ITEST Grant Award # 1758975
Journal of Applied Global Research. Volume 11 Issue 26
(Fall 2018)

FRAMING A STEM EDUCATION-CAREER BRIDGE PROGRAM WITH A GLOBAL PARTNERSHIP MODEL AND FORENSICS ANALYTICS

By Dr. *Joselina Cheng, University of Central Oklahoma, USA*
Rebekah Feng, Becks Intelligence Group, LLC, USA

ACKNOWLEDGEMENTS

This three-year *STEM Education-Career Builder* project was funded (award #1758975) by the National Science Foundation to broaden the STEM participation by female students. The project was based on a global government-industry-university partnership model with career-exploration and job-shadowing venues to promote STEM career awareness and interests. The theoretical frameworks, technological infrastructures, and resources allowed the researchers to explore and incorporate innovative teaching strategies and learning tools to better engage students and improve STEM education.

ABSTRACT

The National Science Foundation funded the University of Central Oklahoma (UCO) for a three-year bridge program to broaden the participation in the Science, Technology, Engineering, and Mathematics (STEM) by female students. UCO is a state university in the United States. The project team proposed a global government-university-industry (GUI) model to collaborate with partnering institutions at the international, federal, and state levels. Partnering institutions included IBM, the FBI, the Oklahoma State Bureau of Investigation (OSBI), the Oklahoma Center for the Advancement of Science and Technology, the Francis Tuttle Innovation Center, and the Established Program to Stimulate Competitive Research. Representatives from these partnering institutions served in the roles of advisory board members and internship sponsors who identified skill requirements and job trends. For phase one (2018), the focus was the research and development (R&D) and the implementation of a STEM program with a focus on Forensics Analytics (FA). The STEM+FA curriculum was designed with real-world applications and emerging technologies (e.g. IBM Watson, simulation, virtual reality). The STEM+FA pilot program consisted of simulated learning environments, STEM modules, cloud-based tutorials, and relational databases. These databases were similar to the Combined DNA Index System and Automated Fingerprint Identification System which have been adopted by the FBI and the OSBI to solve modern-day crimes (e.g. cyber security, homicide). Researchers pilot tested the STEM+FA program by collecting and analyzing quantitative and qualitative data. Findings derived from the pilot study evidenced that the STEM+FA pilot program had positive effects on female student career awareness and perceived competencies; whereas career interest remained unchanged.

Keywords: Partnership Model, Innovation, Simulation, Relational Database, STEM Career Competencies

INTRODUCTION

Problem Statement

The advances in the information communication technologies (ICT), Internet of things, simulated human-computer learning environments, and artificial intelligence not only define how work is conducted today but will also drive future workforce trends (Cheng & Feng, 2016a; NSF, 2018; Rising above the Gathering Storm, 2008). While some of these emerging technologies are available for Science, Technology, Engineering, and Mathematics (STEM) education, many curricula are still taught with teacher-centered lectures. Thus, students are under-prepared to participate in the highly competitive workforce (Bell, 2011; Manlow, Friedman, & Friedman, 2010). According to one international report, "millennials may be our most educated generation ever, but they consistently score below many of their international peers in STEM, literacy, numeracy, and problem solving in technology-rich environments" (Millennials' Weak Skills, 2015, p.1). Simply converting lectures to a digital format (e.g. a PDF or PowerPoint slides) and uploading them to a learning management system such as Desire to Learn is problematic for students seeking STEM degrees due to several reasons (Cheng & Feng, 2016a; Crellin & Karatzpimo, 2010; Dede, Honan, & Peters, 2005; Ji, Michaels, & Waterman, 2014). First, static lectures do not cultivate multisensory environments to accommodate auditory, visual, and kinesthetic learning styles. Second, static lectures do not provide students with an interactive platform to collaborate and develop 21st century competencies.

Need Statement for Innovative Programs to Broaden the Female STEM Participation

STEM educators have a tremendous responsibility to design quality programs and engaging curricula to prepare students and build a pipeline of skillful and equitable graduates (Mitchell & Benyon, 2018). In particular, only 24% STEM jobs are held by women in the United States (Bureau of Labor of Statistics, n.d.; Office of the Under Secretary for Economic Affairs, 2018). In Oklahoma, STEM participation by female students in 2017 was about 13% (Oklahoma's 2016 STEM report card, n.d.). The underrepresentation of women in STEM often stems from gender bias or inequitable opportunities for career exploration or advancement (US Bureau of Labor Statistics, n.d.; Williams, 2015). While national reports urge educators to design programs to promote STEM participation by underserved female population, strategic interventions to foster career awareness, spark interest, and support women pursuing STEM education and careers remain underexplored. One contributing factor to the female under-representation in STEM is the lack of institutional resources and collaborative partnerships with government agencies, research universities, and industries (American Association of University Women, n.d.; McCreedy & Dierking, 2013; National Girls Collaborative Project, n.d.; Women in computer science: getting involved in STEM, n.d.). Many faculty members face institutional constraints such as reduced budgets, technological infrastructures, and limited andragogical guidance. These constraints deter educators from exploring effective course design to better engage female students.. (Brown, 2010; Waterhouse, 2005; Cheng 2016a & 2016b). Thus, faculty members often undergo the pragmatic process by unlearning past teaching habits and philosophies in an effort to teach STEM courses successfully (Allen & Seaman, 2011).

To overcome these constraints, researchers secured funding from the National Science Foundation (NSF) to form partnerships with IBM, the FBI, the Oklahoma State Bureau of Investigation (OSBI), the Established Program to Stimulate Competitive Research (EPSCoR), the Oklahoma Center for the Advancement of Science and Technology (OCAST), and the Francis Tuttle Innovation Center at the international, federal, and the state levels. Representatives from these partnering institutions formed a STEM advisory board and served as internship sponsors to identify job trends and skill requirements. This government-university-industry (GUI) partnership model extended technological infrastructures and maximized institutional resources so that researchers could design engaging STEM curriculum.

