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Predictors of Student Success in an Upper Division Agriculture Chemistry Class

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PREDICTORS OF STUDENT SUCCESS IN AN UPPER DIVISION AGRICULTURE CHEMISTRY CLASS

A Master's Thesis

Presented to

The Graduate College of

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In Partial Fulfillment

Of the Requirements for the Degree

Master of Science, Agriculture

By

Maddison May

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ABSTRACT

To attempt to find what made students successful within a higher division class at Missouri State University's (MSU) Darr College of Agriculture, de-identified academic records of 172 students enrolled in AGR 300 - Food and Agriculture Chemistry were studied over four semesters. De-identified data were collected and compared to final letter grade received at the end of the class using correlation coefficients, analysis of variance, and stepwise regression. Analysis of variance was used to evaluate the influence of semester on letter grade. Correlation coefficients were used to determine and evaluate relationships between the variables and final grade. Stepwise regression was then used to model the factors most important to predicting student success. De-identified predictors looked at included: ACT composite score, ACT math score, incoming GPA, number of hours taken at MSU, hours taken outside of MSU, number of previously taken math classes, number of previously taken science classes, gender, and age. Significant predictors, at the 0.05 level, included incoming GPA ($P<.0001$), ACT composite Score ($P=0.0151$), hours taken at MSU ($P=0.0490$). There was a tendency for Pre-Test score (0.093) to predict student success.

KEYWORDS: grit, academic predictors, successful student, agriculture, undergraduate learning, learning theory, higher education

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INTRODUCTION

Education has a long history of progression. From schools teaching boys as young as seven to fight for their country to modern-day higher learning institutions where all people are welcomed to seek wisdom and truth, education has many influences, that shaped the world into what it is today.

American higher education is unique, with historic roots taken from German and English education systems and incorporated with American values (Thelin, 2011; Eckel and King, 2007). Three pillars are etched into American higher education: Jeffersonian ideal of little government involvement, equal opportunity for all, and capitalism (Eckel and King, 2007). Governmental control over education primarily resides with the states. However, the Federal Government does provide access to student aid and ensures equal opportunity for all who apply to higher education. Colleges practice capitalism by seeking income from student fees and tuition, government (state and federal aid), and auxiliary enterprises such as athletic events, banquets, or renting buildings for events (Eckel and King, 2007).

As more is understood about pedagogy methods, teaching has evolved. Some of the methods to be mentioned here include learning motivations, learning style, experiential learning, and collaborative group testing.

LITERATURE REVIEW

Pedagogy is forever being broadened in terms of application as more information is gained about teaching and learning methodologies. Theories have been formulated as to the best practices of educating students pedagogy has been the life's work of many great theorists. However, to understand how to educate students, one must have a basic understanding of how teaching came to be. The following is a brief overview of the history of teaching, tracing from the Greeks to the end of the American Revolutionary War. Pedagogy methods and select learning styles are also discussed to better understand learning for the modern student.

History of Teaching

Education of the world has a long history. The first form of structured education began around 420 BCE in Athens, Greece, consisting primarily of physical training to be used in battle (Bevis, 2019). Philosophers such as Socrates, Isocrates, Plato, and Aristotle changed education to focus on sciences, mathematics, philosophical awareness, and insight (Bevis, 2019). At this time, education was typically sought by men of wealthy families. While Athens held to educating peoples from around the world, Rome slowly became the education capital due to Roman's culture of commitment and investment within literature and the arts (Bevis, 2019).

The first higher education campus is considered the Museum at Alexandria, Egypt founded around 280 BCE (Bevis, 2019). Students of all disciplines came for scholarly inquiry and research within its halls. As time went on and the Dark Ages emerged, education was not as widespread as it once was and only the wealthy could afford education (Bevis, 2019).

The universities established in the 11th and 12th centuries within Europe are believed to be modeled after Muslin madrasas, or "hall of learning" (Bevis, 2019). Madrasas institutions attracted students from all over the world to study Islamic law. These institutions allowed scholars to live on-site, and at the end of their studies were given documentation of what they studied (Bevis, 2019).

Within the United States, higher education came while still under England's rule. Harvard obtained a royal charter in 1636, becoming the first college within America to officially open (Thelin, 2011). Harvard was designed to educate men destined for high status jobs (teachers, church leaders, government officials, etc.) who would know the difference between civilization and the wilderness (Rudolph and Thelin, 1990). To achieve this, around 130 faculty members from Cambridge and Oxford came to America, bringing with them the traditions and ways of educating in England's elite colleges. Thus, the American higher education system draws strong ties and customs as those in the Old World (Rudolph and Thelin, 1990).

One of the primary teachings and goals of colleges during their early years was teaching theology for Christianity and producing future business leaders (Rudolph and Thelin, 1990). First colleges within The United States had to balance church and state issues due to political support and funding. Part of their income come from state coffers with remaining income from the people who were more concerned with church issues. The expectation of majority of parents at this time was that their sons should receive a high level of education, while ensuring the teachings of Christian values (Rudolph and Thelin, 1990).

During the 1740s, a religious movement known as the Great Awakening, changed higher education within America by opening discussions about the correct balance between education and religion (Warch, 1978). Predominant figures in the movement, such as George Whitefield,

criticized educational institutions of the day as being corrupt, not producing devoted clergymen, nor promoting Christianity as they were traditionally expected to (Warch, 1978). Whitefield and other leaders within the movement called for openings of new institutions centered around Christianity values and teaching. While the Great Awakening had multiple outcomes for American religious views, most notable to change for higher education, was the lessening of ties between religion and education (Warch, 1978).

After the Great Awakening, colleges were freer from religious ties; but had to compete with many new obstacles. Higher education was still seen as a privilege of the upper class due to cost and admission requirements (Rudolph and Thelin, 1990). Tuition of students is thought to be the main drive of admission. Admission requirements for each college varied widely and it is uncertain if requirements were enforced, thus remedial classes were offered (Rudolph and Thelin, 1990).

In addition, early universities were guilty of traditional "classicism" or curriculum standards (Caullery, 1922). The curriculum of American colleges was taken from Europe's institutions and had not changed significantly since Medieval times. American institutions pulled aspects of Oxford, Cambridge, and Scottish universities to make their curriculum and classroom structure (Rudolph and Thelin, 1990). Similar teaching styles shared with Europe's higher education included having students recite coursework during class, tutorial sessions for students, and declamations in order to finish a class (Rudolph and Thelin, 1990).

