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A DATA-CENTRIC ANALYSIS ON STEM MAJORING AND SUCCESS: ATTITUDE AND READINESS

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ABSTRACT

This research studies attitude and readiness of STEM majoring and success with the data from a survey with a total of 501 viable responses, with respect to STEM (science, technology, engineering, and mathematics) related majors that are essential and fundamental to skills relevant to big data business analytics. Recruiting and keeping students in STEM areas have attracted a large body of attention in pedagogical studies. An effective way of achieving such a goal is to show them how rewarding and self-fulfilling STEM careers can be toward perspective students. One example of the abundance of STEM careers is the rapid growth of business analytics positions in the job market, which is a major motivation of this study. Business analytics makes extensive use of data, including data mining, statistical analysis, quantitative modeling, and explanatory and predictive analytics, in order to help make actionable decisions and to improve business operations. We found that there is a statistically significant correlation between STEM interests and success factors of majoring in STEM, which is a natural step forward to filling in the talent gap business analytics. Practical implications are also discussed.

Keywords: Data Analytics, STEM Majors, Survey Research, Principle Component Analysis

INTRODUCTION

Recruiting and retaining college students in Science, Technology, Engineering, and Mathematics (STEM) areas have attracted a large body of attention in pedagogical studies (Buschor, 2014; Garibay, 2015). An effective way of achieving such a goal is to show the perspective students how rewarding and self-fulfilling STEM careers can lead. One example of the abundance of STEM careers is the rapid growth of business analytics positions on the job market, which serves as a motivational scenario of this study. Business analytics makes extensive use of data, including data mining, statistical analysis, quantitative modeling, and explanatory and predictive analytics, to help make actionable decisions and to improve business operations. According to McKinsey & Company (2011), the projected demand for deep business analytical positions could exceed the supply produced with the current trend by 140,000 to 190,000 positions, in addition to the projected need of 1.5 million managers and analysts in dealing with big data business analytics in the United States. Thus, attracting students into STEM majors is very important in order to bridge the talent gaps, including in business analytics related area, among other STEM fields. In this study, we propose several observations from an international survey, illustrating driving forces toward STEM careers. Some of these proposals are counter-intuitive. The contribution of this study is two-fold. First, this study verifies and extends theoretical foundation of STEM majoring driving forces discussed in previous studies. Second, we believe these proposals have practical implications toward recruiting and retaining STEM students. They can also serve as guidelines for educational practitioners.

Increasingly, top thinkers in academia and industries believe that business analytics, especially analytics connected with big data, is going to be a driving force in our economy and society in the next 10 to 20 years (SAS Institution, 2013). We found that there is a statistically significant correlation between STEM interests and critical skills in big data business analytics, which is a natural step forward to filling in the talent gap. Several practical implications are also discussed.

The rest of the paper is organized as follows. Section 2 reviews the literature. Section 3 discusses research methodology and data collection. Section 4 conducts statistical analyses. Finally, section 5 summarizes the research.

LITERATURE REVIEW

Even though there is only a limited body of studies in the literature, previous related studies often use longitudinal data to understand the success factors of STEM majors. Particularly, they investigated the relationship between the individual and institutional characteristics of students and the successfulness of STEM majors. For instance, Kokkelenberg & Sinha (2010) designed and conducted a longitudinal study to understand the determinants of academic success of STEM students, using a large data set collected at Binghamton University. A fixed effect model was constructed and incorporated in a quasi-experiment, to examine of the differences between characteristics of STEM and non-STEM students. Grade Point Average (GPA) and graduation rates were selected as the operationalization of successfulness, which served as the dependent variable in the model. In order to identify the determinants of academic success of STEM students, the authors selected several characteristics at both student- and institution-level, which include: SAT scores, declaration of major during the career as a college student (grade and major), grade elasticities, gender issues, STEM-related preparations, and ethnicities. The study data was collected on over 44,000 subjects (yielding in 926,759 observations over 176 variables) during a 10-year period from Fall 1997 through Spring 2007. Results in this study show that mathematical preparation, earlier declaration of STEM major, long-going interests and/or experiences in STEM subjects, and Asian ethnicity are positively correlated with the academic successfulness as STEM students. Gender differences are particularly significant in engineering majors – but not in other STEM fields. Also, comparing to switching into STEM majors, switching out of them are more frequent from the results of this study. Although several observations were made in this paper, there is an untested issue regarding how do some other factors, such as the attitude of the students toward STEM majors, external influences on major selections, and outlook of (STEM) majors, affect the success of STEM majors. In addition, conducting a nationwide survey to collect data related to these factors was suggested in this article as a complementary data collection technique.

Buschor et al. (2014) conducted a triangulated study using longitudinal data from 843 female high school students who showed interests in STEM majors, in order to understand the determinants of women's career decision making with respect to majoring in STEM areas. The study was designed to understand how and why female students chose STEM majors in high schools, and then actually entered them in colleges; as well as the perceptions of STEM majors from these students. On the quantitative side of this study, data regarding six independent variables, including competence in mathematics and language, study profile, college major, support from father (family), gender stereotypes to mathematics, and expectations of study- and job-related issues, were collected using two questionnaires across a period of two years. In complementary to the quantitative analysis, an interview was designed to collect other predictors of these female students, including the early sense of becoming a scientist, family support for pursuing academic goals, role models in social network, parental influences, mathematics' role in students' decisions, self-recognition (sense of uniqueness), broader interests of different fields, problem solving skills, and students' strategic/econometric decisions. This study revealed that participants were persistent with their career choices, which is contridictory to most studies in the literature. Particularly, the broader interests of different fields, the early sense of becoming a scientist, and students' problem solving skills showed significantly positive impact on selecting STEM majors. However, preference of likelihood in STEM areas (expectations of job-related issues), study profile, and support from the family showed negative to neutral impact on the career selections. Albeit interesting conclusions were made from this study, the generalizability of this study was limited by the small sample size and the lack of validity assurance.