Scope Statements of a Multi-Year STEM Education-Career Bridge Program

For phase one (2018), the project scope was limited to the research and development (R&D) of a pilot program (Figure 1). A STEM bridge program with a focus on forensics analytics (FA) was developed by the project team in spring 2018. The curriculum consisted of simulated learning environments, STEM modules, cloud-based tutorials, and relational databases similar to the Combined DNA Index System (CODIS) and Automated Fingerprint Identification System (AFIS).

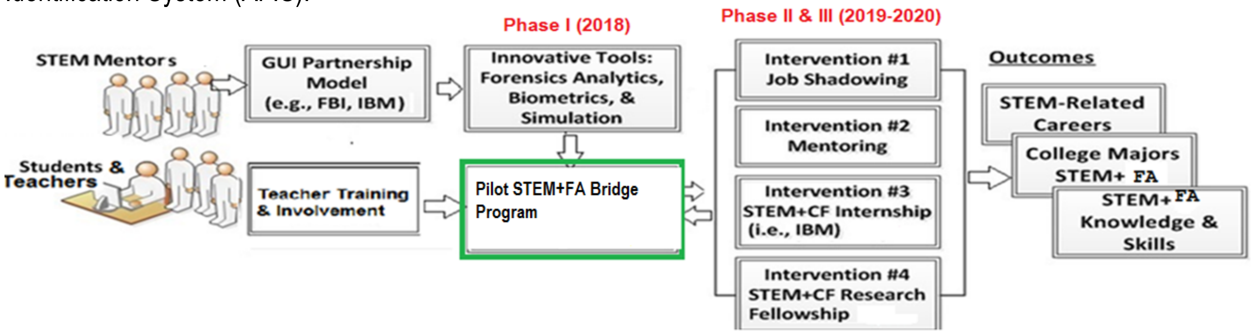

Figure 1. *A STEM Education-Career Pathway with Multi-tier Interventions for Female Students*

Purpose Statement

The STEM+FA pilot program aimed to broaden STEM participation by female students. Table 1 outlines career-exploration venues, job shadowing, guided tours, and hands-on activities were designed to support three program objectives. These program components were intended to help female students acquire interdisciplinary STEM+FA knowledge, enhance technical competencies, and develop the 21st century skills (e.g. collaboration, analytics, problem solving, and computational thinking).

Table 1. STEM+FA Pilot Program Objectives

Description of Program Objective	Supporting Activities/Program Components
1. Promote STEM career awareness	Career-exploration venues (e.g. site visits, job trends, infographics)
2. Promote STEM career interest	STEM tracks, job shadowing, & interactions with professionals
3. Foster STEM career competencies: (1) inter-disciplinary knowledge, and (2) competency to work with emerging technologies	Hands-on crime solving, STEM tracks, human-computer simulations, forensic analytics, biometrics, CODIS, & AFIS database management systems

Figure 2 presents the logic model for the research component of the STEM+FA pilot program. The pilot study sought to answer three research questions (RQ) and three hypotheses (H): Non-attendees were female students who applied for the 2018 pilot program but were selected randomly by a computer program to not attend the program.

RQ1: What are the differences in female career awareness of STEM+FA attendees and non-attendees?
RQ2: What are the differences in female career interests of STEM+FA attendees and non-attendees?
RQ3: What are the differences in female career competencies of STEM+FA attendees and non-attendees?

H1: Female career awareness increases as a result of attending the STEM+FA program. .
H2: Female career interests increase as a result of attending the STEM+FA program.
H3: Female career competencies increase as a result of attending the STEM+FA program.

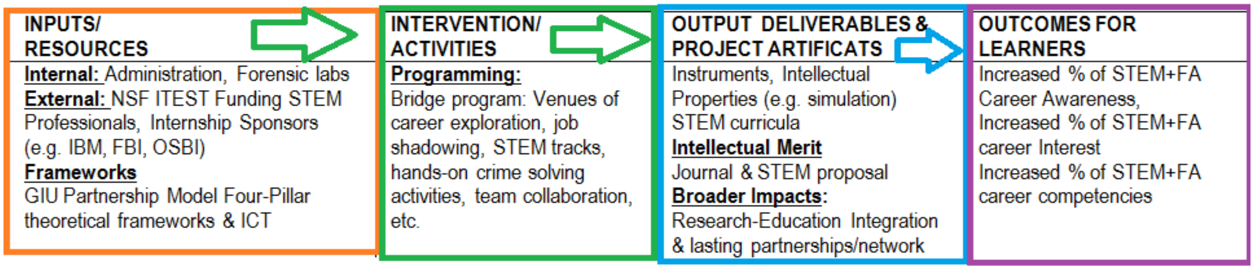

Figure 2. *Logic Model for the STEM+FA Bridge Program*

LITERATURE REVIEW & THEORETICAL FRAMEWORKS

To ensure that the teaching strategies and learning tools are grounded in theory and literature, the proposed STEM+FA pilot was based on the global GIU partnership model and four-pillar theoretical frameworks, as shown in Figure 3 (below). These frameworks provided the researchers with the foundation to design and build upon the research and development (R&D) of the STEM+FA curriculum.