Between unpopular support and logistics of not being able to attend due to time commitments and money, enrollments fell (Rudolph and Thelin, 1990). It was not until 1756, does history record the first mention of American colleges moving from their 'Old-World' roots into a more modern curriculum. Europe primarily focused on the same subjects as those in

ancient times such as sciences, mathematics, philosophy, and languages. Subjects that were emphasized in more modern curriculum included more practical subjects such as English, engineering and physical sciences (Rudolph and Thelin, 1990; Reynolds, 1992). By incorporating these practical subjects, American citizens showed a newfound support for higher education.

The passage of the Morrill Act by Congress in 1862 encouraged technical education (Caullery, 1922). In 1865, Cornell University was established by Ezra Cornell in Ithaca, NY. His intention for forming the university "is to found an institution where any man may be instructed in any subject" (Caullery, 1922). In this, American universities differed from their European counterparts who still taught the five "Faculties", theology, law, medicine, science, and letters. Even still, Cornell had the "disinterested studies" Arts and Sciences while also having professional schools leading graduates towards careers seen in such areas as industrial, commercial, and agricultural (Caullery, 1922).

Nine major colleges came about before the Revolutionary War (1775-1783) which included Harvard, William and Mary, Yale, New Jersey, King's, Philadelphia, Rhode Island, Queen's Dartmouth (Rudolph and Thelin, 1990). During the Revolutionary War, many colleges became the grounds for planning and were converted into hospitals while others had to shut their doors (Thelin, 2011; Rudolph and Thelin, 1990) hence formal education was stagnant.

After the War, between 1782-1802 nineteen new colleges were established due in part to the realized usefulness of higher education within the newly freed American people (Rudolph and Thelin, 1990). Education was not seen as a privilege to the wealthy class anymore, but as means for moving oneself up in socioeconomic class by obtaining higher education (Rudolph and Thelin, 1990). The newly formed United States of American showed support for higher

education, almost all states included financial support or land offerings for educational institutions within their constitutions (Rudolph and Thelin, 1990).

Pedagogy

Pedagogy and education have different definitions that commonly get confused. Pedagogy has ties traced to Isocrates who taught rhetoric to his scholars for use in publicly held job positions later in life (Hinchliffe, 2000). From Isocrates, the definition of pedagogy is defined as "learning [is at] the service of government, political power, and the economy". Pedagogy is a measurable form of education due to being designed for preparing students for specific careers needing to meet certain requirements (Hinchliffe, 2000). Forms of pedagogy include classical, multicultural, critical, social constructivist, and the pedagogy of John Dewey (Gin and Hearn, 2019). Each of these different forms of pedagogy gives educators a variety of tools in which to teach. Having thorough knowledge and understanding of different pedagogies allows teachers to reach a broad range of students and their learning needs (Gin and Hearn, 2019).

Bloom's Taxonomy

Bloom's Taxonomy published in 1956, was the collaborative result of 34 professionals, working to understand student learning and took close to a decade to bring to publication (Seaman, 2011). Today, Bloom's is still considered one of the most popular and most used educational tools (Seaman, 2011). The taxonomy, consisting of six levels, builds on the level before, and continually gets more engaging as one increases levels (Haag Granello, 2001).

The six levels of Bloom's taxonomy consist of: knowledge, comprehension, application, analysis, synthesis, and evaluation at the peak (Bloom et al., 1958). Each level builds upon the level below and is meant for a student to use previous levels of mastery during the learning process. Knowledge, the first and fundamental level, has students regurgitating information and, upon completion, a student should be able to identify concepts or structure of the material (Ramirez, 2017). Comprehension of a topic allows students to understand material to explain concepts and ideas with their own words. Application is achieved by having hands-on activities, as students ease into active learning. Analysis of a topic is completed once a student can break down a topic or concept into smaller ideas/areas. Synthesis and evaluation are the last two levels of the taxonomy. Synthesis is achieved when a student can complete a hands-on activity or project without guidance, thus showing a true understanding of the material taught (Ramiez, 2017). Once true understanding of a topic is mastered, students should then be able to thoroughly discuss their thoughts about the topic (Ramiez, 2017). Bloom's Taxonomy unarguably had a major impact on the education and curriculum fields with worldwide recognition which not only validated itself as one of the most popular teaching tools but also furthered the education field into new areas (Seaman, 2011).

Learning Styles

As the connection between teaching and learning became more apparent, multitudes of methods were developed to aid in student learning. Learning styles became better understood and more formally defined as the application of cognitive style in a learning situation (Riding and Cheema, 1991). Simply put, cognitive style is each individual's preferred learning style (Allport, 1937). Learning style theory revolves around the idea that to be academically successful,

learning environments need to match student's learning style (Kolb, 1984). Learning styles are continually being developed and are expanding.

When it comes to picking the best style for learning, there is not just one. Based upon the literature, information presented in multiple forms may support learning best (Howard-Jones, 2014; Lage et al., 2000). This is summed very nicely by Bartlett, "learning styles are like being left- or right-handed"; "both hands can perform the task, but one has more practice" (Bartlett, 1996). Ideally today's teachers should incorporate many teaching strategies within their curriculum to better fit the various student learning styles of their students (Hofstein and Rosenfeld, 1996). By doing such, teachers will be able to reach students with more cognitive learning styles thus improving comprehension, performance, and motivation of their students (Lage et al., 2000; Hofstein and Rosenfeld, 1996).

Peer Learning. In efforts to accommodate different learning styles, teachers are incorporating peer instruction into their curriculum by becoming "facilitators of discussion" (Mazur, 1997). A key factor in peer instruction/peer learning is students learn from each other through group discussions, group activities, and multimedia applications (Mazur, 1997; Lage et al., 2000). To provide this, a "flip-flopped classroom" was established where students studied lectures and readings at home and interact with other students in class for homework and guided discussion (Mazur, 1997; Lage et al., 2000). This change in the classroom allows for more effective long term, high processed learning via active collaborative learning (Lage et al., 2000).

Under Mazur's Peer Learning model, the main concepts are better understood in class during the guided discussion, increasing class comprehension for traditional lecture-based class thus having higher test scores compared to traditional classroom settings (Mazur, 1997). Students

tested were also “favorably impressed” with in-class activities and the independent aspects of the Peer Learning model reported via survey (Lage et al., 2000).