Garibay (2015) analyzed the differences of the social values after graduation between STEM and non-STEM students, using data from a national survey in 2004 and 2008 on a sample of 6,100 undergraduate students. A multi-level analysis was designed in this study to understand the correlation between STEM majoring and the students' desire to promote a better society. Previous literature discovered that students majoring in STEM fields have less interests in promoting a better society (operationalized as *Social Agency*). This study examined different aspects regarding the social involvement that were defined in a previous related study (Higher Education Research Institute, 2008). These aspects, including understanding of promoting a better society, ability of using academic capabilities in the society, were defined by Cooperative Institutional Research Programs (CIRP) using Item-Response Theory (IRT) – which later became the theoretical foundation of the factor analysis on these constructs (as dependent variables). The results from the factor analysis assured the reliability and validity of the study. On the independent variable side, the author investigated background characteristics (including racial/ethnicity and parental incomes), pre-college characteristics and experiences (including civic depositions, academic grades/SAT scores, and number of math/science course taken in high school), and collegiate experiences (including college majoring and STEM career aspirations). Derived from previous theories, factors such as cross-racial interactions, professor/peer impacts, and pedagogical methods used in class, were also included in the model as control variables. Several nonparametric tests were conducted in this study to ensure the internal validity (statistical significance) of this study. Similar data collection and research methodology are adopted in our study, which justify the design decisions of them here.

In summary, previous studies on STEM success factors focused mainly on the demographic and academic espects of the students, rather than their perception of STEM majors (Kokkelenberg & Sinha, 2010; Buschor et al., 2014), which is one of the key motivations of this study. Moreover, a study by Garibay (2015) also proves that the experiment design and research methodology adopted in this paper is valid. In the next section, we introduce the research methodology, along with the data collected in this study.

RESEARCH METHODOLOGY

The survey in this research yields 501 valid responses (excluding responses with more than 10% missing values). The survey questionnaire consists of four demographic questions: Gender, Ethnicity, Grade, and College Major, and 23 STEM related survey questions. This survey was conducted online via an online survey portal in Fall 2014. Table A in Appendix B shows the demographic information of the survey based on the 501 usable returns. Among these responses, 203 are from two universities from US West Coast in Los Angeles area, California State University at Dominguez Hills and Long Beach City College (CSUDH), 107 from a university in the US East Coast in the Great New York Metropolitan area, Fairfield University (Fairfield), and 191 from twouniversities Beijing and Shanghai, respectively, in the East Coast of China (China). Of the 501 usable responses, 240 are male, 258 female, and 3 left blank (no answer). In addition, 216 are currently enrolled in STEM related majors, 282 are in non-STEM majors, and 3 missing data points (no answer). As far as the years of experience in college are concerned, 5 are high school juniors or seniors taking college level classes, 168 are freshmen and sophomores, and 328 are juniors and seniors. Table 1 presents the list of 23 survey questions and descriptive statistics. A five-point Likert scale is used for all 23 survey questions, where 5 = strongly agree, 4 = agree, 3 = neutral, 2 = disagree, and 1 = strongly disagree.

Description	Mean	Median	St. Dev.	Max.	Min.
Q1. My major is challenging	3.68 (.000*)	4.00	1.06	5	1
Q2. Family influence on major selection	2.68 (.000*)	3.00	1.28	5	1
Q3. Friends influence on major selection	2.53 (.000*)	3.00	0.91	5	1
Q4. Teachers influence on major selection	2.37 (.000*)	2.00	1.19	5	1
Q5. STEM preparedness	2.97 (.4952)	3.00	0.99	5	1
Q6. Interested in science subjects	2.87 (.02**)	3.00	1.24	5	1

Q7. Enjoy math puzzles and games	3.27 (.000*)	3.50	1.25	5	1
Q8. Interested in science and math clubs	2.73 (.000*)	3.00	1.13	5	1
Q9. Globalization reduces jobs in US	2.88 (.00**)	3.00	0.93	5	1
Q10. STEM jobs are cyclical	2.92 (.0752)	3.00	0.95	5	1
Q11. STEM jobs with opportunities	3.05 (.3039)	3.00	1.04	5	1
Q12. STEM jobs dominated by men	2.98 (.7082)	3.00	1.24	5	1
Q13. STEM career is better for men	2.53 (.000*)	3.00	1.08	5	1
Q14. STEM career is more opportunistic	3.19 (.000*)	3.00	0.94	5	1
Q15. People in STEM jobs are smart	3.41 (.000*)	3.00	0.93	5	1
Q16. STEM has promising mid-career	3.10 (.02**)	3.00	0.93	5	1
Q17. STEM career pathways to leadership	3.05 (.2295)	3.00	0.89	5	1
Q18. STEM career is shorter than others	2.63 (.000*)	3.00	0.90	5	1
Q19. STEM jobs are more fun	2.96 (.3281)	3.00	1.01	5	1
Q20. STEM jobs are higher paying	3.35 (.000*)	3.00	0.96	5	1
Q21. STEM jobs are more creative	3.35 (.000*)	3.00	1.01	5	1
Q22. Majoring in STEM is challenging	3.74 (.000*)	4.00	0.98	5	1
Q23. Majoring in STEM is rewarding	3.54 (.000*)	4.00	1.05	5	1

Note: * indicates the mean is different from zero with a p-value smaller than .001, ** p-value < .05

Table 1: Summary Statistics

Table 2 shows the proposals that we have identified and structured based on the observations from the survey responses. Proposals illustrated in Table 2 are often identified by educational practitioners, as well as researchers in academia as discussed in Section 2, although they are not explicitly referred to supportive/rejecting evidences. Thus, it is imperative to find comprehensive and critical evidences to evaluate these proposals.