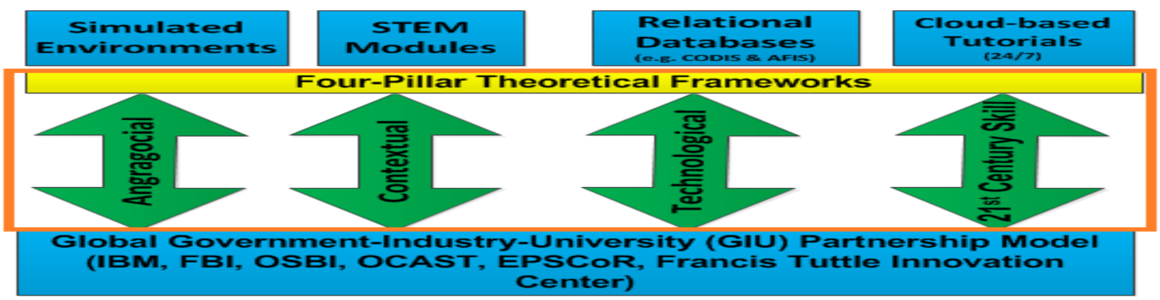

Figure 3. *An Integrated Framework of the Global GIU Partnership Model & Four Pillars of Theorem*

Pillar #1: Andragogical Framework

Malcolm Knowles defined andragogy as "the art and science of helping adults learn". The core of *Adult Learning Theory* is to make "the educational content professionally and personally relevant" (Knowles, 1977, p. 43). Andragogy shifted the educational paradigm with several principles. The first principle is to construct an authentic learning environment with real-world scenarios. Faculty members in higher education need to choose strategies that would enable adults to achieve their learning and developmental goals (Allen & Seaman, 2011).

The second principle is to cultivate a self-directed learning environment for adults. Learning is a dynamic process, which depends on the adult learners' self-efficacy (Waterhouse, 2005). For the context of this study, researchers developed learning modules with aims to motivate adult learners in taking ownership of their learning process, becoming more responsible for planning their own studies, managing projects, and submitting assignments on time.

The third principle is to challenge adult learners in becoming their own and their peers' resources. Collaboration is a "key ingredient for successful adult learning methodologies" which marks the difference in adult learners when compared to children (Allen & Seaman, 2011, p. 58). Students working in teams, if encouraged to share their diverse background, workplace challenges, and innovative solutions, can enrich learning experiences (Allen & Seaman, 2011).

Pillar #2: Contextual Framework

The STEM-Forensic Analytics curriculum was framed by the context of how professionals solve modern-day crimes (e.g. security breach, identify theft, terrorism, homicides) with analytical tools and relational databases. Criminal records are often stored digitally in relational database systems such as CODIS and AFIS. Both CODIS and AFIS were adopted by the FBI and the OSBI. While these databases are rarely available for academia due to due to the sensitivity and confidentiality of the data, the real-world context is very relevant for faculty to teach topics such as cyber security, white-collar crimes, hacking, and security breaches in a highly networked society (Basu, 2013). Further, forensics analytics is an emerging field, which requires students to have interdisciplinary knowledge, soft skills, and technical competencies. Helping students develop these skills can better prepare graduates to interpret criminal patterns, collect evidence (e.g. DNA), process biometrics (e.g. fingerprints), and solve crimes (Cheng & Feng, 2016a, 2016b; Crellin & Karatzpimo, 2010).

Pillar #3: Technological Framework

To participate in the workforce and succeed in a fast-paced, knowledge-based society, today's students must develop high-level and complex skills as described above (Groff, 2013). Research showed that simulation and ICT could cultivate multisensory, interactive, and collaborative learning environments. These environments could encourage interactivity, promote active learning, and enrich experiential learning experience that result in higher learning outcomes and satisfaction (Cheng, 2013; Crellin & Karatzpimo, 2010; Dede et al., 2005; Grillo & Hackett, 2015). To foster these skills, researchers incorporated the following technologies to create the STEM+FA pilot program with aims to engage female students in active learning, knowledge acquisition, and skill development.

Simulation Technology**:** Simulation is often associated with gaming, aviation, medical fields, or military training. For academia, simulation technology can offer STEM educators a cost-effective platform to better engage today's digital learners. Researchers at Harvard University incorporated simulation into course design and found empirical evidence for its effectiveness. The findings merit the use of simulated (SIM) environments which better engage learners with interactive learning and motivate students to achieve higher educational outcomes (Bell, 2011; Brown, 2010; Crellin & Karatzpimo, 2010; Dede et al., 2005; Fostering learning, n.d.; Good et al., 2008; Schiller, 2011; US Department of Education, n.d.). In this study, the adoption of SIM learning environments was to foster human-machine learning, computational thinking, problem solving, and decision-making based on the real-world scenarios.

Information Communication Technology (ICT) Technology**:** Many institutions in higher education adopt learning management systems (LMS) as platforms for online or hybrid courses. Desire to Learn (D2L), an example of LMS, which uses ICT, has several built-in functions. There are two types of ICT. Asynchronous communication (e.g. discussion, emails, and quizzes) allows students or instructors the ability to interact without being at the same place and at the same time (Waterhouse, 2005). In contrast, synchronous communication (e.g. online chats, simulation) encompasses real-time learning events where faculty and students are required to log on and interact simultaneously. The abilities to use ICT are important for several reasons. First, many universities adopt LMS and ICT to facilitate effective faculty-student interaction, course delivery, and assignment submission. Second, multinational corporations (MNCs) such as IBM and Cisco to conduct web-based trainings for employees across the continents (Groff, 2013) also commonly use ICT to coordinate projects among virtual team members and global stakeholders. In this study, the adoption of ICT was to enhance students' ability to use ICT asynchronously and synchronously as ways of modern-day communication in order to succeed in academia and professions.