Collaborative Group Testing. Collaborative Group Testing (CGT) is a testing method that enhances learning and retention, allows collaboration between students, uses critical thinking skills, and decreases testing anxiety (Siegel et al., 2015; May et al., 2019) and is achieved through the testing delivery. Within CGT, there is a multitude of different ways to implement the delivery, but all consist of an individual test of traditional means and a collaborative portion that allows students to work in small groups, both portions are graded and students receive grades based on both tests (Gilley and Clarkston, 2014).

While students view CGT in a positive light, research points to further investigation to fully understand the full benefits of using CGT as a teaching method to enhance student learning (May et al., 2019; Siegel et al., 2015).

Experiential Learning. Experiential Learning Theory is based on learning via two cycles; action/reaction and experience/abstraction (Kolb and Kolb, 2007). Experiential Learning Theory can bring structure to learning by doing within a formal educational setting. Adding “real-life” experiential learning into classrooms, students may become more intrinsically motivated (Kolb and Kolb, 2005).

Another form of experiential learning such as “bootcamps” can help prepare students for challenging subjects such as chemistry (Siebert et al., 2017). After two years of offering “bootcamp” before normal session class started, rates of success jumped to >80% of students taking the “bootcamp” passing the class with a C or higher (Siebert et al., 2017).

Thinking Critically. Critical thinking is defined as “a reasoned purposive, and introspective approach to solving problems” (Rudd et al., 2000). Critical thinking is a useful life

skill to be implemented in all areas of life, not just education. Findings show that <2% of undergraduate students have conceptual levels of connection with topics such as "reflective judgment, problem framing, higher-order thinking, logical thinking, decision-making, problem-solving and the scientific method" (Giancarlo and Facione, 2001). Translating to not many undergraduates have critical thinking skills coming into college.

Primary ways of incorporating critical thinking into higher education include low-level learning tasks such as discussions, quizzes, supplemental material, to be provided online; allowing lecture time to be focus on high leveling critical thinking such as group projects and reflective writing (Mandernach, 2006; Ramirez, 2017).

A more innovative way to incorporate critical thinking is by creating a "Methods of Inquiry" class like that has been implemented at the University of Buffalo. The class draws on both psychology and philosophy to help students grow in learning and critical thinking skills (Ahuna et al., 2011). By successfully passing the Methods of Inquiry class, students from across backgrounds, improved retention/graduation rates of approximately twice those that did not take the course. Students who completed the class successfully were also shown to have a 77.3% graduation rate in five years vs the national rate of 55% within six years (Ahuna et al., 2011). This demonstrates a need to incorporate basic learning skills, such as critical thinking, in higher education.

Predictors of Student Success

With greater, more diverse teaching methods to help student learning, educators are also trying to determine traits, or predictors, of what a successful student possesses. Standardized tests such as ACT scores and high school GPA are traditionally used and proven predictors for

college success measured through college GPA (Komarraju et al., 2013; Saunders-Scott et al., 2017). However, ACT and high school GPA were not able to predict the retention, or success rates, of incoming students (Saunders-Scott et al., 2017). Student success is becoming an important factor for colleges to consider when looking at potential students. Four-year higher education establishments lose around 30% of their freshman class after the first year with an overall graduation rate of 57% and a 31% graduation rate for two-year institutions who enter as freshmen (Komarraju et al., 2013). To retain and ensure students are successful, higher education is starting to look at other ways to gauge successfulness, including cognitive and non-cognitive traits possessed by students.

GPA. A student's high school GPA is the single best factor for college success (Astin and Oseguera, 2005; Geiser and Santelices, 2007). A student's high school GPA shows a bigger picture of achievements gained throughout their schooling by examining a variety of non-cognitive traits such as motivation, perseverance, college readiness, goal striving, academic discipline, study skills, and academic self-confidence (Broghammer, 2017; Komarraju et al., 2013). Research shows that on students with >3.0 high school GPA were more prepared for college than students with <3.0 GPA and was the single most significant trait correlated to college GPA (r=.43) (Komarraju et al., 2013).

Standardized Testing. Standardized tests have been used as one of the primary indicators to gauge how successful a student might be (Broghammer, 2017). The Scholastic Assessment Test (SAT) was developed in 1926 as an alternate test to taking an IQ test by looking at a student's general ability to learn, giving all students a rating or score of their learning abilities (Soares, 2015). In 2016, the newest version of SAT test came out which included required sections of math, reading, writing, and language (Zwick, 2019). Scoring comes

from individual math and reading/writing sections, along with a sum of all section scores (Zwick, 2019). Questions are multiple-choice except for 22% of the math section where the student must supply the answer. Other optional forms of SAT exist, including an essay portion and twenty subject-based tests such as history, French, and physics (Zwick, 2019). The SAT continued to be used as the test of choice until 1959, when the American College Testing (ACT) was introduced as a competitor, focused on good testing measures, not just intelligence (Broghammer, 2017).

The ACT was designed to be closer in content to high school curriculum standards, by looking at national level standards and via curriculum surveys (Soares, 2015). Since the start, ACT is stated to concentrate on content mastery and showcase a student's reasoning skills (Soares, 2015). The ACTs are multiple-choice and have four sections: English, math, reading, and science (Zwick, 2019). Students are given a score based on each section as well as a composite score factoring in all sections (Zwick, 2019). Much like the SAT, there is an optional essay portion for the ACT test as well (Zwick, 2019).

Either the SAT or ACT is common in higher education admission requirements, typically used to compare students based on their test scores and can be viewed as interchangeable scores (Soares, 2015). The ACT is scored in a way that mirrors that of the SAT bell curve in grading (Soares, 2015). When evaluating student success rates with standardize tests, high school grades were found to be a better overall predictor of graduation predictions (Zwick, 2019).

Motivations and Drives. Motivation, in educational terms, is the degree one feels to take part in the learning process and is a driving force for the amount of learning received (Campbell, 1977; Komarraju et al., 2009). Research also points to a correlation between a student's motivation and their preferred instruction pedagogy (Hofstein and Rosenfeld, 1996). Two major categories of motivation are intrinsic and extrinsic (Levesque and Pelletier, 2003). Intrinsic

motivation refers to doing a task for oneself for internal rewards but also activities such as play and exploration encourage intrinsic motivation (Ryan and Deci, 2020; Santrock, 2001). Extrinsic motivation comes from external drives or in other words, external rewards, punishments, or compliance (Ryan and Deci, 2020; Santrock, 2001). While each type of motivation has its time and place, intrinsic motivation has been shown to result in higher quality learning and students showing an eagerness to learn (Ryan and Deci, 2000; Urdan, 2006).

