Factors Influencing Choosing Food and Agriculture Related STEM Majors

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Abstract

The need for food safety related professionals in the food and agricultural sciences is projected to increase by 10% from 2010 to 2020. Undergraduate institutions need to meet this demand by recruiting students into science, technology, engineering and math (STEM) major areas of study that support food safety professional career paths. The predictability of factors influencing students to choose STEM and non-STEM majors in three colleges offering baccalaureate degrees related to food and agriculture sciences, liberal arts and other non-STEM majors was investigated. An online survey obtained information from students (N=458) regarding the influence of factors related to extracurricular activities, aptitude, environment, relationships, career ambitions and educational experiences on a student's choice of major. The survey data was used to generate odds ratios using logistic regression analysis. The odds ratios provided a comparison of predictors that potentially influenced a student's choice of a major when all other factors in the study were accounted for. The inclusive logistic regression model identified three predictors as highly significant ($P < 0.01$) in choosing a STEM major in the colleges of Arts and Sciences, Agriculture and Biological Sciences and Education and Human Sciences. The odds ratios of passion for chosen career (1.50, $P<0.01$), financial gain and stability (1.98, $P<0.001$) and high school courses (1.14, $P<0.001$) were all highly significant. These predictable variables potentially influence recruitment strategies for universities and the educational STEM programs in high schools and introductory college courses.

Introduction

There is a growing need for students educated in the sciences, technology, engineering and mathematics (STEM) related majors supporting food and agriculture careers. Academic institutions need to identify how to best recruit, retain and prepare students for degrees in agriculture related fields of study (Association of Public Land-Grant Universities [APLU], 2009; Bartsch and Levi, 2009; Committee on a Leadership Summit to Effect Change in Teaching and Learning [CLS], 2009). The United States Bureau of Labor Statistics (USBLS) (2012) projected an increasing demand of 10% from 2010 to 2020 for professionals in degrees related to food and agricultural science. At the same time, the APLU forecasted only 55% qualified professionals to fill the demand. This increased demand is considered a standard growth, relative to many other types of applied STEM professional careers. This demand also increases food safety professional's employment opportunities and salaries that are competitive with similar professional STEM career paths.

The National Research Council's Board on Life Sciences special committee produced four broad societal challenges in food, environment, energy and health (Higher Education Challenge Grant Program [HEC], 2013). The first challenge is to generate food plants to adapt and grow sustainably in changing environments. The second is to understand and sustain ecosystem function and biodiversity in the face of rapid change. The third challenge expands sustainable alternatives to fossil fuels. The final societal challenge is to understand individual health. These challenges address the need for students to meet societies' demands both nationally and globally in STEM fields of study is a grave concern by educators, industry and government.

Several factors potentially influence a student's decision regarding their declaration of a major when beginning their course of study. The factors influencing student's career path choices are commonly investigated by focusing on one or two factors such as family, teachers, social groups, gender, ethnicity, courses, academic abilities, attitudes, life experiences, personal

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and professional goals and career aspirations (Baker et al., 2009; Brake et al., 2008; Ferry, 2006; Gerardi, 2006; Hong and Schull, 2010; Kelly et al., 2009; Mallory and Summer, 1986; Marshall et al., 2010; Tang et al., 2008; Thompson and Bolin, 2011; Tillberg and Cohoon, 2005; Whalen and Shelley, 2010). Gaining insight regarding the factors that have a stronger predictability for students to choose a major have potential to influence educational programs and/or recruiting tools used by high schools, colleges, industry and government.

The purpose of this study was to identify the predictability of factors influencing a student to choose a STEM major rather than a non-STEM major when entering college. The colleges included in the sample population were those with agriculture and food science related majors (Colleges of Education and Human Sciences (EHS) and Agriculture and Biological Sciences (ABS)). The colleges of engineering, pharmacy and nursing were not included since these STEM related majors are not closely associated to food safety career paths more commonly observed in food and agricultural sciences. To increase the number of non-STEM majors, the college of Arts and Sciences (AS) was also included in the study. Based on the increased demand for food safety STEM related professionals, this study hypothesized that the predictors related to financial gain and security will have a higher odds ratio for students choosing a STEM major than those choosing a non-STEM major in the colleges of ABS, AS and EHS.