Multimedia-based Learning Technology: Research shows that incorporating multimedia technologies can enhance teaching effectiveness and student success (Cheng, 2009-2014; Cheng & Feng, 2016a, 2016b; Morales, Cory, & Bozell, 2001; Waterhouse, 2005; Zhang, 2004). As the Internet supports the delivery of full-motion audio and video to personal computers, multimedia learning can be an effective method to deliver information in a computer-based presentation. Multimedia courseware can cultivate a multi-sensory learning environment to enhance learning outcomes in two ways. First, multimedia courseware can better address students' auditory, visual, and kinesthetic learning styles by enticing learners to pay full attention through the vividness of presentation and sound (Zhang, 2004). Second, multimedia instruction can maximize the learner's ability to retain information by directing learners to focus their full attention on a task through the vividness of the presentation (Waterhouse, 2005). In this study, the project team adopted and integrated several mediums of communication (e.g. text, graphics, video, animation, and sound) to address student learning styles, enhance learning outcomes, and enrich learning experiences.

***Analytical Technology*:** In a knowledge-based society with big data doubling every two years, many organizations are embracing analytics as strategic solutions to sustain competitiveness. Analytics, which has an interdisciplinary (e.g. STEM) nature, is the integration of emerging technologies and research skills (Figure 4, below).

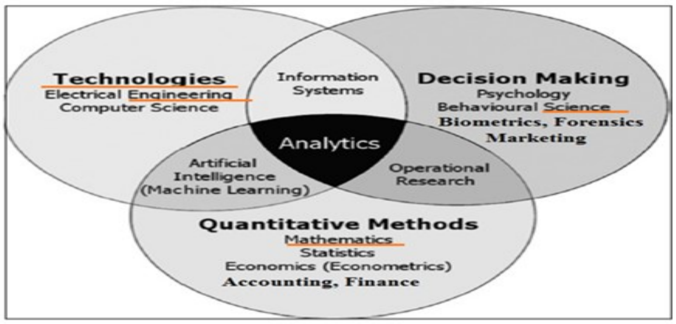

Figure 4. Interdisciplinary nature of Analytics (Adapted from Mortenson, Doherty, & Robinson, 2015, p. 586

Table 2 (below) outlines three levels of analytics and each level can process different types of data. According to IBM (n.d.), the majority of businesses today operate on structured data (e.g. numbers, characters) which only constitutes twenty percent of big data. The remaining eighty percent of data is unstructured (hybrid). Hybrid data include images, sound, videos, photographs, tweets, blogs, biometrics (e.g., fingerprints), and DNA profiles (Bresnick, n.d.).
Descriptive analytics can "process structure data and reveal patterns of information through the iterative exploration of historical data" (Evans & Lindner, 2012, p.1). Both predictive and prescriptive analytics can process both the structured and the hybrid data (Basu, 2013). For predictive analytics, the "increased computing power allows researchers and scientists to run hundreds or thousands of models more quickly to predict the future trends with forecasting techniques" (Basu, 2013). For prescriptive analytics, its "adaptability to the growing volume, velocity, variety, veracity, and value of data" deepens the machine learning, evaluate new processes, predict future scenarios, and recommend optimal solutions based on the past knowledge, current events, business rules, organizational resources, and constraints (Grillo & Hackett, 2015; IBM, 2013; Momin & Mishra, 2015).

Table 2. *Field-tested Innovative STEM Modules and learning Tools (Sources: Basu, 2013, Grillo & Hackett, 2015; IBM, 2013; Momin & Mishra, 2015)*

Level	Focus	Data Type	Function	Discipline	Real-world Applications
Descriptive Analytics	What happened	Structured	Analyze & report historical data	STEM	Aggregated forensic biometrics & segmentation
Predictive Analytics	What will happen	Structured & Hybrid	Infer from data to forecast future events	STEM	Healthcare (IBM Watson); Retailors (Amazon) Entertainment (Netflix)
Prescriptive Analytics	What is the optimal decision?	Structured & Hybrid	Derive from simulated, time-series modeling, or what-if analyses to adapt & maximize objectives with optimal solutions	STEM	Artificial Intelligence & machine learning (Google's driverless car with adaptive algorithms & automated decision making)

Pillar #4: The 21st Century Skill Framework for the Future STEM Workforce

According to a PWC study, sixty-nine percent of employers will demand analytic skills from job candidates regardless of their college degrees or majors by the year 2021 (PWC, 2018; Top 10 trends, 2018). Forensics Analytics is an emerging field that requires multi-disciplinary STEM knowledge, skills, and technical competencies. While analytics can be useful tools to help organizations compete, human resource (HR) administrators are likely to face more challenges finding qualified employees (IBM, 2016). Soft skills preferred by employers include computational thinking, problem solving, project management, collaboration, and decision-making based on real-world scenarios (IBM, 2016; Grillo & Hackett, 2015). One MIT survey found that managers are having trouble hiring analytical talent as only twenty-three percent of college graduates have the necessary skills to meet employers' demands (Deloitte, University Press, 2016).

Figure 5 presents many employer preferred skills that require analytical competencies (underlined and highlighted). Thus, STEM educators need to better prepare graduates with analytical skills to handle explosive data growth as well as the shifts in organizational strategies due to the future labor market trends and emerging technologies (Good, Howland, & Thackray, 2008; IBM, 2016). Thus, this NSF STEM education-career project will leverage the GIU partnership model and job-shadowing venues to expose female students to the interdisciplinary nature of the current and emerging technology and enable them to acquire the skill sets that are needed to be successful in college and in the workforce of the current and future STEM careers.