Proposal	Description
P1	University students are uncertain that STEM jobs are more fun
P2	University students have a positive belief that they are prepared from STEM majors
P3	University students showed less interests (negative) in science objects
P4	University students showed more interests (positive) in puzzles and games
P5	University students showed less interests (negative) in science and math clubs
P6	University students are more impacted (positive) by their teachers with respect to their major selection decisions
P7	University students are more impacted (positive) by their families with respect to their major selection decisions
P8	University students have a strong positive belief that STEM jobs are dominated by men

Table 2: Proposals Regarding Current Perceptions toward Aspects of STEM Majors

This research provides quantitative results regarding the outlined trends, in order to compare them with these in the existing research. The patterns identified from the survey responses can be used to extend current studies, as well as guidelines for educational practitioners.

STATISITICAL ANALYSIS

SUMMARY STATISTICS OF SURVEY QUESTIONS

It is shown in Table 2 that Q1, Q22, and Q23, on the one hand, have the highest common median of 4.00 and a standard deviation around 1.00, with a relatedly high mean of 3.68, 3.74, and 3.54 respectively. Q4, on the other hand, has the lowest median of 2.00 and the lowest mean of 2.37, with a standard deviation of 1.19. The rest of the survey questions have a common median of 3.00 with various standard deviations ranging from 0.89 for Q17 and 1.28 for Q2, except for Q7 with a median of 3.50 and a standard deviation of 1.25. The value next to the Mean in the parentheses is the p-value on the hypothesis test that the mean $\mu=3$, vs. μ is different from 3. An asterisk * indicates that the *p*-value is smaller than .001 and a double asterisk ** means the *p*-value is less than .05.

We observe three trends from the descriptive statistics of the results, which are discussed as follows. First, all 501 respondents in general agree (5=strongly agree and 4=agree) on questions Q1, Q7, Q14, Q15, Q16, Q20, Q21, Q22, Q23 with a mean statistically significantly larger than 3 (neutral) at the 95% confidence level. In other words, it is no surprise that the respondents agree that the major is challenging (Q1) whether in STEM related areas or not, and they enjoy math related puzzles and games (Q7). It is equally no surprise that they agree that STEM career is more opportunistic (Q14) and people in STEM jobs are smart (Q15), which deserve higher pay (Q20) an rewarding (Q23) because they are more creative (Q21) and more challenging (Q22). Second, the respondents in general disagree (2=disagree and 1=strongly disagree) on questions Q2, Q3, Q4, Q6, Q8, Q9, Q13, and Q18 with a mean statistically significantly smaller than 3. In other words, the respondents disagree with the notion that the selection of college majors is influenced by family (Q2), friends (Q3), or teachers (Q4), which is somewhat contrary to the conventional wisdom. However, it is no surprise that the respondents are not interested in science subjects (Q6) or science/math clubs (Q8), and disagree with the notion that globalization reduces STEM jobs in US (Q9) and STEM career is better for men (Q13) with shorter career duration (Q18). Third, the respondents in general are neutral on questions Q5, Q10, Q11, Q12, Q17, Q19 with a mean statistically indifferent from 3 at 95% confidence level. In other words, they are uncertain regarding topics such as STEM preparedness (Q5), STEM jobs are cyclical (Q10), and STEM jobs are more fun. As a conclusion, using the sample as a whole, proposals P1, P3, P4, and P5 are supported; whereas P2, P6, P7, and P8 are not supported.

Since the aggregate descriptive statistics in Table 2 have too many variables to keep track of and may obscure different perceptions toward STEM majoring among three geographically different regions, we now deploy dimension reduction techniques to classify the 23 STEM related variables into fewer latent factors and conduct hypothesis test to see whether any of the regions behave differently.

PRINCIPAL COMPONENTS ANALYSIS

According to Dillon and Goldstein (1984, p.24), principal components analysis (PCA) transforms the original variables set into a smaller set of linear combinations that account for the most of the variance of the original set. The purpose of PCA is to find principal components (or factors) in order to explain as much of the total variance in the original survey questions as possible with as few of these factors. In the PCA, the first principal component (Factor 1) accounts for the largest amount of the total variation in the data by assigning appropriate coefficients (or weights) for the linear combination. Likewise, the second principal component (Factor 2) accounts for the maximum amount of the remaining total variation not already accounted for by Factor 1, and so on. *Varimax* rotation method is used in this research to deal with multicollinearity among survey variables, which maximizes the variance of squared factor loadings within the components. Factor loadings refer to the importance of individual survey variables on a principal component; whereas coefficients are used to combine the individual survey variables for the linear combination of the principal component. A component loading greater than *0.4* corresponding to each survey question is considered statistically significant for the principal component.

	Component Loadings > 0.4					
Cronbach's α = 0.749	1	2	3	4	5	6
Factor 1 STEM jobs are higher paying, fun, creative, opportunistic and rewarding						
Q20. STEM jobs are higher paying	.738					
Q19. STEM jobs are more fun	.695					
Q21. STEM jobs are more creative	.657					
Q14. STEM career is more opportunistic	.601					
Q23. Majoring in STEM is rewarding	.561					
Factor 2 STEM preparedness and career expectation						
Q18. STEM career is shorter than others		.634				
Q10. STEM jobs are cyclical		.563				
Q5. STEM preparedness		.513				
Q11. STEM jobs with opportunities		.499				
Q17. STEM career pathways to leadership		.494				
Q9. Globalization reduces jobs in US		.491				
Q16. STEM has promising mid-career		.400				
Factor 3 STEM subjects and activities						
Q6. Interested in science subjects			.693			
Q7. Enjoy math puzzles and games			.683			
Q8. Interested in science and math clubs			.666			
Factor 4 STEM career challenging & for smart people						
Q15. People in STEM jobs are smart				.749		
Q22. Majoring in STEM is challenging				.646		
Factor 5 External influence on major selection						
Q3. Friends influence on major selection					.708	
Q4. Teachers influence on major selection					.660	
Q2. Family influence on major selection					.656	
Factor 6 STEM jobs in favor of men?						

