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Students' Motivation to Learn Science Through Undergraduate-level Agricultural Coursework

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Abstract

A profound need currently exists in the United States for increased student interest in science, technology, engineering, and mathematics (STEM) -based careers. Our study focused on how students conceptualized their motivation to learn contextualized science via agricultural science while viewed through the lens of both social cognitive theory (Bandura, 1986, 2001) and Azjen's theory of planned behavior (1991). Our non-experimental, descriptive study focused on students enrolled in either an undergraduate-level animal science or plant science course. The questionnaire used for this study was a modified version of the Science Motivation Questionnaire II (SMQ II). The SMQ II has been found to have adequate content validity and criterion-related validity. The science motivation scales with the highest reported average mean scores were grade motivation, career motivation, and intrinsic motivation. The self-determination and self-efficacy scales received lower ratings from the students.

Keywords**:** science; motivation; students

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Introduction

A critical need continues to exist for professionals in the workforce with informed backgrounds in science, technology, engineering and mathematics (STEM) topics (Jackson & Rudin, 2019; Jones et al., 2018; Mena Report, 2018). Projected labor needs indicate STEM concentrations are the fastest growing career-fields and essential to our economic advancement and national defense (Carnevale et al., 2013; Jackson & Rudin, 2019; Jones et al., 2018). Increased funding through state and federal agencies have been invested towards an enriched adeptness in STEM-related areas; however, continued decline in student proficiency in these fields of study has inhibited global advancement by the United States (Drozd et al., 2017; Jackson & Rudin, 2019).

Changes in issues, technology, practices, and ideas require constant review, communication, and understanding between parties such as producers and consumers, faculty and

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students, and so forth (Roberts et al., 2016). Moreover, as changes in science-related areas occur, educational needs change as well. For example, student achievement in science is often not at a level that could be expected of a diverse and technologically-advanced society (National Center for Education Statistics [NCES], 2017a). Many students do not fare well in science content as measured by standardized testing. Throughout recent history, American public education students have not globally led in science achievement scores (NCES, 2017a). Rather, American students have underperformed in comparison to their international counterparts in Singapore, Vietnam, Germany, and other countries as measured by the Program for International Student Assessment (PISA) science literacy scale (NCES, 2017b).

A profound need currently exists in the United States for an increased student interest in STEM-based careers (Guzey et al., 2014). It has been projected that growth in the sciences, mathematics, computer, and engineering occupations will collectively increase by 69% between 2010 and 2020 (Lockard & Wolf, 2012), indicating an expressed need for future workers who have a career interest essential to competing with leading countries in STEM competencies, thus increasing our country's economic growth (Guzey et al., 2014).

Research has indicated "[w]e have been trying to prepare young people for a 21st- century workplace with 19th- century educational structures" (Drew, 2011, p. 18). This indicates the United States cannot currently keep up with the need for graduates capable of meeting the demand in STEM career areas (Byars-Winston, 2014). Several factors exist as contributors to the lack of adequately trained workers in STEM career areas, such as: ". . . individual differences in career preferences, inadequate science and mathematics academic preparation, [and] poor STEM classroom experiences . . ." (Byars-Winston, 2014, p. 343).

A considerable effort towards change from what has traditionally occurred in the past regarding the emphasis and integration of contextualized learning is gaining momentum (National Research Council [NRC], 2009). It has been realized (NRC, 2009) that the integration of practical hands-on, minds-on activities through problem-solving approaches has been shown to elevate student interest in the criterion material, thereby increasing achievement and motivation levels of students as a result (NRC, 2009). Agricultural education has taken a prominent role in emphasizing and contextualizing STEM content through the global agricultural, food, fiber, and natural resources systems (Myers & Dyer, 2006; Parr et al., 2006, 2008; Sanders, 2009; Scherer et al., 2019; Warnick & Thompson, 2007; Young et al., 2009). Through documented research in student scientific and mathematics achievement, indicators exist supporting the ability of agricultural education to be a means to student success in STEM content areas not only on the secondary level, but through post-secondary (e.g., university-level, etc.) education as well (Stubbs & Myers, 2016; Swafford, 2018). Researchers (Stubbs & Myers, 2016) have identified future careers in the agricultural industry will necessitate a greater need in content knowledge and capacities. Agricultural education is ideal for focusing student abilities into achievement through a contextualized pedagogical approach (Stubbs & Myer, 2016).

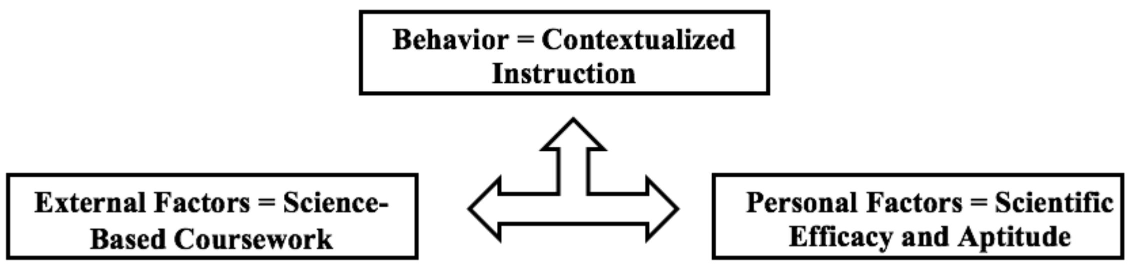
Theoretical Framework

Our study on how students conceptualized their motivation to learn contextualized science is viewed through the lens of both social cognitive theory (Bandura, 1986, 2001) and Azjen's theory of planned behavior (1991). Social cognitive theory regards the notion that a considerable amount of learning attempted by humans occurs best in a social environment (Schunk, 2008). Schunk (2008) goes on to clarify that through social interaction, ". . .people acquire knowledge, rules, skills, strategies, beliefs, and attitudes" (p. 78) contributing to the retention of knowledge in the learning process. The experiences gained through either direct or observational episodes are then stored and reserved for future use and can be influenced through social interaction with other individuals (Bandura, 1986).