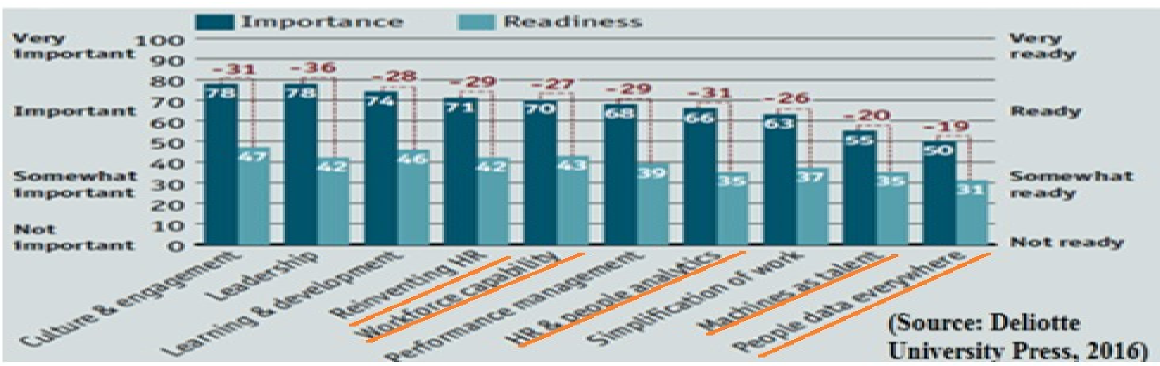

Figure 5. Talent trends: Importance vs. readiness

PHRASE I IMPLEMENTATION & THE PILOT TEST OF A STEM+FA BRIDGE PROGRAM

Now that researchers have presented the discussions of how the teaching strategies were grounded in theory and literature, this section presents the implementation of the STEM+FA pilot program. Researchers operationalized the collaborative GIU partnership model, as previously discussed to form the foundation, as previously. The project team built the STEM+FA pilot program upon the GIU foundation with four-pillar theoretical frameworks. The pilot STEM+FA curriculum, which was developed in the spring of 2018, included STEM+FA modules for hands-on activities, simulated environments, cloud-based tutorials, and simulated databases similar to CODIS and AFIS.

STEM+FA Modules & Career Exploration to Promote Awareness of & Interests in STEM

For phase one (2018), the five-day STEM+FA pilot program was a commuter camp. Table 3 (below) outlines hands-on activities which were categorized by disciplinary tracks. Appendix A presents a detailed schedule filled with guided tours, career exploration, experiential learning, and interactions with STEM professionals and faculty members.

Table 3. *STEM Education-Career Exploration & Hands-on activities*

Day	Site Visits & Speakers	Hands-on & Lab Experimentation	Role Playing & Team Collaboration
1	OSBI & Fusion Center	Biometrics & finger prints (*M&S)	Virtual Triage Center & 911 (*T)

2	OSBI Labs	Crime Scene Investigation (*M)	Simulated Detective Office (*T&E)
3	Edmond Police	Forensic Analytics (*STEM)	SIM Interviews: Witnesses & Suspects (*T&S)
4	Forensics professionals	Blood Testing & DNA database (*S&T)	Virtual Reality (*T) & Analytics
5	Team presentations	Obtain a digital warrant for an arrest	Presenting at a Moot Court (STEM)

***S=Science Track; *T=Technology Track; *E= Engineering Track; *M = Math Track**

SIM Learning Environments & Real-World Applications to Foster the 21st Century Skills

Participants were also provided with job shadow to observe how forensic professionals applied interdisciplinary knowledge and used information communication technologies (ICT) to investigate and solve crimes. Cutting-edge ICT technologies include simulation, virtual reality, forensic analytics, and artificial intelligence. Forensics analytics can be applied to many sub-disciplines of STEM, criminal justice, computer forensics, and social science. Specifically, the five-day schedule included hands-on activities to foster analytical thinking, computational-thinking, problem-solving, innovative, and collaborative skills.

Day-one morning sessions included presentations of career opportunities and workforce analytics by a retired FBI agent and STEM professionals. Afternoon sessions included site visits to the Oklahoma State Bureau of Investigation (OSBI) and the Oklahoma Information Fusion Center. One Homeland Security professional, who collaborated with the OSBI, presented career opportunities. One OSBI professionals demonstrated AFIS (Figure 6 below). Evening sessions immersed participants in simulated triage center and role played as law-enforcement professionals to handle incoming 911 calls (Figure 7 below). Participants also used mobile apps such as *GroupMe* to collaborate on their team projects. Repeated evening activities were designed in a cumulative manner for students to uncover more evidence throughout the pilot week in order to solve four cold cases. Day-two morning sessions included a site visit to OSBI labs. Afternoon sessions included the investigation of physical and virtual crime scenes. Participants recovered artifacts (e.g. bones) and collected fingerprints and DNA from a physical crime scene (Figure 8 below). Participants also used virtual reality to recover digital evidence from a virtual crime scene.

Figure 6. Demo of AFIS

Figure 7. A SIM Triage 911

Figure 8. A crime scene

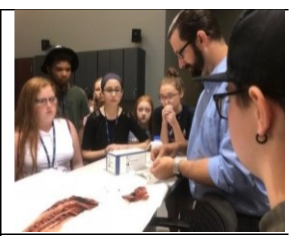

Figure 9. Blood Testing

Day-three morning sessions included a site visit to the local police department learning about law enforcement. Afternoon sessions included digital evidence, cyber security, biometrics (e.g. finger prints), and forensic analytics, and job shadowing with simulation to immerse students in crime solving. Day-four morning sessions included a site visit to Forensic Science Institute, DNA presentations, and blood-testing activities (Figure 9 above). Afternoon sessions included presentations of forensics analytics, DNA profiles, fingerprints searches via Structured Query Language (SQL), and data mining. Day five morning sessions included team presentations, parental engagement, and academy graduation.