Q12. STEM jobs dominated by men						.689
Q13. STEM career is better for men						.667

Table 3: Principal Components with Varimax Rotation

Table 3 presents the component loadings of PCA using SPSS Modeler, with 0.4 as the threshold for component loading and Cronbach's α = 0.749 (which is considered acceptable when $\alpha \geq 0.7$). It is perceivable from Table 3 that the first principal component, named "Factor 1 STEM jobs are higher paying, fun, creative, opportunistic, and rewarding", consists of five variables in descending order based on factor loadings in the parentheses: Q20 Higher paying + (.738), Q19 More fun ± (.695), Q21 More creative + (.657), Q14 More opportunistic + (.601), and Q23 STEM is rewarding + (.561).

Description	CSUDH	Fairfield	China	Relationship **
Q20. STEM jobs are higher paying +	3.32 (0.94) +	3.17 (0.78) +	3.48 (1.06) +	Fairfield < China
Q19. STEM jobs are more fun ±	2.95 (0.84) ±	2.80 (0.87) - *	3.05 (1.22) ±	Fairfield < China
Q21. STEM jobs are more creative +	3.15 (0.87) +	3.04 (0.89) ±*	3.73 (1.10) +	Fairfield/CSUDH< China
Q14. STEM career is more opportunistic +	3.20 (0.93) +	3.01 (0.73) ±*	3.27 (1.03) +	Fairfield < CSUDH/China
Q23. Majoring in STEM is rewarding +	3.64 (1.03) +	3.63 (0.78) +	3.38 (1.18) +	China < Fairfield/CSUDH

Note: * Indicates a change from the aggregate data, ** indicates the p-value is less than .05 for the comparison + Indicates the response is positive (mean>3), ± indicates neutral (mean=3), - indicates negative (mean<3). The format, μ (σ), indicates the mean and standard deviation of the respective respondents group.

Table 4: Factor 1 STEM jobs are higher paying, fun, creative, opportunistic and rewarding

Figure 1 in Appendix C depicts the decomposition of variables in Factors 1 and 2, respectively, by geographical regions: China, CSUDH, and Fairfield. Table 4 shows the hypothesis tests on each of the five variables within Factor. at 95% confidence level confirm that Chinese respondents (China) are more positive with respect to Q21 More creative + (3.73) than their counterparts in CSUDH (3.15) and Fairfield (3.04), but they are less positive on Q23 STEM is rewarding + (3.38) than CSUDH (3.64) and Fairfield (3.63). However, the respondents from Fairfield are less positive on Q20 Higher paying + (3.17) than in China (3.48), with CSUDH (3.32) in between, which explains in part why Silicon Valley is attracting many talent students from China for STEM related jobs. However, students in Fairfield may be more interested in traditional business-related jobs such as finance and accounting due to geographic proximity to Wall Street in New York City.

Factor 2 illustrates STEM preparedness and career expectation as shown in Figure 1 in Appendix C. It is interesting to see from Figure 1 in Appendix C that respondents from China are less confident about Q5 STEM Preparedness ± (2.65) than their American counterparts in CSUDH (3.18) and Fairfield (3.13). It is worth noting that this negative mean (2.65<3) drags the overall mean for all three regions to neutral (2.97), from the positive means of CSUDH (3.18>3) and Fairfield (3.13>3). In addition, respondents from China are more positive that Q16 STEM career is more promising from mid-career (3.24) than US respondents from either CSUDH (3.03) or Fairfield (3.00).

Description	CSUDH	Fairfield	China	Relationship **
Q18 STEM career is shorter than others -	2.60 (0.83) -	2.71 (0.76) -	2.61 (1.04) -	
Q10 STEM jobs are cyclical ±	2.90 (0.88) ±	2.90 (0.78)±*	2.97 (1.11) ±	
Q5 STEM preparedness ±	3.18 (0.99)+*	3.13 (0.83)+*	2.65 (0.99)-*	China < Fairfield/CSUDH
Q11 STEM jobs with opportunities ±	3.03 (1.06) ±	3.13 (0.92) +*	3.02 (1.09) ±	
Q17 STEM career pathways to leadership ±	3.02 (1.03) ±	2.96 (0.78) ±	3.12 (1.18) ±	
Q9 Globalization reduces jobs in US -	2.89 (0.93)±*	2.93 (0.84) ±*	2.85 (0.98) -	
Q16 STEM has promising mid-career +	3.03 (0.89)±*	3.00 (0.75) ±*	3.24 (1.05)+	

Note: * Indicates a change from the aggregate data, ** indicates the p-value is less than .05 for the comparison+ Indicates the response is positive (mean>3), ± indicates neutral (mean=3), - indicates negative (mean<3)

The format, μ (σ), indicates the mean and standard deviation of the respective respondents group.

Table 5: Factor 2 STEM preparedness and career expectations

Figure 2 in Appendix C shows the decomposition of variables in Factors 3 - 6, respectively, by geographical regions: China, CSUDH, and Fairfield. For example, Factor 4 in Figure 2 in Appendix C can be characterized as: Majoring in STEM is challenging and people who can get a STEM job are smart. Students from all three regions concile on the two variables within Factors, with Chinese students most agree, students at CSUDH least agree, and students at Fairfield in the middle. Table 6 highlights the hypothesis test results between different regions.

It is seen in Table 6 that Factor 3 describes the respondents' attitudes toward STEM subjects and activities – related studies have summarized that the students attitudes toward STEM subjects and activities are important factors in terms of majoring decisions (Cole and Espinoza, 2008). Chinese students are interested in studying science subjects (3.27) and joining clubs (3.21); they also enjoy participating in mathematical games and puzzles (3.13). These responses illustrate that Chinese students are more interested in STEM majors. Toward this principal component, CSUDH and Fairfield respondents share similar attitude toward the factors within. For instance, they show negative response toward the interests of science subjects (2.66 and 2.58) and clubs (2.47 and 2.38). However, they are more interested in mathematical games are puzzles (3.37 and 3.35), comparing to the China respondents (3.13). The results within this principal component show evidential differences between China and US respondents. Also, within US components, Fairfield respondents are slightly more leaning to the negative side, comparing to the CSUDH respondents. Such discoveries align with the insights derived from the first principal component.