Methods

Participants

The sample population identified for this study included 1,826 students from the three colleges of ABS, EHS, AS. A total of 458 students completed the survey, of which 79% were in their first semester of college at South Dakota State University. Recruiting students with newly declared majors reduced the impact of environmental factors possibly contributing to their decision after immersion in a university experience within their major (Hodges and Barbuto, 2002; Mallory and Summer, 1986; Tang et al., 2008). The convenience sample was based on the following criteria: STEM majors most closely related to food and agricultural sciences are in the colleges of EHS and ABS and diversity among non-STEM majors in the colleges of EHS, ABS and AS (visual and performance arts, journalism, marketing, business, rural sociology, economics and consumer affairs). Several studies focus on one variable such as rural in comparison to non-rural life experiences, gender, work experience or ethnic groups (Brake et al., 2008; Hodges and Barbuto, 2002; Mallory and Sommer, 1986). Thompson and Bolin (2011) compared STEM to non-STEM influential factors, however their investigation was limited to education and business majors, and this seven-year cohort study analyzed secondary academic data, not personal values and experiences of the participants.

Survey Tool Development

A survey obtained data on the factors that were influential for a student declaring a major area of study. The survey design was retrospective and prospective in nature (Hodges and Barabuto, 2002; Kelly et al., 2009; Tang et al., 2008;). Participants reflected on life's experiences influencing their college major decision. The prospective portion of the survey incorporated personal and professional goal statements related to career path, including college major. Participants assigned a numerical value of a self-perceived level of influence. Other survey items were descriptive such as identification of class-size or involvement in an extracurricular activity.

The survey was developed for delivery and distribution via Internet using QuestionPro©, an on-line survey program. Survey management practices incorporated for online delivery included a perceived ease of use, monetary incentive, technology that does not allow additional ballot stuffing, confidentiality and privacy (Dillman et al., 2009; Singh et al., 2009). This study was deemed exempt by the South Dakota State University Institutional Review Board.

Students outside the sample group completed the survey tool and provided feedback regarding the readability and clarification of questions throughout the development phase (Radhakrishna, 2007). The internal reliability of the survey was measured with Cronbach's alpha ($p < 0.05$) and inter-item correlation using Pearson's Product-Moment Correlation for identification of inconsistencies. Influential factors were addressed with several questions on the survey to improve reliability (Gliem and Gliem, 2003), particularly factors that were of an emotional or psychological nature.

Survey Distribution

Faculty in the colleges of EHS, ABS and AS provided the survey link to the target population through the universities online course management system. Coverage error was addressed by distribution of the survey through required classes of all newly declared majors (Dillman et al., 2009; Key, 1997). Students maintain money debit accounts accessed with their student ID card. As an incentive to participate in the study, $2 was credited to each student's debit account when a completed survey was submitted electronically. Their names were also entered for a $25 drawing (Dillman, 2012; Porter and Whitcomb, 2003).

Statistical Analysis

The survey question format was developed for statistical analysis of the data using logistic regression and principal component analysis (PCA). Students identified their declared major, which was categorized into a STEM or non-STEM major. A total of 62 major areas of study were listed on the survey with 49 different majors identified by the participants.

There is no test that provides an absolute value to combine survey items into predictor variables (Webster,

2001). Therefore, the statistical tool of PCA and experience with the survey items by the researchers generated predictor variables utilized in the logic regression models. This also reduced the number of predictor (independent) variables as identified by Meda et al. (2009) and avoid multicollinearity. Principal component analysis results identified commonality between survey items using factor-loading computations (Table 1). Principal component analysis supported the creation of 20 predictor variables (SAS Support Website [SASWS], 2005) from the initial 38 survey items. Each of the 20 predictor variables (Table 2) created from PCA was assigned a title to provide meaning to the predictor. The 20 predictor variables were placed into one of eight groups including relationships, extracurricular activities, graduating class size, agriculture environment, educational experiences, career ambitions and aptitude. These groups were incorporated into logistic regression models (SASWS, 2005).