Integration of Three-level Analytics and Simulated CODIS & AFIS Systems

The project team used *Microsoft Office Access* to design and simulate databases which were similar to CODIS and AFIS. Principals of descriptive, predictive, and prescriptive analytics, as previously presented in Table 1 on p. 3, were also incorporated to store structured and hybrid data (e.g. DNA profiles, biometrics of fingerprints). Participants were presented with a demonstration on how to use Structured Query Language (SQL) to perform searches for matched criminal records. Figure 10 presents an excerpt of one simulated dataset with a matched DNA profile. Figure 11 presents an excerpt of one simulated dataset with matched fingerprints.

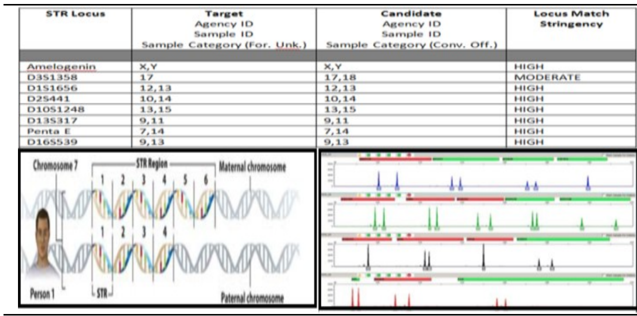

Figure 10. Excerpt of one matched DNA profile in a Simulated CODIS

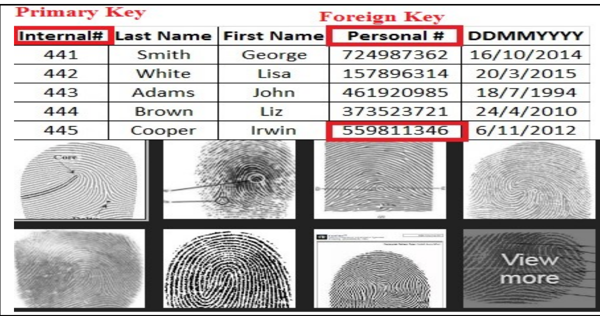

Figure 11. Excerpt of matched fingerprints in a simulated AFIS

Just-in-Time (JIT) Tutorials for Global Accessibility without Location Constraints

To help students learn simulation technologies, design databases, perform searches, and solve crimes, the project team created four cloud-based tutorials, as shown in Table 4 (below). These tutorials were created using *Camtasia* (screen capturing software) and *IBM Watson* to create multimedia-based tutorials. Students could access these tutorials 24/7 without any location constraints.

Table 4. *Cloud-based Tutorials*

Module #	Topic	Format	Module Time
1	Overview of Learning in Simulated Environments	Self-Paced Online	5 minutes
2	Creating and Managing Avatars	Self-Paced Online	6 minutes
3	Collaborating in Virtual Learning Environments	Self-Paced Online	8 minutes
4	Creating a Relational Database & Structured Query Language (SQL)	Self-Paced Online	10 minutes
5	Interfacing with IBM Watson & Artificial Intelligence	Self-Paced Online	15 minutes

METHODOLOGY

To ensure that the teaching strategies and learning tools are andragogically, contextually, skillfully, and technologically sound, researchers conducted a pilot test of the STEM curricula and the FA program. The STEM+FA pilot program was developed in spring 2018 and field-tested the efficacy of this innovative program in summer 2018.

Research Design, Method, & Population

This study has an explanatory design. The method is mixed. The timespan is cross sectional for the first phase. The generation population included 115 female students who applied for the STEM+FA pilot program. The target population included 50 female students who were randomly selected by a computer program to attend to attend the pilot program. The sample population consisted of 25 female students who volunteered to participate in the pilot study, attended the STEM+FA pilot program, and completed the pre- and post-survey

Instruments & Reliability

The pre-pilot and the post-pilot survey instrument were designed to collect both the quantitative and the qualitative data. The open-ended questions of both surveys were designed with a seven-point Likert Scale (e.g., *Strongly Disagree, Disagree, Somewhat Disagree, Neither, Somewhat Agree, Agree, and Strongly Agree). These* seven-point Likert Scale were designed primarily to measure STEM career awareness, interest, and perceived competencies. The open-ended questions of both surveys were text-based. Table 5 presents the calculated Cronbach's alpha of each scale based on the following formula to measure internal consistency (coefficient of reliability). Researchers tested Likert-scale questions in both the pre-pilot and post-pilot surveys and found these scales highly reliable.

Table 5. *Coefficient of Reliability for Each Scale*

Research Construct/Variable/Scale	Pre-survey (alpha)	Post-survey (alpha)	Formula
Career Awareness (CA)	0.92	0.87	$\alpha = \frac{N \cdot \bar{c}}{\bar{v} + (N-1) \cdot \bar{c}}$ Where: • N = the number of items. • $\bar{c}$ = average covariance between item-pairs. • $\bar{v}$ = average variance.
Career Interest (CI)	0.88	0.91	
Perceived Career Competencies (PCC)	0.86	0.80	

Timeline & Protocols of the Online Data Collection

Both the online pre-pilot and the post-pilot surveys were hosted by Qualtrics. Quantitative and qualitative (mixed) data were collected via the pre-pilot and the post-pilot survey. Participants were administered with the pre-pilot survey one week before they attended the STEM+FA pilot program. Participants were administered with the post-pilot survey when they completed the STEM+FA pilot program. Quantitative data were derived from the closed-ended questions of both surveys. Qualitative data were derived from text-based comments by female attendees.