Figure 2 in Appendix C represents Factor 4 that has to do with whether STEM careers are for smart people with leadership potentials. Respondents from all three groups believe that STEM careers are for smart people (3.14, 3.53, and 3.62). With respect to other two factors, Chinese respondents believe that STEM majors are more promising from mid-career (3.24), and they are better pathways to leadership (3.12), than other majors; while their US counterparts show no polarity toward these two factors. Such pattern explains that why Chinese students show more respect to STEM careers, and tend to select STEM careers.

Factor 5 in Table 6 reveals the external influences on major selection. Previous studies also included external impacts on majoring decisions (i.e. families and teachers) (Grier and Johnston, 2009); however, they did not include friends as an external influence in this context. One point worth noting is that these are the influences on selecting of all majors, rather than solely STEM majors. Chinese respondents are indifferent toward their friends' impacts on their major selection decisions (2.99) – while their families (2.36) and teachers (1.87) do not have any impacts on their major selection. CSUDH students report that all external

	CSUDH	Fairfield	China	Relationship **
Factor 3 STEM subjects and activities				
Q6 Interested in science subjects -	2.66 (1.24) -	2.55 (1.08) -	3.27 (1.22)+*	Fairfield/CSUDH < China
Q7 Enjoy math puzzles and games +	3.37 (1.27) +	3.35 (1.14) +	3.13 (1.27)±*	Fairfield < CSUDH
Q8 Interested in science and math clubs -	2.47 (0.84) -	2.38 (0.87) -	3.21 (1.22)+*	Fairfield/CSUDH < China
Factor 4 STEM career for smart people				
Q15 People in STEM jobs are smart +	3.14 (1.02) +	3.53 (0.72) +	3.62 (1.14) +	CSUDH < Fairfield / China
Q22 Majoring in STEM is challenging +	3.50 (1.03) +	3.67 (0.75) +	4.03 (0.96) +	CSUDH < Fairfield < China
Factor 5 External influence on major				
Q3 Friends influence on major selection -	2.12 (1.05) -	2.49 (1.03) -	2.99 (0.14)±*	CSUDH < Fairfield < China
Q4 Teachers influence on major selection -	2.47 (1.21) -	3.07 (0.98) ±*	1.87 (1.06) -	China < CSUDH < Fairfield
Q5 Family influence on major selection -	2.67 (1.27) -	3.29 (1.09) +*	2.36 (1.28) -	China < CSUDH < Fairfield
Factor 6 STEM jobs in favor of men?				
Q12 STEM jobs dominated by men ±	2.99 (0.88) ±	3.28 (0.84) +*	2.81 (1.06) -*	China < CSUDH < Fairfield
Q13 STEM career is better for men -	2.30 (0.98) -	2.75 (0.94) -	2.65 (1.21) -	CSUDH < China/Fairfield

Note: * Indicates a change from the aggregate data, ** indicates the p-value is less than .05 for the comparison + Indicates the response is positive (mean>3), ± indicates neutral (mean=3), - indicates negative (mean<3). The format, μ (σ), indicates the mean and standard deviation of the respective respondents group.

Table 6: Decomposition of Variables in Factors 3 - 6

influences are insignificant toward their major selection decisions (2.12, 2.67, and 2.47).

Finally, Factor 6 is concerned about whether STEM jobs are in favor of men or not. Gender difference in STEM majors has been proven to be a significant factor in STEM majoring decisions – which aligns with our study. CH students do not believe that STEM jobs are dominated by men (2.81); whereas USEC students show quite opposite opinions (3.28); responses from USWC students lie in between (2.99). In terms of STEM careers are better for men than women, even though all three groups disagree – USWC students feel slightly strongly than their Chinese and USEC counterparts (2.30 versus 2.65 and 2.75). Such finding is somewhat surprising since generally US west coasters are considered more reluctant to gender differences (Griffith, 2010).

RESULTS AND DISCUSSIONS

This section presents the proposals highlighted in Table 2 regarding the STEM majoring extracted from the survey responses. Explanations and managerial discussions are provided as well.

P1. UNIVERSITY STUDENTS ARE UNCERTAIN THAT STEM JOBS ARE MORE FUN.

As considering the driving forces of STEM majoring decisions, the first proposal (P1) indicates that the students are not convinced that the STEM jobs are more fun, comparing to other types of jobs. In general, the responses show an uncertain sentiment (2.96) toward this proposal. However, students from Fairfield University believe that STEM jobs are less fun that other jobs. This is partially due to that in that area, business jobs (i.e. accounting, financial services) are much more popular than other types of jobs. Even though the state of Connecticut hires slightly higher STEM workers (4.8%) than the country average (4.1%), according to the 2014 National Science Foundation (NSF) data (National Science Foundation, 2014); that might due to the family background of the student body: students enrolled to Fairfield University came from medium to well established families. This relates to P6 that is discussed below. According to P1, college educators and recruiters should showcase to perspective STEM students how fun and joyful a STEM career can be to them.

P2. UNIVERSITY STUDENTS HAVE A POSITIVE BELIEF THAT THEY ARE PREPARED FROM STEM MAJORS.

It is discussed in the literature that students always believe they are prepared for the STEM majors – this is the foundation of the second proposal (P2). In order to assess this proposal, we examined the responses of the questionnaire. The US university students from both coasts (3.18 and 3.13) believe they are prepared for the STEM majors – since a great amount of them have taken Advanced Placement (AP) courses related to STEM subjects. On the contrary, Chinese university students believe they are not well prepared (2.65) for the STEM majors – partially because of the cultural differences: the Chinese students are more modest and underrepresented. Also, English-as-a-second-language would reflect in the students' preparedness as well, as pointed out by the practitioners.