The triadic reciprocality model of social cognitive theory (Bandura, 1986) suggests "behavior, cognitive and other personal factors, and environmental events all operate as interacting determinants of each other" (p. 18), and constantly occur or change over a lifetime. When operationalizing the triadic reciprocality model, we chose Stripling and Roberts' (2013) version to reference as follow: "behavior is the teaching of contextualized mathematics, external environment is the teacher education program, and personal factors are self-efficacy and mathematics ability" (p. 138), found in *Investigating the Effects of a Math-Enhanced Agricultural Teaching Methods Course*. The model combines interacting variables (i.e., behavior, human factors, and environmental factors and events) as factors (Bandura, 1986) relating to how university students theorized their incentive to learn science through a conceptualized approach. In this instance, we allow for *behavior* to be the contextualized instruction of science (agricultural science), *personal factors* as individualistic efficacy and aptitude in science, and *external factors and events* as science-based courses related to animal science and plant science (see Figure 1).

Figure 1

Triadic Reciprocality Model (Adapted from Bandura, 1986)



The theory of planned behavior (Azjen, 1991) extends from Fishbein and Azjen's theory of reasoned action (1975). They both exhibit informational and motivational developmental influences and their relationships on behavior (Connor & Armitage, 1998). According to Chumbley et al. (2015), "The theory of planned behavior suggests that behavioral intentions can be best viewed as consequences of an individual's attitude, which is a result of values and beliefs, in turn affected by demographic variables and knowledge" (p. 109). When the data for our study are holistically analyzed through both lenses, the value and benefit of learning contextualized science by students is evident.

Purpose and Objectives

The purpose of our study was to identify how agricultural students conceptualized their motivation to learn science through the context of agricultural science. We also sought to determine whether previous experience in college science courses or the students' major had an impact on these motivational factors. Specific research objectives of our study were to:

1. Evaluate motivational factors of students to learn in science-based courses related to animal science and plant science.

2. Evaluate students' motivational factors to learn in science-based courses based on their identified degree program.

3. Evaluate students' motivational factors to learn in science-based courses based on their previous experience in college science courses (i.e., biology and/or chemistry).

Our study aligned with Research Priority 4 of the American Association for Agricultural Education (AAAE) National Research Agenda: Meaningful, Engaged Learning in All Environments (Edgar, Retallick, & Jones, 2016). The indicated need to explore elements impacting student interest and motivation posited by Edgar et al. (2016) added credence to the need for our study.

Methods

Our non-experimental, descriptive study focused on students enrolled in either an introductory-level animal science or plant science course at a university in the southern United States. These courses are required components of all degree plans in the university's college of agriculture and thus presented the opportunity for the broadest sample of students. After we received Institutional Review Board (IRB) approval, we used a modified version of Glynn et al.'s (2011) Science Motivation Questionnaire II (SMQ II) to collect data during the third week of the semester.

Instrumentation / Data Collection

The Science Motivation Questionnaire (SMQ) was originally designed to assess students' general motivation to learn science (Glynn & Koballa, 2006). Glynn et al. (2011) indicated the questionnaire serves as an efficient and valid tool for "assessing components of students' motivation to learn science in college courses, and that the components play a role in students' science achievement" (p. 1159). The SMQ II encompasses five latent variables (i.e., Intrinsic Motivation, Self-Determination, Self-Efficacy, Career Motivation, and Grade Motivation) which serve as empirical indicators of components of college students' motivation to learn science (Glynn et al., 2011).

Taasoobshirazi and Glynn (2009) indicated the items on the revised questionnaire were designed so the word "science" in each item can be replaced with the term "biology", "chemistry", or "agricultural science", respectively. Glynn and Koballa (2006) posited the questionnaire was applicable in all facets of science. For the purposes of our study, the general term "science" was replaced by the term "agricultural science."

The construct validity of the SMQ II scales was supported by way of exploratory and confirmatory factor analyses conducted by the developers of the questionnaire (Glynn et al., 2011). Moreover, Glynn et al. (2011) provided evidence of criterion-related validity by relating the scales to students' GPAs in college science course. Face and content validity for the modified SMQ II used in our study were reviewed and confirmed by a panel of university faculty members. The panel members indicated the statements "My career will involve agricultural science" and "I will incorporate agricultural science in my career" were too similar. The latter was removed, which resulted in 24 science motivation items which were retained on the modified questionnaire. Each item was coupled with a five-point scale of temporal frequency (1 = *Never*, 2 = *Rarely*, 3 = *Sometimes*, 4 = *Often*, 5 = *Always*).

Four scales (i.e., Grade Motivation, Intrinsic Motivation, Self-Determination, Self-Efficacy) were comprised of five items, allowing for a possible score range from five to 25. The scale Career Motivation only had four items and a possible score range of four to 20. The questionnaire began with the prompt, "In order to better understand what you think and how you feel about agriscience, please respond to each of the following statements from the perspective of 'When I am in an agricultural science course . . .'" (Glynn et al., 2011, p. 1165).