Categories of Predictor Variables

All students completing the survey identified participating in at least one extracurricular activity. The predictor variables of extracurricular activities (Table 2) generated from the factor loading values from PCA (Table 1) included agriculture, academic/leadership, athletics, scouting, debate and arts. Previous studies (Baker et al., 2009; Balschweid and Talbert, 2004) focused on one or two specific extracurricular activities, not several as this study did.

Based on the PCA results (Table 1), the relationship predictor variables (Table 2) included personal relationships (parents, friends and relatives), educators (high school and college teachers) and employment (supervisor or co-worker). The students rated the level of influence by each person on a scale of 0 to 10 (0 = not influential and 10 = extremely influential). Similar studies focused on fewer variables. Ferry (2006), Marshall and others (2010) investigated the influence of family and community within a specific ethnic groups career development. While another study focused on the influence of parents and teachers while accounting for gender when choosing a major in computer sciences (Tillberg and Cohoon, 2005).

Due to the increasing demand for food and agricultural science professionals (USBLS, 2012), the survey addressed market forces, passion for a career and a more passive approach. The students were presented with ten statements and asked to identify if the statement was not a factor, somewhat agree, essentially agree and couldn't agree more. Based on the PCA results (Table 1), the predictor variables (Table 2) addressing career ambitions included research, passion/enjoyment, financial gain/security, parents career and passive. Several of the predictor variables were in agreement with investigations addressing market forces and parent's career (Hodges and Barbuto, 2002; Kelly et al., 2009; Tang et al., 2008; Tillberg and Cohoon, 2005).

Students assigned a self-perceived value (0 to 10) to life experiences that may have influenced a

Table 1. Potential Influential Factors from Student Survey Condensed into Predictor Variables using Principal Component Analysis

	Loading Factors			
Extracurricular Activities (Values > 37 flagged "*")	**Agriculture**	**Arts**	**Athletics**	**Academics Leadership**
4-H	82*	5	1	-4
FFA	81*	-2	6	-1
Scouting	1	69*	-2	-19
FCCLA/FBLA	4	-4	-16	57*
Athletics	-4	-11	84*	-18
Theater/Oral-Interp	16	55*	3	47*
Music/Dance	18	55*	6	21
Debate	-24	53*	2	-10
Speial Interest/NHS/SC/FL	-3	-1	15	74*
Relationships (Values > 47 flagged "*")	**Personal**	**Employment**	**Educators**	
Parents	79*	-1	16	
Friends	60*	26	23	
Relative	79*	12	0	
HIgh School Teacher	16	0	84*	
College Teacher	10	28	69*	
Employer	11	85*	12	
Career Ambition (Values > 45 flagged "*")	**Passion**	**Financial**	**Parents Passive**	
Researched career	53*	50*	-21	
Financial Gain	-16	79*	13	
Job Security	26	74*	4	
Parent's Career	24	-5	71*	
Passion	86*	2	-2	
Enjoyment	85*	2	7	
Passice-Courses	-52	13	46*	
Goals	65*	33	-5	
Passive - more research needed	-22	11	66*	
Relationships (Values > 52 flagged "*")	**Experiences**			
High School Course	31			
College Course	45			
Job	44			
Vounteer Work	63*			
Extracurricular Activities	48			
Movie or Book	54*			
Trip or Vacation	64*			
Youth Camp	58*			

Note:
Printed values are multiplied by 100 and rounded to the nearest integer.
* refers to items that have commonality from factor loading computations using Rotate Factor Pattern - Rotation Method Varimax, SAS (version 9.2, Cary, NC, USA)

student's choice of major. Using PCA (Table 1), the predictor variables of events (volunteer work, movie or book, trip/vacation and youth camp), high school and college courses were created (Table 2). A similar study by Tang et al. (2008) focused on opportunities, such as life's experiences, impacting students to explore careers.

Inclusive Logistic Regression Model

Logistic regression analysis calculated the odds ratio of the predictors using an inclusive model (Table 3). The inclusive model included all 20 predictors (Table 2) potentially influencing a student to choose a STEM or non-STEM major (Pallant, 2010). The results were statistically significant at one of three alpha levels: $P < 0.05$; $P < 0.01$; and $P < 0.001$. All data was standardized through logistic regression analysis, therefore all ordinal variables were weighted the same. The Statistical System Software package SAS (Version 9.2, Cary, NC, USA) was used to conduct the analysis.