Assessment of Program Objectives

The STEM+FA pilot bridge program was strategically planned, implemented, and executed to bolster students' learning experiences. Female participants were engaged in hands-on activities, team collaboration, field trips, simulation, and professional interactions. Mixed data were analyzed to determine if three program objectives had been met. The purpose of the pre-pilot survey was to establish a baseline; whereas the post-pilot was to measure any increases in female student career awareness, interests, and perceived career competencies as a result of attending the STEM+FA pilot program. Researchers calculated and compare the differences (gain) in STEM-related career awareness, interest, and perceived competencies of female attendees. Table 6 summarizes that two out of three program objectives were met. Female participants agreed that they became more aware of career opportunities and felt more competent in their abilities to pursue STEM-related careers after attending the STEM+FA pilot program.

Table 6. Comparison of the Pre-pilot and Post-pilot Aggregated Results

Description of Program Objective	Post-Survey (out of 7)	Pre-Survey (out of 7)	% Difference (Gain)	Objective Achieved?
Program objective #1: Promote STEM Career Awareness	6.12	4.62	21%	Yes
Program objective #2: Promote STEM Career Interest	4.38	4.37	0%	No*
Program objective #3: Foster STEM Competencies	4.67	5.94	27%	Yes

* See the Discussion section for additional information

Research Component: Data Analyses for Three Research Questions & Research Hypothesis

Research Question #1: ***"****What are the differences in female career awareness of STEM+FA attendees and non-attendees?"* To determine how the STEM+FA pilot program affected female student career awareness, researchers compared the post results of the female attendees to those of the non-attendees. Non-attendees were those who applied for the pilot program but were randomly selected by a computer program to not attend the 2018 STEM+FA pilot program. The size of non-attendees was seventy-two but only seventeen completed the post-survey. Table 7 summarizes the differences in career awareness.

Table 7. *Comparison of the Career Awareness Means*

Career Awareness (Research Construct)	Attendees				Non-attendees	
	Pre- Mean (n = 24)	Pre- SD	Post- Mean (n = 21)	Post-SD	Mean (n = 17)	SD

1A. I am aware of career opportunities in STEM.	6.04	0.95	6.57	0.81	5.41	1.97
1B. I understand what STEM professionals do.	5.33	1.31	6.43	0.81	4.88	1.83
1C. I am aware of career opportunities specific to forensics analytics (FA).	4.67	1.17	6.19	1.12	4.59	2.12
1D. I understand what FA professionals do.	4.38	1.41	6.29	0.96	4.47	1.91
1E. I am aware of STEM+FA internships.	3.71	1.57	5.67	1.46	4.53	2.07
1F. I am aware of STEM+FA research opportunities.	3.58	1.61	5.57	1.33	4.65	2.15
Career Awareness Composite Score	**4.62**	**0.98**	**6.12**	**0.87**	**4.75**	**1.89**

Research Hypothesis (H) #1: "*Female career awareness increases as a result of their STEM+FA program attendance*", researchers used Stata software to perform an independent samples t-test. Table 8 outlines the statistical differences for each sub scale of the career awareness research construct. Statistical significances (at 95% confidence) evidence, that attendees became more aware of the career opportunities after attending the 2018 STEM+FA pilot program. Thus, the research hypothesis was accepted.

Table 8. *Differences in Career Awareness derived from the pre- and the post-survey*

Career Awareness	t	Df	*p-value*
1A. I am aware of career opportunities in STEM	-2.45	20	0.0119
1B. I understand what STEM professionals do.	-4.02	20	0.0003
1C. I am aware of career opportunities specific to forensics analytics (FA).	-5.00	20	0.0000
1D. I understand what FA professionals do.	-6.21	20	0.0000
1E. I am aware of STEM and FA internships.	-5.12	20	0.0000
1F. I am aware of STEM and FA research opportunities.	-5.75	20	0.0000
Career Interest Composite Score	-6.27	20	0.0000
p-value < 0.05			

Research Question #2: "*What are the differences in female career interests of STEM+FA attendees and non-attendees?*" To determine how the STEM+FA pilot program affected female student career interests, researchers compared the post results of the female attendees to those of non-attendees. Table 9 summarizes the differences in career interests.

Table 9. *Career Interests Means*

Career Interests (Research Construct)	Participants				Non-attendees	
	Pre- Mean (n = 24)	Pre- SD	Post- Mean (n = 21)	Post- SD	Mean (n = 15)	SD
2A. I am interested in pursuing a higher education degree in STEM.	5.83	1.05	5.81	1.29	5.53	1.81
2B. I am interested in pursuing a four-year college degree in forensics Analytics (FA).	4.00	1.53	3.76	1.95	4.47	2.17
2C. I am interested in pursuing a two-year degree.	3.46	1.56	3.48	1.75	4.27	1.83
2D. I am interested in attending a trade school to learn more about FA.	3.83	1.61	3.62	1.86	3.80	2.15
2E. I am interested in becoming professionally certified in computer-related subject matters (e.g. Microsoft's certification …)	3.88	1.68	4.14	1.46	4.07	1.91
2F. I am interested in pursuing a STEM career.	5.63	1.50	5.81	1.33	5.53	1.89
2G. I am interested in pursuing a FA career.	4.04	1.40	4.00	1.64	4.93	2.02
Career Interests Composite Score	4.38	1.07	4.37	1.12	4.66	1.59

Research Hypothesis #2: "*Female career interests increase as a result of their STEM+FA program attendance*." Researchers used Stata software to perform an independent samples t-test. Table 10 outlines the statistical values for each sub scale of the career interest research construct. There were no statistical significances to evidence any differences in career interests as a result of attending the STEM+FA program. Thus, the research hypothesis was rejected.