As recommended by DeVellis (2003), the items were randomly ordered, strongly-worded, unambiguous declarative statements in the form of short, simple sentences without jargon. The Flesch-Kincaid formula indicated readability of the SMQ II was at the sixth-grade level (Taasoobshirazi & Glynn, 2009). Glynn et al. (2011) reported the questionnaire had an overall reliability coefficient of 0.92. To do our due diligence and assess the reliability of the questionnaire after making modifications, we conducted a post-hoc reliability test. The reliability test indicated the modified questionnaire used in this study had the same Cronbach's alpha Coefficient ($\alpha = 0.92$) as the original SMQ II. Reliability analysis were also conducted on a granular level by evaluating the reliability of each science motivation scale (Career Motivation $\alpha = 0.90$; Intrinsic Motivation $\alpha = 0.89$; Self-Efficacy $\alpha = 0.89$; Self-Determination $\alpha = 0.88$; Grade Motivation $\alpha = 0.84$).

Participants

Students in the selected courses were solicited to participate in our study after the conclusion of a lecture section during the third week of each course's schedule. There were two lecture sections of the plant science course. Each section included 30 students. There were three sections of the animal science course. Each section included 45 students. A paper-based version of our modified SMQ II was distributed and collected in one day after both the animal science and the plant science courses' lectures. Students were given approximately 30 minutes to complete the modified SMQ II. We offered the students neither extra credit nor other incentives.

Out of the 195 students enrolled in the two courses, 161 students responded to the SMQ II. One-hundred and twenty-one respondents were enrolled in the animal science course and 40 respondents were enrolled in the plant science course. Thus, our response rate was 82.5%. Students who participated in this study were mostly female ($n = 106$, 65.8%) and had previously taken a college science course (i.e., biology and / or chemistry; $n = 117$, 72.7%). Regarding the grade classification of the students, 52 (32.3%) were freshman, 31 (19.3%) were sophomores, 45 (28.0%) were juniors, 28 (17.4%) of the students indicated they were seniors, and three (1.90) were graduate students. Most students indicated their grade point average (GPA) fell within the 2.51 - 3.0 ($n = 45$, 28.0%) and 3.01 - 3.5 ($n = 35$, 21.7%) ranges.

Data Analysis

The data we collected were entered and analyzed using the Statistical Package for Social Sciences (SPSS©), Version 25 software. Descriptive statistics (i.e., frequencies and percentages) were calculated to evaluate items related to demographic characteristics and science motivation. Moreover, descriptive statistics were analyzed to compare the motivational factors of the students based on their major and previous experience in college-level science courses. Measures of central tendency and dispersion were computed to analyze individual items, science motivation scales, and summative science motivation scores. A modified version of Glynn et al.'s (2007) summated SMQ score range descriptors (*Low Motivation*, SSMQ = 24; *Moderate Motivation*, SSMQ = 49 – 72; *High Motivation*, SSMQ = 73-96; *Very High Motivation*, SSMQ = 97+) were used to interpret the SSMQ scores in this study.

Findings

Our first research objective sought to evaluate the motivational science learning factors of students. The students had an overall summated science motivation (SSMQ) score of 104.63—falling 15.37 points below the top threshold (i.e., 120) of science motivation scores and is considered to be a very high level of motivation to learn science (Glynn et al., 2007). Four of the science motivation scales (i.e., Grade Motivation, Intrinsic Motivation, Self-Determination, and Self-Efficacy) were comprised of five items while the Career Motivation scale only contained a total of four items. Career Motivation (*SSMS* = 18.39, *SD* = 2.87), Grade Motivation (*SSMS* = 23.03, *SD* = 2.60), and Intrinsic Motivation (*SSMS* = 21.94, *SD* = 3.50) were the scales in which the students had the highest summated science motivation scores (see Table 1).

Table 1

Summated Science Motivation Scores by Scale

Scale	No. of Items in Scale (score range)	SSMS[1]	*SD*
Career Motivation	4 (4 – 20)	18.39	2.87
Grade Motivation	5 (5 – 25)	23.03	2.60
Intrinsic Motivation	5 (5 – 25)	21.94	3.50
Self-Determination	5 (5 – 25)	20.90	3.47
Self-Efficacy	5 (5 – 25)	20.64	3.29

Note. [1]Summated Science Motivation Score. Overall SSMS = 104.63

Conversely, the science motivation scales with the lowest average science motivation scores were Self-Determination (*SSMS* = 20.90, *SD* = 3.47) and Self-Efficacy (*SSMS* = 20.64, *SD* = 3.29). Of the items in the Career Motivation scale, students indicated the overall highest temporal frequency with "Learning agricultural science will help me get a good job" (*Always* = 122, 76%) and "Knowing agricultural science will give me a career advantage" (*Always* = 121, 75%). On the Grade Motivation scale, the students reported the highest temporal frequencies associated with "Scoring high on agricultural science tests and labs matters to me" (*Always* = 127, 79%) and "Getting a good agricultural science grade is important to me" (*Always* = 124, 77%; see Table 2).