P3. UNIVERSITY STUDENTS SHOWED LESS INTERESTS (NEGATIVE) IN SCIENCE OBJECTS.

Interests in the subjects are the most important driving force in major selection decision making processes, which is formulated in P3. From the responses, it is evidential that university students from the US show clearly less interests (2.66 and 2.55) toward science topics – while Chinese university students are far more interested (3.27) in science topics. This explains why international students from China in US universities often enrolled in STEM majors. This is practically useful for recruiting purposes, since recruiters can thus alter their goals and projections while recruiting students for science majors.

P4. UNIVERSITY STUDENTS SHOWED MORE INTERESTS (POSITIVE) IN PUZZLES AND GAMES.

Serious games have become a very useful tool for pedagogical purposes, particularly for STEM education purposes (Young et al., 2012). This trend is also observed in STEM education practitioners. We evaluate this trend using the responses from the questionnaire responses. University students from US show strongly positive attitude (3.37 and 3.35) toward puzzles and games under pedagogical occasions, while Chinese university students are uncertain (3.13) regarding puzzles and games. This is partially because that comparing to US, serious games are not very popular in China universities. To improve STEM perception in China, university might consider enhancing serious games in pedagogical occasions. P4 also suggests that we should continue enhance students' problem solving skills, utilizing their interest in puzzles.

P5. UNIVERSITY STUDENTS SHOWED LESS INTERESTS (NEGATIVE) IN SCIENCE AND MATH CLUBS.

Previous studies have identified science and math clubs as a key factor affecting academic success in STEM majors (Wang, 2004). And cultural differences will draw students from different geographic regions apart in terms of attending these clubs. Related to P3, university students from US show less interest (2.47 and 2.38) in science and math clubs, while Chinese university students are more interested (3.21) in them, as stated in P5. Thus, recruiting students into math and science clubs will not be an efficient way of promoting STEM majors in US universities, comparing to their Chinese counterparts. Further studies can be conducted in order to discover what are the factors that cause the negative view of science and math clubs, for the purpose of better attracting students.

P6. UNIVERSITY STUDENTS ARE MORE IMPACTED (POSITIVE) BY THEIR TEACHERS WITH RESPECT TO THEIR MAJOR SELECTION DECISIONS.

Previous studies have indicated that teachers have impacts on students' decision making of college majors – as discussed in Section 2 above. We encapsulated this trend in the sixth proposal (P6). We are going to evaluate if this trend is consistent with our sample. Surprisingly, all three demographic groups show opposite trends toward P6. Both CSUDH and China student show strongly negative attitude (2.47 and 1.87) toward the teachers' role on majoring, while Fairfield students are neutral (3.07) toward P6. This reveals practical values since exercises from Fairfield teachers might be valuable for recruiting STEM majors.

P7. UNIVERSITY STUDENTS ARE MORE IMPACTED (POSITIVE) BY THEIR FAMILIES WITH RESPECT TO THEIR MAJOR SELECTION DECISIONS.

Similarly to P6, previous studies identified families as one of the important driving forces of college majoring, as discussed in literature review section (formulated as P7). We use our responses to assess if this trend is consistent with our sample. CSUDH and Chinese respondents reported that their families have negative impacts (2.67 and 2.36) on their majoring decisions, while Fairfield students receive fairly strong positive impacts (3.26) from their families. Related to the explanations of P1, Fairfield students came from medium to well established families; thus, their families have stronger impacts on their major selection decisions. Also, the relatively strong family impacts also draw them away from being interested in STEM majors.

P8. UNIVERSITY STUDENTS HAVE A STRONG POSITIVE BELIEF THAT STEM JOBS ARE DOMINATED BY MEN.

It is argued in the literature that STEM jobs are dominated by men – thus, gender is a strong factor impacting STEM majoring decisions. We capture this trend in the last proposal (P8), and use the questionnaire responses to evaluate it. According to the survey results, the three distinct demographic groups show different attitude toward this proposal: students from China are negative (2.81) with P8; students from CSUDH show uncertain (2.99) attitude; while students from Fairfield strongly agree (3.28) with P8. This observation is extremely useful for recruiting purposes: in order to increase the gender diversity of STEM majors, recruiters need to be more attentive with female students from the east coast of US.

CONCLUDING REMARKS

In this research, we have presented several STEP majoring and success factors. While some of our research findings are counter-intuitive, intersting insights can be derived from these proposals and findings. We now summarize the paper by focusing on the following two practical considerations: with respect to majors and with respect to grades.

WITH RESPECT TO MAJORS

Students majoring in Technology, Engineering, and Mathematics make career decisions under the least influences from their teachers; while science and non-STEM students exhibit the opposite trend. This is due to the fact that majors in Technology, Engineering, and Mathematics are prone to be affected by their peers for career choices (Grier and Johnston, 2009). An additional point worth noting is that students have negative (FA, TE) to neutral (FR) responses to these questions – which means that they make their career selections independently. This observation aligns with the fact that internal factors, such as COMP, AWPR, and INTR are more important that EXTI.

Although respondents in this study believe STEM majors are both challenging and rewarding at the same time; students majoring in Technology, Engineering, and Mathematics think their majors are more challenging than rewarding; while science and non-STEM students think STEM majors are otherwise. That proves similar findings from previous studies (Garibay, 2015). Similarly, students majoring in Technology think they are underprepared for their majors; while other major groups think they are prepared for the STEM major.

WITH RESPECT TO GRADES

College freshmen receive lowest influence on their career decisions from the teachers; while sophomores receive the highest influence on their career decisions from their families. The reason is that college students usually decide their majors during the sophomore year when family is the most important driving force. Similar findings are observed in prior related studies (Buschor et al., 2014)

Along the career as college students, respondents show a consistent interest in math puzzles and games – which aligns with the observations in the literature: (serious) games can be used to attract students in regards of pedagogical purposes.