When evaluating student motivation, the Self-Determination Theory (SDT) gives educators a better understanding of their student's motivations (Ryan and Deci, 2020). Under SDT, humans are believed to be wanting to grow in learning, but this is sometimes needed to be supported by educators supporting relatedness, competence, and autonomy within the classroom (Ryan and Deci, 2020; Urdan, 2006). Three types of motivation exist within SDT and include intrinsic, extrinsic, and amotivation (Ryan and Deci, 2020). Amotivation is when one is neither intrinsic or extrinsically motivated with no sense of purpose or expectation of reward (Ryan and Deci, 2020). Extrinsic motivation is broken down into four subcategories or regulatory styles within SDT (Ryan and Deci, 2020).

External regulation is thought of as when one is motived by rewards or to avoid a certain outcome, introjected regulation in contrast is when one is pushed by internal motivations. Identification is when a student has chosen to be motivated but is still being driven by extrinsic forces. Lastly, integration is defined as motivation stemming from coexisting within an organization or process (Ryan and Deci, 2020).

Grit. Grit is defined as perseverance and passion for seeking long term goals and is being looked at within a student's success in education (Duckworth et al., 2007). Grit is measured by one of two self-report tests. Grit-O Scale, the first test measuring grit is comprised of 12

questions over four areas of grittiness: scientific integrity, pursuing goals, precise fit with grit, and low ceiling effects (Duckworth et al., 2007). In efforts to validate a better and shorter testing system, the Short Grit Scale (Grit-S) was developed. When tested, Grit-S shows a closer measurement of grit based on personality traits and long-term goals. The Grit-S scale outperformed the Grit-O test by saving time, psychometrically stronger, and fitting data closer (Duckworth and Quinn, 2009).

Grit score is a strong predictor of education received, fewer career changes, high GPAs among undergraduates, completing hard tasks, and overall good work performance (Duckworth et al., 2007; Duckworth and Quinn, 2009). High levels of grit are also positively correlated with educational obtainment, maturity, fewer career changes, academic outcomes (high grades), and higher GPA even if students had a lower SAT score (Duckworth et al., 2007; Strayhorn, 2014). How to increasing one's grit score is unclear, however, age is a significant factor in raising grit scores (Duckworth et al., 2009).

Our objective for this study was to determine what, if any factors would predict student success in Food and Agriculture Chemistry (AGR 300) taught at Missouri State University (MSU) Darr College of Agriculture using de-identified student data. De-identified final letter grade in the course was given a numerical value and compared to twelve possible predictors using analysis of variance, correlation coefficient, and stepwise regression.

MATERIALS AND METHODS

De-identified data along with the scale of final grade received, as seen in Table 1, were provided to the student investigator Spring semester of 2019 in order to conduct statistical analyses. Data had been collected from 172 students who were enrolled in AGR 300 at MSU during the four consecutive semesters Fall 2016 thru Spring 2018. Any student that did not complete the class in any given semester was not included within statistical analysis.

In order to find which of the twelve predictors tested significant to final grade three different statistic models were used. Analysis of variance (PROC MIXED, SAS 9.4) was used to evaluate the influence of semester on letter grade. Correlation coefficients (PROC CORR, SAS 9.4) were used to determine and evaluate relationships between the variables and final grade. Stepwise regression (PROC REG SAS 9.4) was then used to determine the factors most important to predicting student success by using R^2 as selection criteria.

Data had been collected from 172 students who were enrolled in AGR 300 at MSU during four consecutive semesters Fall 2016 thru Spring 2018. All data gathered, were given to the student researcher as de-identified data sets. Any student that did not complete the class in any given semester was not included within statistical analysis.

Food and Agriculture Chemistry is a three-credit hour class typically taken during a student's junior or senior year and is considered a higher division chemistry class comparable to Organic Chemistry. Class objectives include having students understand and recognizing concepts found in both biochemistry and organic chemistry. Also having students recognize that principles learned in AGE 300 are found throughout the Agriculture industry. Prerequisites for all semesters studied included a C- or better in a biology and chemistry class level 100 or higher.

The predictors used self-reported and verified by de-identified official MSU records: ACT composite score, ACT math score, incoming GPA, number of hours taken at MSU, hours taken outside of MSU, number of previously taken math classes, number of previously taken science classes, gender, and age. Pre-test score, post-test score, and the difference of pre/post-test scores were determined from in-class assessments conducted each semester.

De-identified student ACT composite and ACT math scores were evaluated as separate predictors. When students took the ACT multiple times, only the highest score reported to MSU was used. De-identified student's cumulative GPA from semester previous to enrolling in AGR 300 was used as the incoming GPA predictor. Missouri State University keeps track of three types of GPA for students: cumulative, semester, and MSU GPA. All three types of GPA are calculated by taking a student's total quality points over credit hours attempted. Cumulative GPA is considered all hours taken in a student's college career at the time calculated. Semester GPA is when one given semester is only taken into consideration. MSU GPA is taking only MSU courses into account. Quality points received for each letter grade can be seen in Table 2.

Total hours of college classes taken at MSU and other higher education institutions were separate predictors. De-identified data on the number of math and science classes taken in previous semesters were also recorded as separate predictors, including any remedial classes within the subject. Gender of the student along with age was considered as separate independent variables. Gender was assigned a numerical value of one if male and two if female. Pre and Post-Tests had been administered during the first and last week (respectively) of the academic semester either online or in class by the instructor. Questions pertaining to class objectives were asked. De-identified test scores and difference in Pre/Post-Test scores were analyzed by the student researcher as a possible predictor of student success.

A limitation within this study was that 37 Pre-Test and 24 Post-Test scores were never recorded. The instructor stated that this was in large part due to students missing class or not taking the test, in addition some students registered for the class after the pre-test time allotment while others may not have needed or thought they needed extra credit points earned for taking either the pre- and/or post-test.

Another limitation for this study is analyzing only one class at one institution. Other institutions with different teachers and types of students would help diversify future research in this area.

Table 1. Numerical value given to final letter grade received in AGR 300 during fall 2016, spring 2017, fall 2017, and spring 2018 semesters for statistical analysis.