Table 2

Students' Science Motivation Responses

			f (%)				
Scale / Item	Major	*n*	*Never*	*Rarely*	*Sometimes*	*Often*	*Always*
Career Motivation							
Learning agricultural science will help me get a good job	Overall	161	1(1)	4(2)	11(7)	23(14)	**122(76)**
	Ag. Sci.	59	0(0)	1(2)	0(0)	10(17)	**48(81)**
	Ag. Bus.	19	0(0)	0(0)	2(11)	2(11)	**15(79)**
	Ani. Sci.	65	1(2)	3(5)	5(8)	9(14)	**47(72)**
	Wildlife	18	0(0)	0(0)	4(22)	2(11)	**12(67)**
Knowing agricultural science will give me a career advantage	Overall	161	1(1)	1(1)	12(7)	26(16)	**121(75)**
	Ag. Sci.	59	0(0)	0(0)	2(3)	7(12)	**50(85)**
	Ag. Bus.	19	0(0)	0(0)	2(11)	3(16)	**14(74)**
	Ani. Sci.	65	1(2)	1(2)	6(9)	10(15)	**47(72)**
	Wildlife	18	0(0)	0(0)	2(11)	6(33)	**10(56)**
Understanding agricultural science will benefit me in my career	Overall	161	1(1)	4(2)	9(6)	26(16)	**121(75)**
	Ag. Sci.	59	0(0)	1(2)	1(2)	8(14)	**49(83)**
	Ag. Bus.	19	0(0)	0(0)	1(5)	3(16)	**15(79)**
	Ani. Sci.	65	1(2)	3(5)	4(6)	10(15)	**47(72)**
	Wildlife	18	0(0)	0(0)	3(17)	5(28)	**10(56)**
My career will involve agricultural science	Overall	161	1(1)	7(4)	19(12)	18(11)	**116(72)**
	Ag. Sci.	59	0(0)	1(2)	3(5)	3(5)	**52(88)**
	Ag. Bus.	19	0(0)	0(0)	3(16)	4(21)	**12(63)**
	Ani. Sci.	65	1(2)	5(8)	9(14)	8(12)	**42(65)**
	Wildlife	18	0(0)	1(6)	4(22)	3(17)	**10(56)**
Grade Motivation							
Scoring high on agricultural science tests and labs matters to me	Overall	160	1(1)	0(0)	7(4)	25(16)	**127(79)**
	Ag. Sci.	59	0(0)	0(0)	1(2)	9(15)	**49(83)**
	Ag. Bus.	19	0(0)	0(0)	1(5)	5(26)	**13(68)**
	Ani. Sci.	64	1(2)	0(0)	4(6)	8(13)	**51(80)**
	Wildlife	18	0(0)	0(0)	1(6)	3(17)	**14(78)**
Getting a good agricultural science grade is important to me	Overall	161	2(1)	1(1)	1(1)	33(20)	**124(77)**
	Ag. Sci.	59	1(2)	0(0)	0(0)	10(17)	**48(81)**
	Ag. Bus.	19	0(0)	0(0)	1(5)	6(32)	**12(63)**
	Ani. Sci.	65	1(2)	0(0)	0(0)	10(15)	**54(83)**
	Wildlife	18	0(0)	1(6)	0(0)	7(39)	**10(56)**
It is important that I get an "A" in agricultural science courses	Overall	161	1(1)	0(0)	7(4)	31(19)	**122(76)**
	Ag. Sci.	59	0(0)	0(0)	2(3)	11(19)	**46(80)**
	Ag. Bus.	19	0(0)	0(0)	2(11)	4(21)	**13(68)**
	Ani. Sci.	65	1(2)	0(0)	3(5)	10(15)	**51(78)**
	Wildlife	18	0(0)	0(0)	0(0)	6(33)	**12(67)**
I think about the grade I will get in agricultural science courses	Overall	161	1(1)	2(1)	8(5)	35(22)	**115(71)**
	Ag. Sci.	59	0(0)	1(2)	2(3)	10(17)	**46(80)**
	Ag. Bus.	19	0(0)	0(0)	2(11)	7(37)	**10(53)**
	Ani. Sci.	65	1(2)	1(2)	4(6)	12(18)	**47(72)**
	Wildlife	18	0(0)	0(0)	0(0)	6(33)	**12(67)**
I like to do better than other students on	Overall	160	1(1)	2(1)	22(14)	64(40)	**70(44)**
	Ag. Sci.	59	0(0)	0(0)	5(8)	21(36)	**33(56)**
	Ag. Bus.	19	0(0)	0(0)	4(21)	6(32)	**9(47)**