The perception of challenging nature of STEM majors declines during the course of their college career, with a minor exception in the junior year. The reason behind this observation is that students have the lowest awareness of (STEM) majors when entering colleges as freshmen. With their confidence in (STEM) majors increasing along with their awareness in STEM, they feel less challenging in these STEM related majors. Also, it is worthnoting that the perception being rewarded in STEM majors is consistent at a relatively high level, which confirms that STEM majors are in general appealing to college students.

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APPENDIX A - SURVEY QUESTIONNAIRE: WHAT ACCOUNTS FOR STEM DECISION MAKING?

A Survey of Attitude and Readiness for STEM

1. Your gender: 1 = Male 2 = Female

2. Your ethnicity:

1 = Non-Hispanic White	2 = Hispanic/Latino
3 = Black	4 = American Indian or Alaskan Native
5 = Asian	6 = Native Hawaiian or Pacific Islander
7 = Mixed race	

3. Your grade:

1 = High School Junior	2 = High School Senior
3 = College Freshman	4 = College Sophomore
5 = College Junior	6 = College Senior

4. Your major or major-to-be:

1 = Science 2 = Technology 3 = Engineering
4 = Mathematics 5= A non-STEM major

5. Questions on Attitude and Readiness for STEM

(1 = Strongly Disagree, 2 = Disagree, 3 = Neither, 4 = Agree, 5= Strongly Agree)

1) MC My major is (or will be) challenging.
2) FA My family influences me in choosing my major.
3) FR My friends influence me in choosing my major.
4) TE My school teachers influence me in choosing my major.
5) PR I am prepared for college education in STEM.
6) SC I like science subjects such as physics and chemistry.
7) GAI enjoy doing math puzzles and games.
8) CL I am interested in joining science, chess, robotics, and/or math clubs.
9) GL Globalization reduces STEM jobs in the US.
10) JA STEM jobs are usually abundant but they disappear when economy is bad.
11) JM I am aware of the job market and career opportunities in STEM.
12) DO STEM jobs are dominated by men.
13) ME A STEM career is better for men than for women.
14) OP A STEM career is more opportunistic than other careers.
15) PE People who can get a STEM job are smart.

16) MI A STEM career is more promising for my mid-career and beyond than other careers.
17) PA A STEM career has better pathways to leadership than other careers.
18) SH A STEM career is shorter than other careers.
19) FU STEM jobs are more fun than other jobs.
20) HP STEM jobs are higher paying than other jobs.
21) CR STEM jobs are more creative than other jobs.
22) MS Majoring in STEM is challenging.
23) MR Majoring in STEM is rewarding.

APPENDIX B – DEMOGRAPHIC INFORMATION OF THE SURVEY RESPONDENTS

Ethnicity	Gender	CSUDH	Fairfield	China	Subtotal
Asian	Male	11	1	84	96
	Female	9	2	105	116
	No Answer			2	2
Subtotal		20	3	191	214
Blank	Male	17	1		18
	Female	10	2		12
Subtotal		27	3		30
Hispanic/	Male	67	5		72
		43			
Latino	Female		2		45
	No Answer	1			1
Subtotal		111	7		118
Mixed race	Male	8			8
	Female	9	1		10
Subtotal		17	1		18
Native Hawaiian/	Male	2			2
Pacific Islander	Female	1			1
Subtotal		3			3
Non-Hispanic White	Male	9	34		43
	Female	16	58		74
Subtotal		25	92		117
No Answer			1		
Total Male		114	42	84	240
Total Female		88	65	105	258
Total No Answer		1		2	3
Grand Total		203	107	191	501