Results and Discussion

Description of Respondents

Of the potential 1,826 students exposed to the survey link, 458 students fully completed the survey (response rate of 25%) with 311 students choosing a STEM major compared to 147 non-STEM majors. Although there was an imbalance, the number of students responding by majors was representative of the number of graduates with the same majors at South Dakota State University. Additionally, an imbalance within a sample is found to be of minor importance when using logistic regression (Crone and Finley, 2012).

The majority (47%) of the students responding to the survey were from the ABS College. Twelve percent were enrolled in the AS College and 31% in the EHS College. Several students (9.74%) were from the University College (UC). All of the UC students were in the first two years of the college and newly declared non-STEM majors. Including these students increased the critical mass of the sample for the logistic regression analysis. Students that are undecided about their major had the option to enroll in the UC to support them in the process of choosing a major.

The representation of the sample group (those completing the survey) to the reference population (students in the colleges of ABS, EHS and AS) was identified by comparing the percentage of each major completing the survey to the percentage of students that graduated in 2013 with the same majors. When referring to the 49 majors identified by the respondents, 42 majors had percentage differences of 2% or less between sample group and reference population. The trend-lines (Figure 1) demonstrate similarities between the sample group and reference population.

The students represented a rural demographic. 53% of the students were from schools with less than 100 students in their graduating class (10.5% less than 25 students) and 28% were from graduating classes greater than 200 students. Growing up on a farm was self-identified by 36% percent of the students. The greatest percentage of students (45%) had a high school grade point average (GPA) of 3.6 to 4.0 (scale of 0 – 4), while the highest percentage range of ACT scores were 21 to 25 (47%). ACT served as the indicator for scholastic aptitude since it is the standard adhered to by the South Dakota Board of Regents (2010).

Table 2. Predictor Variables - created through principal component analysis and utilized in Logistic Regression Analysiss Models

Variables	Description of Question
1. ACT exam-score (aptitude)	Stand-alone. College entrance exam majority of students take for SDSU admittance. Ranging from <15 to >30, or NA
2. Grow up on a farm	Stand alone (Yes or No)
3. Graduating Class Size	Stand alone: <25, 26-50, 51-100, 101 – 200, > 200, Home Schooled, NA
4. Scouting	Stand-alone (refers to Boy or Girl Scouts).
5. Debate	Stand alone since < 5% chose this activity
6. Academics and Leadership	Family Community and Career Leaders of America (FCCLA), Future Business Leaders of America (FBLA), National Honor Society (NHS), Student council (SC), Foreign Language (FL)
7. Athletics	Stand alone –all sports including rodeo, martial arts, cheerleading
8. Agriculture	4-H and/ FFA
9. Arts	Theater, Dance, Music, Oral Interpretation, Film
˙Items below assigned a value (0 to 10, or 1 to 5) of self-perceived influence by students completing survey	
10. Work Relationships	Employer, Coworker
11. Personal Relationships	Parents, Friends, Relatives
12. Educators	High School and College Teachers
13. High School Course	Stand alone
14. College Course	Stand alone
15. Event	Book, Movie, Youth Camp, Vacation
16. Research	Thoroughly researched career possibilities. Stand alone
17. Parents Career	Closely related to parents career. Stand alone
18. Passion/Enjoyment	Passion for career, enjoyment, money not as much of an issue,
19. Financial Gain/Security	Career goals clear, Financial Gain, Job security
20. Passive	Decision tied to completed coursework, limited career research

N=458 Results of Principal Component Analysis of 38 item survey
Note: ACT – College Entrance Exam Test; NA – Not applicable
˙All values standardized by Logistic Regressions Analysis
Principal Component Analysis computed using Rotated Factor Pattern – Rotation Method Varimax, SAS (version 9.2, Cary, NC, USA)

Logistic Regression Analysis

Based on the purpose of this study, an inclusive regression model incorporated all the predictor variables to identify the odds ratio of one predictor influencing a student to choose a STEM major (Table 3). The inclusive model goodness-of-fit analysis reached the 99.99% confidence level. Three of the 20 predictors significant at a 99.9% confidence level were financial gain/stability, passion/satisfaction and high school course.