agricultural science tests	Ani. Sci.	64	1(2)	2(3)	8(13)	**29(45)**	24(38)
	Wildlife	18	0(0)	0(0)	5(28)	**9(50)**	4(22)
Intrinsic Motivation							
Learning agricultural science is interesting	Overall	161	0(0)	3(2)	13(8)	39(24)	**106(66)**
	Ag. Sci.	59	0(0)	0(0)	2(3)	9(15)	**48(81)**
	Ag. Bus.	19	0(0)	0(0)	1(5)	7(37)	**11(58)**
	Ani. Sci.	65	0(0)	2(3)	8(12)	16(25)	**39(60)**
	Wildlife	18	0(0)	1(6)	2(11)	7(39)	**8(44)**
I enjoy learning agricultural science	Overall	160	1(1)	2(1)	13(8)	38(24)	**106(66)**
	Ag. Sci.	59	0(0)	1(2)	1(2)	11(19)	**46(80)**
	Ag. Bus.	19	0(0)	0(0)	1(5)	6(32)	**12(63)**
	Ani. Sci.	64	1(2)	1(2)	9(14)	13(20)	**40(63)**
	Wildlife	18	0(0)	0(0)	2(12)	**8(44)**	**8(44)**
I am curious about discoveries in agricultural science	Overall	161	1(1)	4(2)	18(11)	38(24)	**100(62)**
	Ag. Sci.	59	0(0)	1(2)	5(8)	10(17)	**43(73)**
	Ag. Bus.	19	0(0)	1(5)	1(5)	6(32)	**11(58)**
	Ani. Sci.	65	1(2)	2(3)	9(14)	15(23)	**38(58)**
	Wildlife	18	0(0)	0(0)	3(17)	7(39)	**8(44)**
Learning agricultural science makes my life more meaningful	Overall	161	2(1)	4(2)	34(21)	41(25)	**80(50)**
	Ag. Sci.	59	1(2)	0(0)	6(10)	12(20)	**40(68)**
	Ag. Bus.	19	0(0)	0(0)	5(26)	4(21)	**10(53)**
	Ani. Sci.	65	1(2)	3(5)	18(28)	20(31)	**23(35)**
	Wildlife	18	0(0)	1(6)	5(28)	5(28)	**7(39)**
The agricultural science I learn is relevant to my life	Overall	161	1(1)	5(3)	23(14)	65(40)	**67(41)**
	Ag. Sci.	59	0(0)	0(0)	3(5)	22(37)	**34(58)**
	Ag. Bus.	19	0(0)	0(0)	3(16)	**13(68)**	3(16)
	Ani. Sci.	65	1(2)	4(6)	15(23)	19(29)	**26(40)**
	Wildlife	18	0(0)	1(6)	2(11)	**11(61)**	4(22)
Self-Determination							
I put enough effort into learning agricultural science	Overall	161	0(0)	2(1)	16(1)	63(39)	**80(50)**
	Ag. Sci.	59	0(0)	0(0)	6(10)	18(31)	**35(59)**
	Ag. Bus.	19	0(0)	0(0)	3(16)	7(37)	**9(47)**
	Ani. Sci.	65	0(0)	1(2)	6(9)	25(38)	**33(51)**
	Wildlife	18	0(0)	1(6)	1(6)	**13(72)**	3(17)
I study hard to learn agricultural science	Overall	161	3(2)	4(2)	24(15)	58(36)	**72(45)**
	Ag. Sci.	59	1(2)	1(2)	8(14)	19(32)	**30(51)**
	Ag. Bus.	19	0(0)	1(5)	5(26)	4(21)	**9(47)**
	Ani. Sci.	65	2(3)	1(2)	6(9)	25(38)	**31(48)**
	Wildlife	18	0(0)	1(6)	5(28)	**10(56)**	2(11)
I prepare well for agricultural science tests and labs	Overall	159	1(1)	3(2)	27(17)	**68(43)**	60(38)
	Ag. Sci.	59	1(2)	1(2)	8(14)	22(37)	**27(46)**
	Ag. Bus.	19	0(0)	1(5)	6(32)	5(26)	**7(37)**
	Ani. Sci.	63	0(0)	1(2)	9(14)	**30(48)**	23(37)
	Wildlife	18	0(0)	0(0)	4(22)	**11(61)**	3(17)
I spend a lot of time learning agricultural science	Overall	161	2(1)	8(5)	28(17)	**63(39)**	60(37)
	Ag. Sci.	59	1(3)	0(0)	6(10)	17(29)	**35(59)**
	Ag. Bus.	19	0(0)	1(5)	4(21)	**10(53)**	4(21)
	Ani. Sci.	65	1(2)	6(9)	13(20)	**25(38)**	20(31)
	Wildlife	18	0(0)	1(6)	5(28)	**11(61)**	1(6)
	Overall	161	1(1)	3(2)	36(22)	**61(38)**	60(37)

I use strategies to learn agricultural science well	Ag. Sci.	59	1(2)	0(0)	7(12)	24(41)	**27(46)**
	Ag. Bus.	19	0(0)	1(5)	5(26)	4(21)	**9(47)**
	Ani. Sci.	65	0(0)	1(2)	20(31)	**23(35)**	21(32)
	Wildlife	18	0(0)	1(5)	4(22)	**10(56)**	3(17)
Self-Efficacy							
I am sure I can understand agricultural science	Overall	160	0(0)	3(2)	19(12)	**71(44)**	67(42)
	Ag. Sci.	58	0(0)	0(0)	5(9)	22(38)	**31(53)**
	Ag. Bus.	19	0(0)	1(5)	4(21)	**7(37)**	**7(37)**
	Ani. Sci.	65	0(0)	2(3)	9(14)	**30(46)**	24(37)
	Wildlife	18	0(0)	0(0)	1(6)	**12(67)**	5(28)
I believe I can earn a grade of "A" in agricultural science courses	Overall	160	0(0)	2(1)	32(20)	**65(41)**	61(38)
	Ag. Sci.	58	0(0)	0(0)	7(12)	18(31)	**33(57)**
	Ag. Bus.	19	0(0)	1(5)	4(21)	6(32)	**8(42)**
	Ani. Sci.	65	0(0)	1(2)	17(26)	**29(45)**	18(28)
	Wildlife	18	0(0)	0(0)	4(22)	**12(67)**	2(11)
I believe I can master agricultural science knowledge and skills	Overall	161	0(0)	3(2)	29(18)	**70(44)**	59(37)
	Ag. Sci.	59	0(0)	0(0)	4(7)	25(42)	**30(51)**
	Ag. Bus.	19	0(0)	0(0)	4(21)	**9(47)**	6(32)
	Ani. Sci.	65	0(0)	3(5)	18(28)	**24(37)**	20(31)
	Wildlife	18	0(0)	0(0)	3(17)	**12(67)**	3(17)
I am confident I will do well on agricultural science labs and projects	Overall	161	0(0)	4(2)	29(18)	**70(40)**	58(36)
	Ag. Sci.	59	0(0)	1(2)	4(7)	24(41)	**30(51)**
	Ag. Bus.	19	0(0)	0(0)	6(32)	**8(42)**	5(26)
	Ani. Sci.	65	0(0)	3(5)	14(22)	**27(42)**	21(32)
	Wildlife	18	0(0)	0(0)	5(28)	**11(61)**	2(11)
I am confident I will do well on agricultural science tests	Overall	159	0(0)	6(4)	41(26)	**68(42)**	45(28)
	Ag. Sci.	58	0(0)	1(2)	8(14)	24(41)	**26(45)**
	Ag. Bus.	19	0(0)	1(5)	**7(37)**	**7(37)**	4(21)
	Ani. Sci.	64	0(0)	3(5)	21(33)	**27(42)**	13(20)
	Wildlife	18	0(0)	1(6)	5(28)	**10(56)**	2(11)

