings contradict the hypothesis: From this study, health science does not lower STEM grit for the first two years of college. Upper-division findings contradict the hypothesis as well: While upper-division STEM Perseverance of Effort remains high with health science inclusion, overall grit remains higher for non-STEM compared to STEM including health science. Therefore, while health science students may show more grit than traditional STEM students early in college, their grit patterns converge more later in college.

Based on these findings, it seems sensible to adjust the definition of STEM at the college level to include health science. Not only are there similarities in curricula and laboratory experiences between the two areas, but such classification also may facilitate the incorporation of common coursework with mixed cohorts of traditional STEM and health science students, that could offer a mode of grit enhancement, particularly based on the lower-division traditional STEM students of the current study (Kuh, 2008; Liberal Education and America's Promise, 2018).

In contrast to health science, social science study participants present a converse grit pattern: Social science students tend to show low Grit-S and Consistency of Interest early in college, but high Grit-S and Consistency of Interest later in college, in partial agreement with the hypothesis. As to including social science in the college definition of

STEM, while both social science and traditional STEM show lower lower-division Grit-S and Consistency of Interest, it may seem sensible from a grit standpoint to include social science in STEM, to develop cohort and community learning models, as well as other support systems, that benefit both student groups concurrently. However, given the different types of skills developed and used by the social sciences compared to traditional STEM, and the documented stresses associated with the laboratory-based pedagogy experienced by traditional STEM students (Otrel-Cass et al., 2009), it is possible that the type of grit support effective for traditional STEM students would be less applicable to social science students. Furthermore, social science students seem not to struggle as much with Grit-S and Consistency of Interest in the upper division, whereas traditional STEM students apparently do. Thus, grit support for traditional STEM students may need to be more persistent than for social science students in order to achieve comparable average grit. Given the greater similarity between the curricula and curricular issues associated with traditional STEM and health science, combined with the divergent grit component trends observed between health science and social science, it seems more sensible from an academic grit standpoint to include health science, but not social science, as part of STEM.

Although computer-based STEM is not a focus for the current study and its design, data from this study suggests that computer-based STEM students have significantly higher mean grit scores and subscores compared to non-computer STEM students at the upper division (Table 5). Thus, from a grit standpoint it may make sense, for both research and student support purposes, to disaggregate computer-based STEM from non-computer STEM. Further directed studies would need to be conducted before drawing any formal conclusions in this matter.

Limitations

The Duckworth lab acknowledged several limitations of the Grit and Grit-S Scales. First, the scales could be viewed more as a measure of behavioral consistency than of grit and perseverance (Duckworth et al., 2007). They counter-argued that the achievements correlated with the Grit Scale in their study (including first-year cadet retention at West Point Military Academy (by binary multiple logistic regression, $p < .03$), and final round achieved at the Scripps National Spelling Bee (by ordinal regression, $p < .04$)) were ones where subjects all were trying to achieve a similar high-achievement goal, and where prior consistency of behavior would seem not to be a sufficient predictor.

Second, while surveys by self-report (particularly online) provide convenient administration and enhanced accessibility to participants, such surveys also may be prone to individual interpretation (or misinterpretation) by subjects, and to social desirability bias (Duckworth et al., 2007). Duckworth et al. acknowledged that the transparency of the questions in the Grit Scale made it susceptible to social desirability bias (or the tendency for some to offer responses more in tune with how they would like to answer rather than how they ought to answer in reality). They counter-argued that the strong correlations established between grit and achievement would be strengthened even further if controlled for social desirability bias. The current study implemented a version of the Grit-S Scale (Duckworth, 2007) with questions sequenced such that reversed-scored questions (i.e., the items focused on Perseverance of Effort) were distributed relatively evenly through the question stack. This organization of questions should help to blunt the effect of social desirability bias, though probably would not eliminate it completely.

Third, Duckworth and Quinn (2009) acknowledged that grit levels may not necessarily be consistent throughout all of the aspects of one's life, and as such, having subjects respond to these inventories one time only in a general context may not provide a complete picture as to levels of grit in an academic context. While the current study is cross-sectional and does not address possible changes in individual grit levels throughout one's undergraduate experience, a possible future study could be longitudinal, examining grit levels for the same participant pool on an annual basis while in college.

A fourth limitation to the current study, though not pertaining to the Grit and Grit-S Scales, pertains to sample size for survey administration. Using the undergraduate student body population of 6,700 for Harvard University (2018) as a guide, Qualtrics (2010) estimated that a sample size of 364 would be needed for a 95% confidence level and 5% margin of error. Sample sizes short of these values would make it more difficult to establish significant correlations. While the final sample size of the current study is 657, certain subgroups in the study are small in size (e.g., 12 community college social science study participants; four upper-division community college health science study participants), reducing the reliability of data interpretation involving such subgroups. This makes it particularly difficult to analyze data for individual academic disciplines of study that are not being grouped together with other disciplines. Therefore, if a study like this is done again, the total sample size should be much larger.

Fifth, survey collection occurred during November and December 2018, a limited timeframe coinciding with the end of fall term. It has been demonstrated previously that aspects such as math and science self-confidence may swing widely between the start and end of freshman year (Brainard & Carlin, 1998). Should grit follow suit, survey responses could be significantly different between terms of the academic year, and as such, survey responses at the end of fall term may not be representative of responses from such participants at other times of the year. Therefore, a possible future study could examine grit both at the start and end of the academic year, either through different sample pools or as a test-retest study where the same initial sample pool takes the survey again at year-end.

Sixth, because the majority of study participants emanate from MTurk, a computer-based work platform, it is possible that the collected survey responses are skewed towards particular skill and personality profiles that are not fully representative of the college populations at-large. For instance, it was noticed that a sizeable portion of the sample population responded to the study survey during the middle of the night (data not shown), suggesting that this study may have attracted respondents with greater average perseverance than normal. However, results from the current study suggest that computer-focused STEM students do not overestimate the largely negative correlation between college STEM and grit, while the stronger grit-based correlations in the current study generally occur with Consistency of Interest, not Perseverance of Effort. Nevertheless, future similar studies should consider administering the surveys not just online but also in person.

Seventh, while some safeguards were put in place to inhibit subjects from responding to the survey more than once, the survey design was not set up to prevent multiple responses completely. Multiple responses from MTurk participants largely were traceable through worker identification codes, in which case only the first response was accepted from that participant. Additionally, the survey was set up so that subsequent responses from a software-recognized previously-used IP address would not be allowed ("SurveyMonkey [Website]," 2017). However, future similar studies should pursue additional means for preventing such multiple responses.

Finally, the current study is correlative rather than causal, and does not assess whether higher grit causes greater academic persistence, and whether such persistence is different for STEM compared to non-STEM. Following a controlled experimental design by Job, Dweck, and Walton (2010), a future study to begin exploring causal grit effects could involve taking a sample of college students at the start of the academic year, and randomly assigning half to provide answers to the Grit-S Scale, with the other half answering similar items but worded in a negatively-biased fashion. Participants then would provide data at the start of the following year indicating who switched majors and who did not. Any differences in persistence rates between groups would be attributable to the presentation of grit in a positive versus negative manner.

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