Two of the significant ($P < 0.01$) predictors recognized as influential factors were related to career ambi-

tions (Table 3). The odds ratio of passion/job satisfaction was 1.50 (P < 0.01) for choosing a STEM over a non-STEM major. Students valuing financial gain/stability had even higher odds ratio (1.98, P < 0.001) of choosing a STEM major in the three colleges studied. These results were in agreement with the Social Cognitive Career Theory (SCCT), which evolves throughout a person's lifetime (Lent and Brown, 2006). An individual's behavior (choosing a major) is reflective of the goals (career ambitions) they set and strive for.

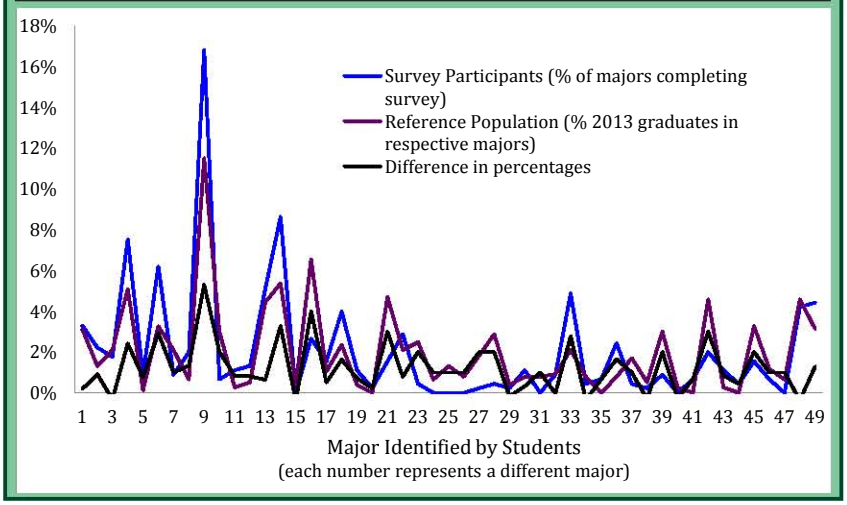
The predictor of high school courses was positive (1.14, P < .001) when all other variables were held constant (Table 3). The survey did not identify specific courses. These results were supported by the SCCT, which relates expected outcomes to actual experiences (Lent and Brown, 2006). College courses were not identified as significant. A majority (79%) of the students completing the survey were in their first semester of college. Therefore the experience of a college course influencing their choice of a major was not available to them.

Table 3. Inclusive Model - Odds ratios of predictor cariables influencing students to major in a STEM field of study when all other cariables are accounted for. Sample (N=458)-- Newly declared majors from colleges of Agriculture Biological Sciences, Arts and Sciences, Education and Human Sciences.

Predictor Variables	Coefficient	Std Error	Odds Ratio
Aptitude -- ACT exam score	0.30	0.16	1.36
Agriculture Environment -- Grew up on farm	-0.03	0.10	0.97
High School Graduating Class Size	-0.31	0.32	0.73
Extracurricular Activities			
Scouting	0.85	0.64	2.33
Debate	1.20	0.72	3.32
Agriculture (4-H and FFA)	-0.05	0.11	0.95
Academic/Leadership (FCCLA, FBLA, NHS, SC, quiz bowl, FL)	0.20	0.15	1.22
Arts (theater, music, visual, dance, film)	0.09	0.13	1.07
Athletics	-0.40	0.23	0.67
Relationships			
Personal (parents, friends, relatives)	0.08	0.12	1.08
Educator (high school and college teachers)	-0.04	0.13	1.04
Employment (employer and co-worker)	0.04	0.13	0.96
Career Ambitions			
Researched	-0.11	0.20	0.90
Parents Career	-0.22	0.19	0.80
Passion/Enjoyment	0.40	0.15	1.50**
Financial Gain/Security	0.68	0.15	1.98 ***
Passive	0.34	0.18	1.40
Educational Experiences			
High School Course	0.13	0.04	1.14 ***
College Course	-0.04	0.04	0.96
Events (movies, books, camps)	-0.11	0.14	0.89