Note. Temporal frequency scale: 1 = *Never*, 2 = *Rarely*, 3 = *Sometimes*, 4 = *Often*, 5 = *Always*

"Learning agricultural science is interesting" (*Always* = 106, 66%) and "I enjoy learning agricultural science" (*Always* = 106, 68%) were the two items with the highest temporal frequency rating in the Intrinsic Motivation scale. The students indicated the greatest temporal frequency in the Self-Determination scale for "I put enough effort into learning agricultural science" (*Always* = 80, 50%) and "I study hard to learn agricultural science" (*Always* = 72, 45%). For the Self-Efficacy scale, the greatest number of students selected always on the temporal frequency scale for the following two items: "I am sure I can understand agricultural science" (67, 42%) and "I believe I can earn a grade of "A" in agricultural science courses" (61, 38%).

Our second research objective sought to evaluate students' motivational factors to learn in science-based courses based on their identified degree program. Students majoring in Agriculture Science, on average, had the highest summative science motivation scores (*SSMS* = 109.46, *SD* = 10.52). Moreover, the students majoring in Agriculture Science had the highest average science motivation scores for each of the five scales (i.e., Career Motivation *ASMS* = 19.17, *SD* = 1.90; Grade Motivation *ASMS* = 23.51, *SD* = 2.01; Intrinsic Motivation *ASMS* = 23.17, *SD* = 2.69; Self-Efficacy *ASMS* = 22.01, *SD* = 2.79; Self-Determination *ASMS* = 21.75, *SD* = 3.50). Aside from the students majoring in Agriculture Science, students majoring in Agribusiness (*SSMS* = 103.11) and Animal Science (*SSMS* = 102.08) had the next highest summative science motivation scores. With a summative science motivation scores of 99.61 (*SD* = 11.83), students majoring in Wildlife Science had the lowest levels of science motivation on all five scales (see Table 3).

Table 3

Declared Major of Students by Average Science Motivation Scores

Scale	Major	*n*	Items in Scale (score range)	Scale *ASMS*[1] (*SD*)
Career Motivation	Agriculture Science	59	4 (0 – 20)	19.17 (1.90)
	Agribusiness	19	4 (0 – 20)	18.53 (2.37)
	Animal Science	65	4 (0 – 20)	17.89 (3.47)
	Wildlife Science	18	4 (0 – 20)	17.50 (3.13)
Grade Motivation	Agriculture Science	59	5 (0 – 25)	23.51 (2.01)
	Animal Science	64	5 (0 – 25)	22.91 (2.96)
	Agribusiness	19	5 (0 – 25)	22.47 (3.00)
	Wildlife Science	18	5 (0 – 25)	22.44 (2.41)
Intrinsic Motivation	Agriculture Science	59	5 (0 – 25)	23.17 (2.69)
	Agribusiness	19	5 (0 – 25)	21.79 (2.82)
	Animal Science	64	5 (0 – 25)	21.17 (4.03)
	Wildlife Science	18	5 (0 – 25)	20.83 (3.60)
Self-Efficacy	Agriculture Science	57	5 (0 – 25)	22.01 (2.79)
	Agribusiness	19	5 (0 – 25)	19.95 (3.79)
	Animal Science	64	5 (0 – 25)	19.91 (3.42)
	Wildlife Science	18	5 (0 – 25)	19.67 (2.45)
Self-Determination	Agriculture Science	59	5 (0 – 25)	21.75 (3.50)
	Animal Science	63	5 (0 – 25)	20.76 (3.28)
	Agribusiness	19	5 (0 – 25)	20.37 (4.09)
	Wildlife Science	18	5 (0 – 25)	19.17 (2.71)

Note. [1]Average Science Motivation Score for Scale.

In reference to Table 2, students majoring in Agriculture Science had the highest temporal frequencies on 22 of the 24 items on the Science Motivation Questionnaire. The two items which the students majoring in Agriculture Science did not have the highest percentage of students which indicated "*Always*" for temporal frequency were "Getting a good agricultural science grade is important to me" which was rated highest by the students majoring in Animal Science (*Always* = 54, 83%), and "I use strategies to learn agricultural science well" which was rated highest by the students majoring in Agribusiness (*Always* = 9, 47%).

Our third research objective was to evaluate the students' motivational factors to learn in science-based courses based on their previous experience in college science courses (i.e., biology and / or chemistry). Students who reported having no previous experience (*SSMS* = 105.67, *SD* = 11.39) in college-level science courses had a higher average science motivation score when compared to students who indicated having previous experience (*SSMS* = 104.44, *SD* = 13.57) in science courses at the university level (see Table 4).