Final Letter Grade	Value Given
A+	1
A	1
A-	1
B+	2
B	2
B-	2
C+	3
C	3
C-	3
D+	4
D	4
F	5

Table 2. Missouri State University's, Springfield MO quality points earned per final letter grade received to calculate GPA of students.

Letter Grade	Quality Points
A	4.00
A-	3.70
B+	3.30
B	3.00
B-	2.70
C+	2.30
C	2.00
C-	1.70
D+	1.30
D	1.00
F	0.00

RESULTS AND DISCUSSION

De-identified demographics of student's studied can be found in Table 3. On average, 43 students were enrolled within the class each semester, with females accounting for 54.7% the class over the which is comparable to the MSU's 59% female to male student ratio during Fall 2018 (University, 2019). Average age of students in the data set was 19-22. Mean values of incoming GPA of students tested were 2.95 (Table 4). This is comparable to MSU's typical undergraduate GPA average of 3.1 during the Fall 2016-Spring 2018 semesters (University, 2016; University, 2017b; University, 2017a; University, 2018).

Typical final letter grade received in the data set was C (31.4%), followed by A (21.5%), D (20.4%), B (15.7%), and F (11%). Nine students of the 172 had to retake AGR 300 within the four semesters studied.

A summary of statistics for each of the predictors can be found in Table 5. Of the three statistic models used, analysis of variance was used to evaluate the influence of semester on final letter grade and was determined to be insignificant to this study.

Correlation Coefficients

Correlation coefficients were calculated to evaluate relationships between variables evaluated and final letter grade. The correlation coefficients of all predictors tested can be seen within Table 6. Composite ACT score was found to be a significant factor in predicting student success. Students studied had ACT composite scores ranging from 14-34 with a mean of 22. The ACT math score was also significantly correlated with final grade. These findings are consistent with

research showing that standardized testing scores show correlations with college successfulness (Zwick, 2019).

A significant predictor was student's incoming GPA. There is currently a multitude of factors that is thought to contribute to final letter grades and GPA of students such as: study habits, physical location within the classroom, reviewing text or notes before class, and seeking outside assistance (Gossard et al., 2006). Our findings support research showing prior GPA is significant in success with organic chemistry classes (Austin, 2018). Further research is needed to better understand how GPA is related to student success within an undergraduate classroom.

Hours of instruction taken at MSU or transfer hours for students were not considered significant. The amount of math classes or science classes taken in previous semesters were also not significant to this study.

Pre-Test scores of students were significantly correlated with final letter grade. Possibly this reflects students with a high Pre-Test score appeared to have had a greater understanding of chemistry before entering AGR 300. More research is needed to see why Pre-Test scores are significant in predicting student success.

Post-Test score was found to be significant along with the difference in Pre/Post-Test scores. We believe that this showcases that learning took place within AGR 300.

Regression Analysis

Finally, stepwise regression was used to model significant factors that were most important to predicting student success. Residual plots for significant factors identified in stepwise regression, show that a linear statistic model for analysis was acceptable as seen in Figure 1. Figure 2 shows a Residual vs Predicted plot; this plot shows slight clustering around

middle of the trendline, somewhat symmetrical but no overall pattern or heteroscedasticity. Figure 3 shows Observed vs Predicted values. Within this plot there appears to have some symmetric qualities but no overall pattern or heteroskedasticity. Most significant to predicting student success was incoming GPA (R^2= 0.31), ACT composite score (R^2 = 0.05), MSU hours (R^2 = 0.03), and Pre-Test score (R^2= 0.41) respectively as seen in Table 7. As GPA is increased by one point, letter grade increased 0.93 points on a scale of 1-5, where A=1. Figure 4 shows final grade received within AGR 300 and incoming GPA. This again supports prior research supporting student success is tied to student GPA (Austin, 2018).

The ACT composite score was deemed as significant within this model. Figure 5 displays student ACT composite score along with final grade received within AGR 300 in the semesters studied. For a one-point increase in ACT composite score, final letter grade increased 0.07 points on a score of 1-5, (1=A F=5). This supports the ACT is a good indicator of student success within higher education (Zwick, 2019).

Figure 6 shows final grade received within AGR 300 and amount of MSU hours taken. If amount of MSU hours increased by one hour, letter grade increased 0.07 points on a scale of 1-5, where A=1. Further research is needed to better evaluate the number of hours taken at MSU vs other institutions and its role in student success.

Students with greater Pre-Test scores of students may reflect greater student success (P=0.09). Students with a high Pre-Test score appeared to have had a greater understanding of chemistry before entering AGR 300. A total of 37 Pre-Test scores were never recorded during the study. Further research is needed to fully evaluate if Pre-Test score plays a role within this model. Possibly this reflects students with a high Pre-Test score appeared to have had a greater understanding of chemistry before entering AGR 300. A total of 37 Pre-Test scores were never

recorded during the study. Further research is needed to fully evaluate if Pre-Test score plays a role within this model.

Table 3. Demographics of student's studied within AGR 300 during fall 2016, spring 2017, fall 2017, and spring 2018 semesters.

	Fall 2016	Spring 2017	Fall 2017	Spring 2018	Total Count	Total %
Male	17	17	22	22	78	45.3
Female	32	21	21	20	94	54.7
Total Students	49	38	43	42	172	100
Age						
19-22	34	20	25	18	97	56.4
23-26	11	16	14	14	55	32.0
27-31	2	0	4	2	8	4.7
≥32	2	2	0	8	12	7.0
Incoming GPA[1]						
<2	0	2	2	3	7	4.1
2-2.9	24	19	26	19	88	51.2
3-3.9	23	17	14	19	73	42.4
4	2	0	1	1	4	2.3
Final Letter Grade Received						
F	5	3	7	4	19	11.0
D	8	8	8	11	35	20.4
C	15	14	13	12	54	31.4
B	6	5	8	8	8	27
A	15	8	7	7	7	21.5

[1]Cumulative GPA of each student's at end of previous semester before enrolling in AGR 300

Table 4. Overview of all GPA ranges of all 172 students of AGR 300 Food and Agricultural Chemistry during fall 2016, spring 2017, fall 2017, and spring 2018 semesters.

GPA Ranges	% of Students
4-3.5	16.76
3.4-3	27.17
2.9-2	50.29
1.9-1.22	4.62

Table 5. Summary of statistics for all twelve predictors tested for academic success within AGR 300 during fall 2016, spring 2017, fall 2017, and spring 2018 semesters.