Note: Goodness of Fit: Wald: 56. P < 0.0001***
*, **, *** Significant at P < 0.05, 0.01, or 0.001, respectively using Chi-Square
Coefficients and Odds Ratios Calculated with Logistic Regression Analysis, SAS (version 9.2, Cary, NC, USA)

Figure 1. Comparison of sample group (N=458) to reference population: Percentage of students by major completing survey compared to percentage of students graduating by major in colleges of Education and Human Sciences, Arts and Sciences, Agriculture and Biological Sciences



A study by Brake and others (2007) asked 25 students to share the three most important activities or people that influenced their decision to pursue a career in technology/engineering. The number of students identifying math or science classes and clubs was marginal, 12 of the 25 students. When teachers were included in the results, along with classes and clubs, the results accounted for all of 25 students. However, the odds ratios for teachers (high school or college) were not significant (P > .01) in this study (Table 3).

The odds ratios for the predictors in the relationships category were not significant (P > .01) (Table 3). Examples of these variables included influence from family, friends, coworkers, employers and teachers. This same phenomenon is seen in similar studies where teachers, family and community were identified as influential in choices related to career, major and choice of college, regardless if it is STEM or non-STEM (Ferry, 2006; Hong and Schull, 2010; Marshall et al., 2010).

Growing up on a farm and size of high school were not significant (P > 0.1) (Table 3). Students were asked if they grew up on a farm; they were not asked to identify if growing up on a farm influenced their choice of a major. Thirty-six percent of the respondents grew up on a farm. This was substantial when considering the number of people that actually live on farms in the United States is 2% (Environmental Protection Agency [EPA], 2012). When the logistic regression models were applied solely for growing up on a farm and size of high school, they did not have a good fit (P > 0.5).

Conclusions

Students are 1.5 times more likely to choose a STEM major in the colleges of ABS, AS and EHS if a passion for their career and job satisfaction were important to them. This observation is based on the significant odds ratio (1.50, P<0.01) of passion/satisfaction (Table 3). Additionally, students valuing financial gain/stability are 1.98 (P < 0.001) times more likely to choose a STEM major in the same three colleges (Table 3).

The results of this study supported the hypothesis: based on the increased demand for food safety STEM related professionals, this study hypothesized that the predictors related to financial gain and security will have a higher odds ratio for students choosing a STEM major than those choosing a non-STEM major in the colleges of ABS, AS and EHS. Additionally, the odds ratios for passion/enjoyment (1.50) and high school course (1.14) were also significant (P < 0.01). Therefore, the career ambitions predictors of financial gain/security and a passion/enjoyment potentially impact recruitment strategies to STEM majors in the colleges studied.

The significant odds ratio (1.14, P < 0.001) of the high school course predictor potentially supports the importance of educational systems striving to make STEM related courses engaging and with a problem-solving approach (Next Generation Science Standards (NGSS), 2013). The survey included one item related to high school courses, more research is needed focusing on the impact of high school classes specific to students that have chosen a major related to STEM courses connected to the safety of the food supply.

Additional studies to build from this project include focusing solely on food safety related majors to investigate factors that influenced their career path. More in-depth data could be useful in recruitment strategies for students to food safety related majors (particularly those related to agriculture and food sciences).

Limitations of the Study

The population studied was limited to students in three colleges at South Dakota State University. Since this study focused on STEM majors related to agriculture and food science, the colleges of Engineering, Nursing and Pharmacy were not included in the research. Since these three colleges have programs that are solely STEM in nature, the results would likely have higher odds ratio values, increasing the predictability in the models that were studied.

Gender differences were not analyzed in the initial logistic regression models. Follow-up tracking identified 39% of the students as males and 61% female. The analysis was later conducted with and without gender. There was no statistical significant difference in the results when the gender was included in the logistic regression model. However, equal numbers of males and females may have changed the results.

The percentage of students living on farms was not representative of the U.S. population. However when targeting only three colleges, with one being the Agriculture college, the higher percentage was expected. Growing up on a farm is a different experience from growing up in an urban area.

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