Table 4

Summative Science Motivation Scores for Students Who Have and Have Not Taken Previous College-Level Science Courses

Experience	Scale	*n*	Items in Scale (score range)	Scale ASMS[1] (*SD*)	SSMS[2] (*SD*)
Yes					104.44 (13.57)
	Career Motivation	117	4 (0 – 20)	18.20 (3.06)	
	Grade Motivation	117	5 (0 – 25)	22.92 (2.77)	
	Intrinsic Motivation	117	5 (0 – 25)	21.82 (3.70)	
	Self-Efficacy	115	5 (0 – 25)	20.87 (3.12)	
	Self-Determination	116	5 (0 – 25)	20.78 (3.65)	
No					105.67 (11.39)
	Career Motivation	42	4 (0 – 20)	19.00 (2.14)	
	Grade Motivation	41	5 (0 – 25)	23.39 (1.99)	
	Intrinsic Motivation	41	5 (0 – 25)	22.32 (2.94)	
	Self-Efficacy	41	5 (0 – 25)	20.27 (3.56)	
	Self-Determination	41	5 (0 – 25)	21.34 (2.95)	

Note. [1]Average Science Motivation Score for Scale; [2]Summated Science Motivation Score.

When comparing the students' science motivation scores by the scales, students with no previous experience in college-level courses had a higher average science motivation scores on the Career Motivation (*ASMS* = 19.00, *SD* = 2.14), Grade Motivation (*ASMS* = 23.39, *SD* = 1.99), Intrinsic Motivation (*ASMS* = 22.32, *SD* = 2.94), and Self-Determination (*ASMS* = 21.34, *SD* = 2.95) scales. The Self-Efficacy scale was the only science motivation scale in which students with previous experience in college-level science courses (*ASMS* = 20.87, *SD* = 3.12) exceeded the average score of students without previous experience (*ASMS* = 20.27, *SD* = 3.56).

Conclusions, Discussion, and Recommendations

The purpose of our study was to identify how agricultural students conceptualized their motivation to learn science through the context of agriculture. Our study also sought to determine if students' previous experience in college-level science courses and grade classification had an impact on their science motivation. Although this study provided insight on students' sources of motivation to learn science, caution should be exercised when attempting to generalize the findings beyond the participants in this study.

Our first research objective sought to evaluate various motivational factors (i.e., intrinsic motivation, self-determination, self-efficacy, career motivation, and grade motivation) of students to learn in science-based courses related to animal science and plant science. Of the five science motivation scales, the students majoring in Agriculture Science reported highest agreement with items related to grade motivation, career motivation, and intrinsic motivation. Similarly, Chumbley et al. (2015), who assessed the science motivation of secondary agricultural science students, reported the students' highest motivating factor to learn science was grade motivation. The impact of academic achievement in science courses has been reported to be a strong motivational factor in students' motivation to learn science in previous literature (Pintrich & Schunk, 1996; Tuan et al., 2005).

The second-highest rated motivational factor was career motivation. According to previous research, the lack of students' motivation to learn science can be linked to their inability to conceptualize the applicability of science in their future careers (Arwood, 2004; Druger, 1998;

Glynn et al., 2007). Moreover, Glynn et al. (2007) indicated an individual's belief that science is relevant to their career has the propensity to influence the achievement of the individual, both cognitively and affectively. Based on the findings of our study, it is implied the students perceived science to be closely linked to their career aspirations.

Our second research objective was to evaluate students' motivational factors to learn in science-based courses based on their identified degree program. Between the four different degree programs, students majoring in Agriculture Science had the highest summative science motivation scores (*SSMS* = 109.46, *SD* = 10.52) while students majoring in Wildlife Science had the lowest summated science motivation scores (*SSMS* = 99.61, *SD* = 11.83). Students majoring in Agriculture Science also had the highest average science motivation score for each of the five scales. As such, it can be concluded students studying Agriculture Science exhibited the highest levels of motivation on each of the five scales and the overall scale used within the SMQ II.

Considering the findings for research objective two, we had a few questions we believe deserve further investigation from subsequent science motivation-related studies. How many college-level science courses do students in degree programs beyond the four addressed in this study take? What impacts would any differences in quantity of college-level science courses have on motivation to learn science? Can any differences in science motivation be attributed to the college-level science course requirements between different degree programs? Moreover, perhaps deeper exploration into the quality of experiences students in different degree programs have within their college-level science courses could account for differences in science motivation scores.

Our third research objective sought to evaluate students' motivational factors to learn in science-based courses based on their previous experience in college-level science courses (i.e., biology and / or chemistry). Our findings indicated students with no previous experience in college-level science courses (*SSMS* = 105.67, *SD* = 11.39) had higher levels of science motivation on four of the five scales than students with previous experience (*SSMS* = 104.44, *SD* = 13.57). The exception was the self-efficacy scale, as students with prior experience in college-level science courses had higher summated science motivation scores (*SSMS* = 20.87, *SD* = 3.12) than those students who did not (*SSMS* = 20.27, *SD* = 3.56).

These findings left us with some questions. What experiences did the students who had prior experience with college-level science courses have during those courses? If negative, did such experiences have resulting negative impacts on their science motivation? For those students who had not previously taken college-level science courses, is there the possibility that a lack of experiences in college-level science courses in and of itself resulted in an increase in science motivation? If so, would their motivation change once they begin engaging in the college-level science courses as part of their prescribed degree program? Moreover, it was interesting to observe that students with prior experiences in college-level science courses reported they were more self-efficacious in their science motivation than did students without prior experiences. Perhaps prior experience with college-level science subject matter yielded a greater belief in their own abilities to address contextualized science within their agricultural science coursework. The questions and ideas posited here are deserving of future inquiry.