Variable	N	Mean	Standard Deviation	Min	Max
ACT composite Score	120	22.47	3.99	14	34
ACT math score	120	22.24	4.42	14	34
Incoming GPA[1]	172	2.95	0.57	1.22	4
MSU Hours[2]	172	59.00	30.62	0	145
Transfer Hours[3]	158	44.71	31.35	2	160
Number of Math Classes[4]	172	2.11	0.67	0	3
Number of Science Classes[5]	172	4.09	2.02	0	17
Gender	172	1.55	0.50	1	2
Age	172	23.4	3.79	19	39
Pre-Test Score[6]	135	10.08	3.18	3	19
Post-Test Score[7]	148	17.86	5.27	6	29
Difference in Pre vs Post-Test[8]	156	7.94	6.12	-13	23

[1] Cumulative GPA of each student's at end of previous semester before enrolling in AGR 300
[2] Total hours of college classes taken at MSU
[3] Total hours of college classes taken other higher education institutions
[4] The number of math classes taken in previous semesters, including any remedial classes
[5] The number of science classes taken in previous semesters, including any remedial classes
[6] Pre-Tests were administered during the first week of the semester. Questions pertaining to class objectives were asked and test score received were analyzed as a possible predictor.
[7] Post-Tests were administered during the last week of the semester. Questions pertaining to class objectives were asked and test scores received were analyzed as a possible predictor.
[8] Pre and Post-Tests were administered during the first and last week (respectively) of the academic semester. Questions pertaining to class objectives were asked and the difference in test scores received was analyzed as a possible predictor.

Table 6. Correlation coefficients for all twelve predictors tested within AGR 300.

Variable Tested	P	R Value
Grade		1.00
ACT composite score	*<.0001*	*-0.3824*
ACT math score	*0.0002*	*-0.3343*
Incoming GPA[1]	*<.0001*	*-0.5857*
MSU Hours[2]	0.1448	-0.1117
Transfer Hours[3]	0.729	0.0278
Number of Math Classes[4]	0.3801	-0.0673
Number of Science Classes[5]	-0.1027	-0.1027
Pre-Test score[6]	*<.0001*	*-0.4315*
Post-Test score[7]	*0.0002*	*-0.3048*
Difference in Pre/Post Test Scores[8]	*0.0328*	*-0.1710*
Gender	0.7843	0.0210
Age	0.7551	-0.0210

Significant predictors at the P=0.05 level italic.

[1] Cumulative GPA of each student's at end of previous semester before enrolling in AGR 300

[2] Total hours of college classes taken at MSU

[3] Total hours of college classes taken other higher education institutions

[4] The number of math classes taken in previous semesters, including any remedial classes

[5] The number of science classes taken in previous semesters, including any remedial classes

[6] Pre-Tests were administered during the first week of the semester. Questions pertaining to class objectives were asked and test score received were analyzed as a possible predictor.

[7] Post-Tests were administered during the last week of the semester. Questions pertaining to class objectives were asked and test scores received were analyzed as a possible predictor.

[8] Pre and Post-Tests were administered during the first and last week (respectively) of the academic semester. Questions pertaining to class objectives were asked and the difference in test scores received was analyzed as a possible predictor.

Table 7. Significant predictors of final grade within AGR 300 with corresponding p, partial r^2, model r^2, parameter estimate, standard error, type II sum of squares, f value, and pr > f.

Variable Tested	P	Partial R^2	Model R^2	Parameter Estimate	Standard Error	Type II Sum of Squares	F Value	Pr > F
Incoming GPA[1]	0.0002	0.31	0.31	-0.93	0.24	14.48	15.11	0.0002
ACT composite Score	0.0359	0.05	0.36	-0.07	0.03	4.36	4.55	0.0359
MSU Hours[2]	0.0928	0.03	0.39	-0.01	0.004	2.77	2.89	0.0928
Pre-Test Score[3]	0.0930	0.02	0.41	-0.06	0.04	2.77	2.89	0.0930

[1] Cumulative GPA of each student's at end of previous semester before enrolling in AGR 300
[2] Total hours of college classes taken at MSU
[3] Pre-Tests were administered during the first week of the semester. Questions pertaining to class objectives were asked and test score received were analyzed as a possible predictor.

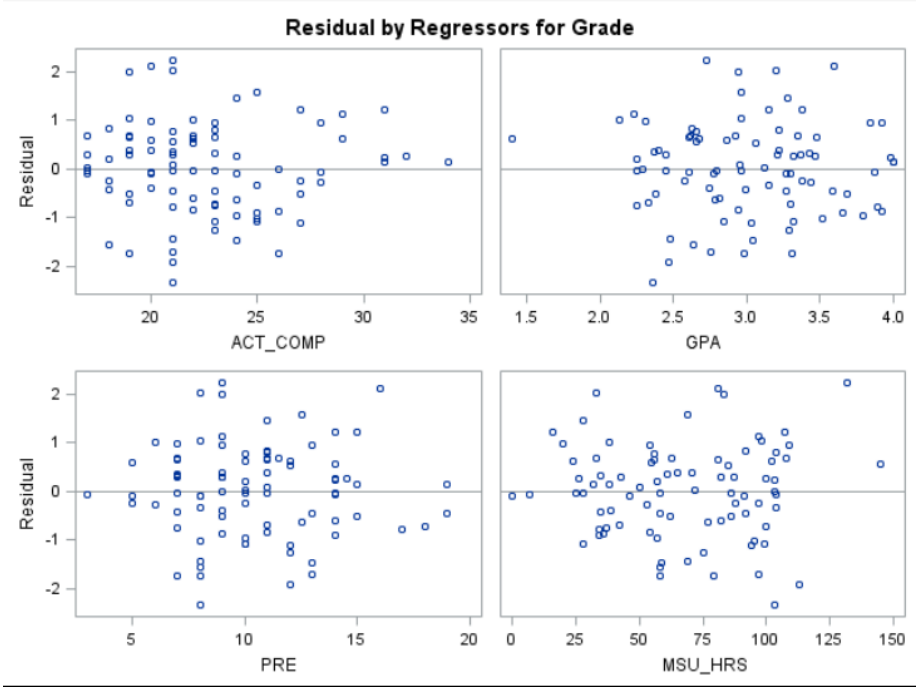

Figure 1. Residual plots for significant factors (left to right, top to bottom: ACT composite score, incoming GPA, Pre-Test score, and MSU hours) predicting student success within AGS 300 taken from PROC REG SAS 9.4 results.