Table A: Respondents' Demographic Information

APPENDIX C – DECOMPOSITION OF FACTORS IN THIS STUDY

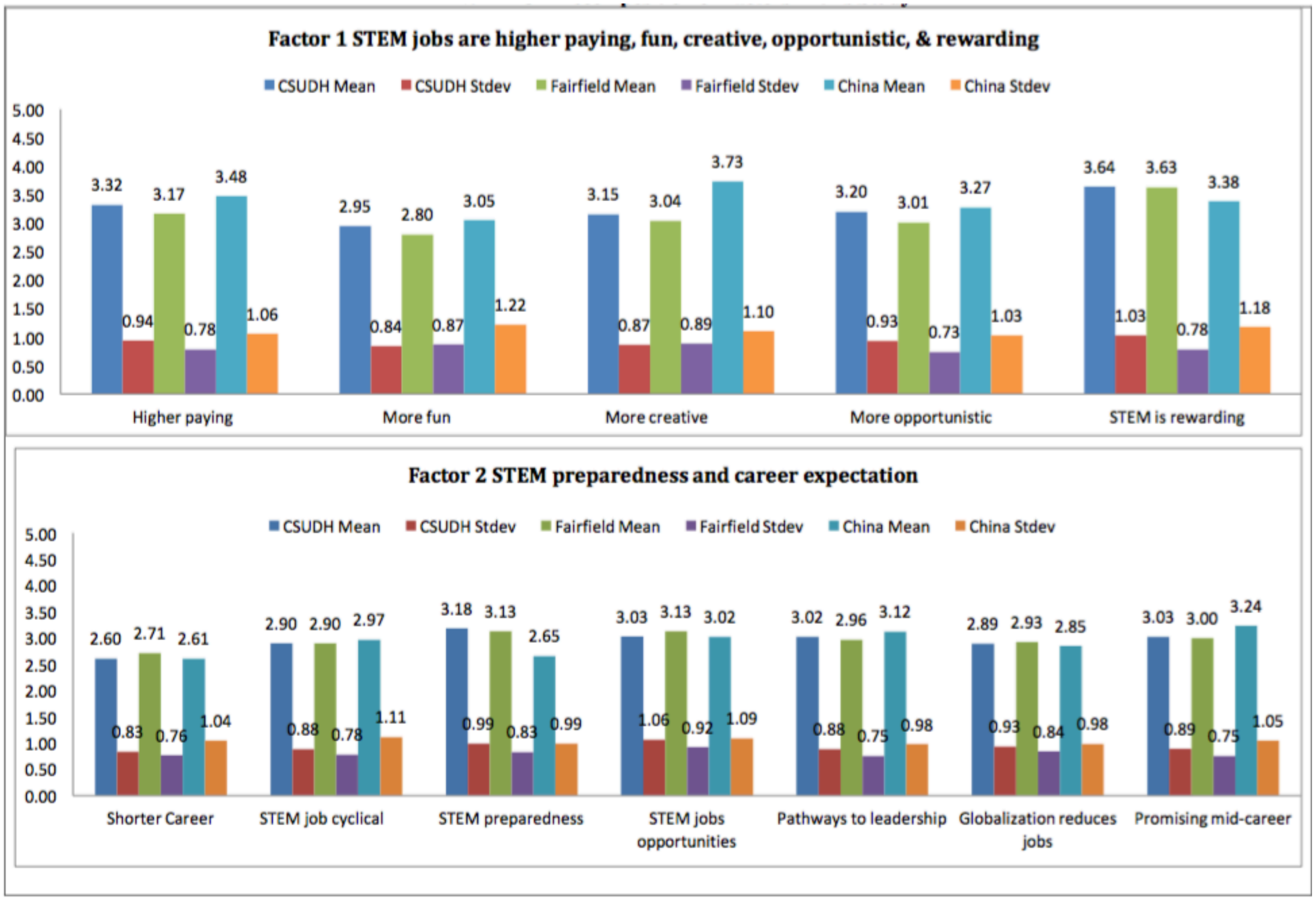

Figure 1: Decomposition of Variables in Factors 1 and 2

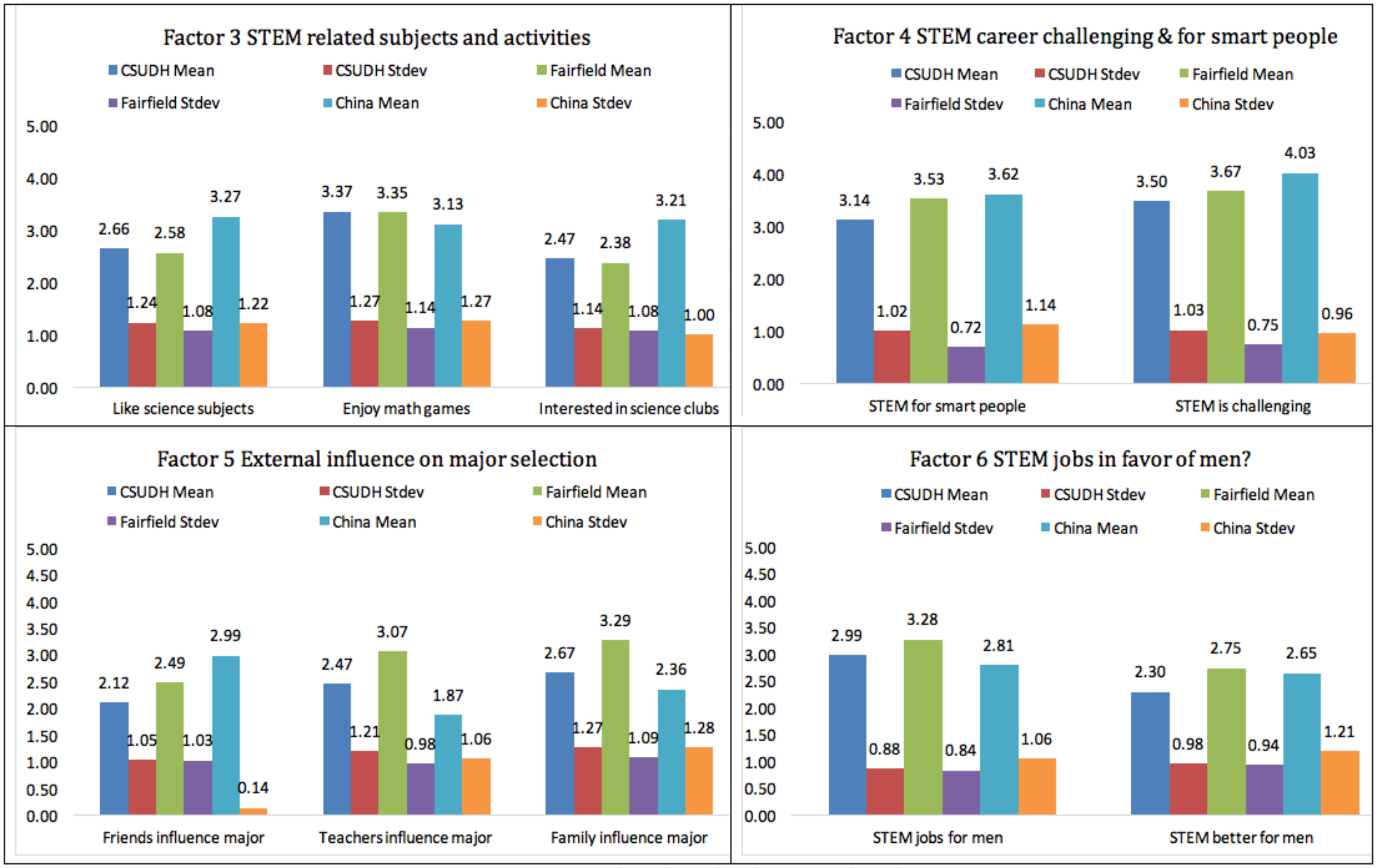

Figure 2. Decomposition of Variables in Factors 3 through 6