Our third research objective, which sought to evaluate students' motivational factors to learn in science-based courses based on their previous experience in college science courses, presented a comparison between two unequally-sized groups. This served as a limitation for our study. Future studies should re-evaluate this research objective using groups of the same relative sizes. Having equal groups of students (with varying science coursework experience) and drawn from a probabilistic sample would bolster the ability to conduct more sophisticated analyses to determine if previous course experience has an impact on student motivational factors to learn science.

Edgar et al. (2016) described the need to ensure student engagement and motivation within the agricultural learning environment remain priorities. Further, Edgar et al. (2016) noted "many assumptions about pedagogical practice should be investigated to determine appropriate processes to guide engagement and learning" (p. 39). Interestingly, the two highest motivational factors of the students in this study were career- and grade-motivation. Based on the literature from Glynn et al. (2011), these empirical indicators are subsets of extrinsic motivation. An implication can be made that the students' motivation to learn science had a stronger link to extrinsic motivation as compared to intrinsic motivation. This is a contradiction to one of Knowles' (1984) assumptions that internal motivations are more powerful and more driving than external ones. Per Glynn et al. (2011), university faculty should consider focusing science-heavy content toward specific career areas within students' fields of interest to help motivate students to learn and apply technical science content inside of and beyond the university classroom.

Recommendations for Research

We also identified of the importance of readily identifying a career as a motivator to learn science. Our research identified those students who found a reason behind learning the science content, such as a way they could use it beyond the university classroom, found it to be motivational to do so. Researchers have found contextualizing science as well as other STEM content provides a reason behind the learning and allows it to be seen as important to the individual learner (Haynes et al., 2012; Myers & Dyer, 2006; Parr et al., 2006, 2008; Warnick & Thompson, 2007; Young et al., 2009). Results from our study have identified those researched found a greater motivation to learn science in the animal science and plant science courses resulting from the contextualized approach of those taking traditional college-level science coursework.

Finally, due to the relatively small number of students participating in our study (n = 161), it is recommended that our study be replicated to either corroborate or contradict our findings. The participants in our study were enrolled in either an introductory-level animal science or plant science course at a university in the southern region of the United States. This convenience sample limits the ability to generalize the findings beyond the students enrolled in these courses. To enhance the generalizability of this study, it is recommended similar science motivation studies should be conducted with a probabilistic sample.

Measuring students' motivation to learn science can be quite difficult. As illustrated by Glynn et al. (2011):

> When measuring the motivation to learn science, science education researchers attempt to determine why students strive to learn science, what emotions they feel as they strive, how intensely they strive, and how long they strive. Measuring the motivation to learn science is challenging because a construct and its components are not directly observable variables. For this reason, they are called *latent* (emphasis in original) variables. Although latent variables cannot be directly observed, they can be measured by means of observed variables (items) that serve as empirical indicators. The items on the Science Motivation Questionnaire were designed to serve as empirical indicators of components of students' motivation to learn science in college courses. (p. 1161)

As such, this is a limitation of our study in and of itself. To further explore students' science motivation, we recommend future science motivation studies consider using a variety of research designs and approaches to better understanding this phenomenon, including qualitative inquiry, mixed-methods designs, and so forth. Differing approaches would be quite useful to more thoroughly addressing the need for motivating and engaging learning in agricultural subject matter, as recommended by Edgar et al. (2016).

Recommendations for Practice

The students who participated in our study indicated their motivation to learn science was largely influenced by their desire to achieve high grades. This extrinsic source of motivation may indicate students perceive involvement in the animal science and plant science courses as a means to an end. Measures should be taken to enhance the intrinsic desire of students to learn science. Through the lens of the self-determination theory (SDT), Kusurkar et al. (2011) put forth 12 practical teaching tips to enhance intrinsic motivation of students, including: (1) identify and nurture what students need and want, (2) have students' internal states guide their behavior, (3) encourage active participation, (4) encourage students to accept more responsibility for their learning, (5) provide structured guidance, (6) provide optimal challenges, (7) give positive and constructive feedback, (8) give emotional support, (9) acknowledge students' expressions of negative effect, (10) communicate value in uninteresting activities, (11) give choices, and (12) direct with "can, may, could" instead of "must, need, should." Professional development should be provided to faculty involved in teaching agricultural science-related coursework to provide them with teaching tools to bolster students' intrinsic desires to learn science content.

The findings of our study indicated students' motivation to learn science were linked to their ability to see connections between the science content and their career aspirations. Glynn et al. (2007) reported similar results and recommended "instructors should do more to connect concepts in life science and physical science to the varied careers that non-science majors have in mind" (p. 1102). Furthermore, Glynn et al. (2007) posited it was unrealistic to expect students to make connections between science and their careers on their own. It is recommended faculty from both traditional and contextualized science courses crosswalk their respective curricula to emphasize where career opportunities may occur as a result of learning science. Faculty members should be strategic when deciding which career opportunities to highlight. It is important the instructors link science concepts with the actual career aspirations of the students in their respective courses. To accomplish this task, faculty need to develop an understanding of their students' interests, readiness to learn, and career goals. Having a deeper understanding of students' aspirations will allow them to make appropriate connections—thus moving away from the "one size fits all" mindset.

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