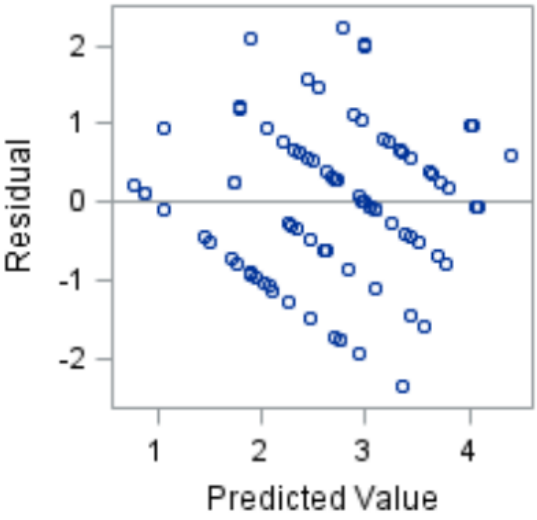

Figure 2. Residual vs predicted plot predicting student success within AGS 300 taken from PROC REG SAS 9.4 results.

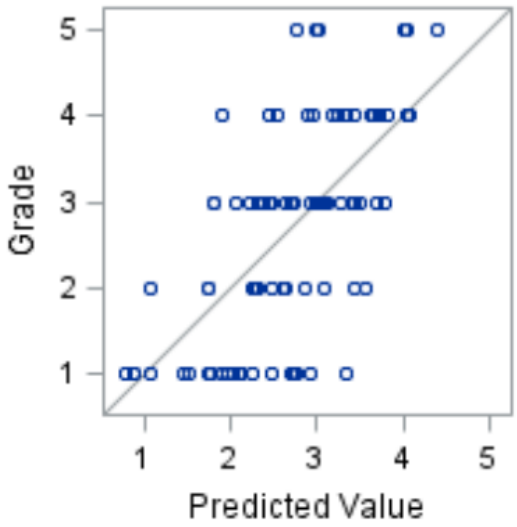

Figure 3. Observed final letter grade[1] vs predicted plot predicting student success within AGS 300 taken from PROC REG SAS 9.4 results.
[1]Final Letter grade on a 1-5 scale; 1=A, 2=B, 3=C, 4=D, 5=F

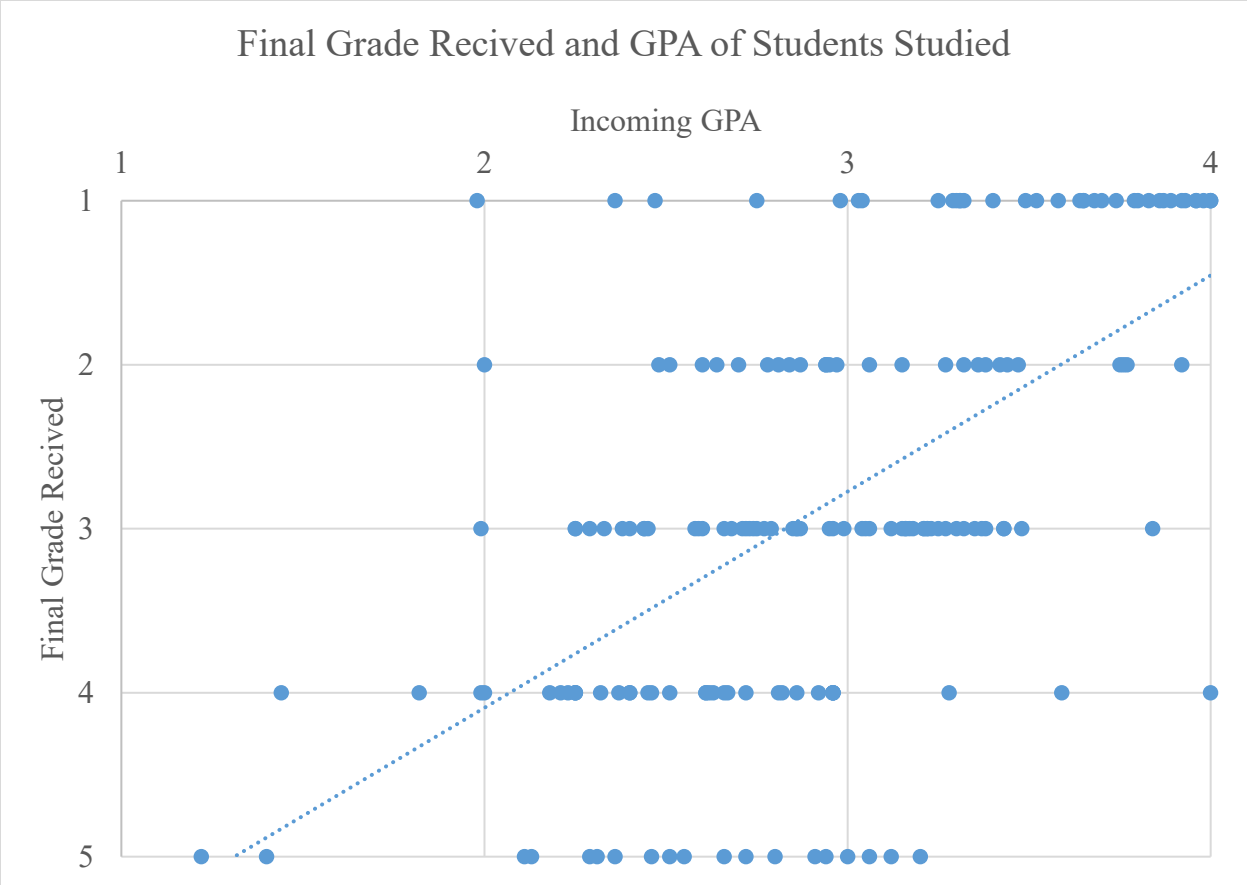

Figure 4. Final grade received[1] and incoming GPA of students in AGR 300 for students studied during fall 2016, spring 2017, fall 2017, and spring 2018 semesters.
[1]Final Letter grade on a 1-5 scale; 1=A, 2=B, 3=C, 4=D, 5=F

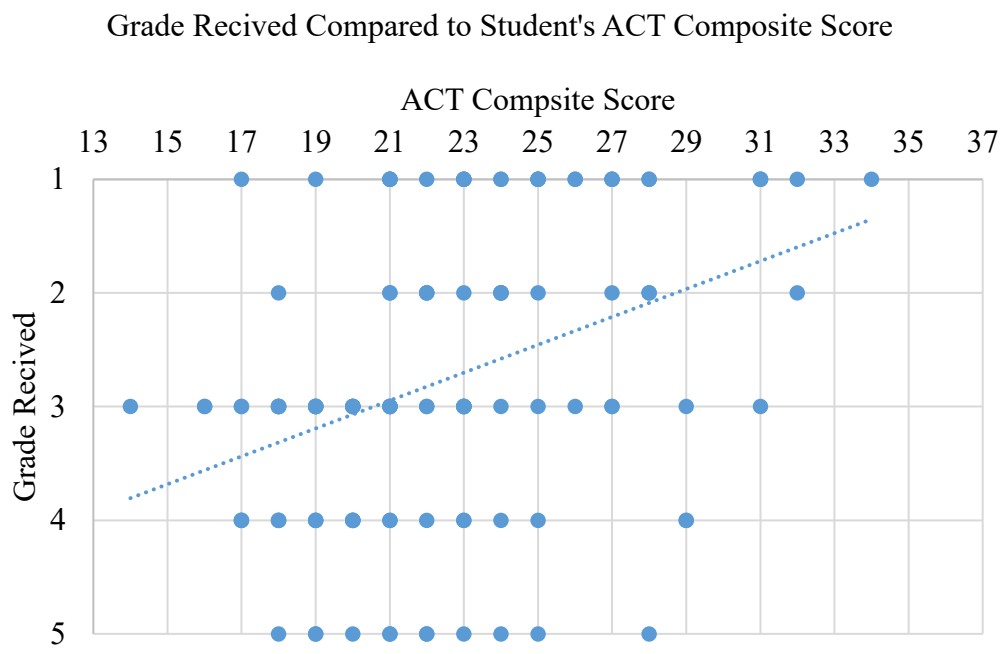

Figure 5. ACT composite score and final letter grade received[1] in AGR 300 studied during fall 2016, spring 2017, fall 2017, and spring 2018 semesters.
[1]Final Letter grade on a 1-5 scale; 1=A, 2=B, 3=C, 4=D, 5=F

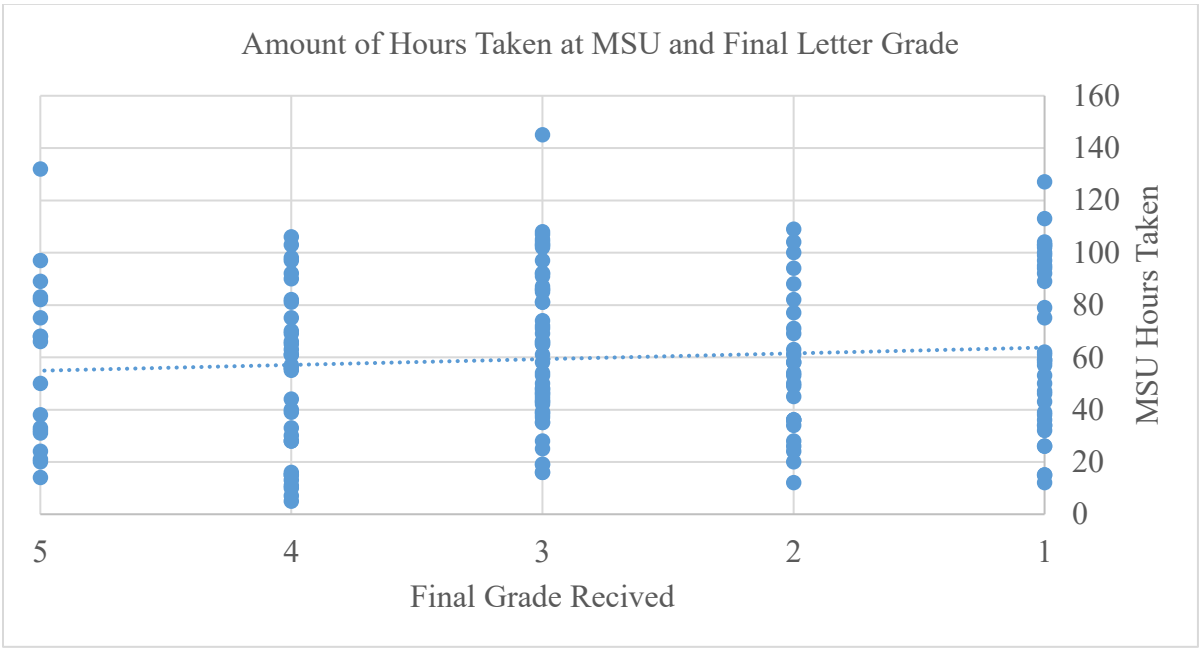

Figure 6. Hours taken at MSU and final grade received[1] in AGR 300 for students studied during fall 2016, spring 2017, fall 2017, and spring 2018 semesters.
[1]Final Letter grade on a 1-5 scale; 1=A, 2=B, 3=C, 4=D, 5=F

CONCLUSIONS

Previous research shows that a true understanding of academic performance does not rest on a single predictor but instead, a combination of conditions must come together for a student to be successful (Noble and Sawyer, 2002). This study shows that of the factors tested; ACT composite score, ACT math score, incoming GPA, Pre-Test score, Post-Test score, and difference in Pre/Post-Test scores have roles in student success.

Further research is needed in four specific areas of this study. With the number of Pre/Post-Tests scores missing (61 tests total), further research is needed to determine to what extent these predictors have on the overall study and student success. The amount of science and math classes being not ranked as a significant predictor calls for this relationship to be investigated further to determine if institutions need to reevaluate the true need of prerequisite, lower division courses need to be enrolled within higher division classes. To find out if grit plays a role as a predictor of student success within agriculture, a Grit-S test should be administered in addition to monitoring student grades, attendance, participation within class, and time spent studying for the class could also shed light on the grittiness of students. Finally, to evaluate if students are intrinsic or extrinsically motivated, a test should be given to students such as the Situational Motivation Scale (SIMS), the Academic Motivation Scale, or Motivated Strategies for Learning Questionnaire (MSLQ). All three of the example tests stated give students a measure of what type of motivation is being used by students using concepts based in self-determination theory such as student learning strategies (Guay et al., 2000; Pintrich et al., 1991).

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