Table 10. *Differences in Career Interest derived from the pre- and the post-survey*

Career Interests	t	Df	*p-value*
2A. I am interested in pursuing a higher education degree in STEM.	-0.36	20	0.3622
2B. I am interested in pursuing a four-year college degree in computer forensics (CF).	0.55	20	0.7050
2C. I am interested in pursuing a two-year CF degree.	-0.48	20	0.3168
2D. I am interested in attending a trade school to learn more about CF.	0.28	20	0.6075
2E. I am interested in becoming professionally certified in computer-related subject matters (e.g. Microsoft's certification in computer programming, databases, or analytics).	-1.02	20	0.1595
2F. I am interested in pursuing a STEM career.	-1.02	20	0.5000
2G. I am interested in pursuing a CF career.	0.00	20	0.5000
Composite	-0.68	20	0.2529
p-value > 0.05			

Research Question #3: "What are the differences in female career competencies of STEM+FA attendees and non-attendees?" To determine how the STEM+FA pilot program affected female students' perceived career competencies, researchers compared the post results of the female attendees to those of non-attendees. Table11 summarizes the differences in their perceived career competencies.

Table 11. *Career Competencies Means*

	Participants				Non-attendees	
Career Competencies *I understand…*	**Pre- Mean (n = 24)**	**Pre- SD**	**Post- Mean (n = 21)**	**Post- SD**	**Mean (n = 12)**	**SD**
5A. Cybersecurity	5.00	1.72	6.05	0.92	5.50	1.51
5B. Forensic biometrics	3.38	1.72	5.86	1.28	4.33	1.56
5C. Computer databases	4.08	1.77	5.57	1.66	4.75	1.66
5D. Computer programming	4.17	1.97	5.62	1.72	4.92	1.44
5E. DNA	5.79	1.18	6.33	1.35	5.42	1.51
5F. Blood testing	5.42	1.44	6.62	0.50	5.17	1.47
5G. Information and communication (ICT) technology	4.46	1.62	5.62	1.40	4.92	1.17
5H. Media technology	5.00	1.25	5.86	1.31	5.08	1.31
Composite	4.67		5.94			

Research Hypothesis #3: "*Females' perceived career competencies increase as a result of attending the STEM+FA program."* To determine the effects of the STEM+FA pilot program on female student perceived career competencies, Table 12 outlines the statistical values for each sub scale of the Career Competencies research construct. Statistical significances (at 95% confidence) evidence, that female students self-reported higher Career Competencies as a result of attending the STEM+FA pilot program. Thus, the research hypothesis was accepted.

Table 12. *Career Competencies*

Career Competencies *I understand…*	**t**	**Df**	***p-value***
5A. Cybersecurity	-2.71	20	0.0067
5B. Forensic biometrics	-5.50	20	0.0000
5C. Computer databases	-3.03	20	0.0033
5D. Computer programming	-3.33	20	0.0017
5E. DNA	-2.03	20	0.0277
5F. Blood testing	-3.84	20	0.0005
5G. Information and communication technology (ICT)	-3.63	20	0.0008
5H. Media technology	-2.72	20	0.0066

p-value > 0.05

DISCUSSION

This section presents the reflection upon lessons learned. The STEM+FA pilot program achieved the first and the third program objectives to enhance the career awareness and career competencies of female attendees. The second program objective was not achieved since the means of career interests of female attendees did not change much from the pre-pilot to post-pilot survey. However, carefully considerations should be taken into account as some items might be viewed as mutually exclusive. For example, high interest in attending a trade school might be linked to low interest in pursuing a 4-year degree. In contrast, interest in two-year degree was highly and positively correlated with the plan to attend a trade school in the post-pilot responses. Thus, wording of these sub questions in the pre-pilot and post-pilot survey should be revised.

Further, the low or no increase in career interests could be contributed by other factors. Unfortunately, researchers were unable to perform a meaningful factor analysis due to the small sample size. Judging from the qualitative comments of female attendees, a thematic analysis was performed to reveal the following: First, many female attendees did not have any technical background in databases, SQL programming, and data mining. Second, there were too many activities to perform within a five-day commuter program. Third, only a handful of universities offer a degree in forensics analytics. The majority of universities offer analytics in their colleges of business, computer science, or engineering schools.

Limitations

For the research component, the researchers identified several factors that limit the generalization to a larger population. First, the timespan was cross sectional and the field test was limited to a short summer program. Second, the sample population was too small. Third, all participants were from the same state. Fourth, participants self-reported their career awareness, interests, and perceived confidence career competencies.

Recommendations for Future Study

Upon the completion of the pilot STEM+FA pilot, this NSF-funded program will adopt a triangulation research design with a mixed method and a longitudinal timespan over a three-year period. The sample size should be increased, as allowed by the funding. Participants will be from different schools. Additional instruments will be developed to assess soft skills (e.g. problem solving, computational thinking) and technical competencies instead of being self-reported by participants. An external evaluator will assess the program effectiveness by using instruments with established validity and proven reliability. A cycle of the STEM curricula design, R&D, implementation, research efficacy, and program calibration will be repeated yearly to ensure the delivery of a quality curricula and a value-added STEM+FA bridge program.

SIGNIFICANCE OF BROADER IMPACTS & CONTRIBUTIONS TO STEM EDUCATION

The STEM+FA curriculum implementation illustrated that the inclusion of the partnership model, strategic teaching andragogy, and innovative learning tools can enhance interdisciplinary knowledge and career competencies of female students. This pilot study is significant for several reasons. First, the simulation technology made it possible for female students to explore and learn. Traditionally, simulated gaming environments are often associated with male students due to the gender bias (Brown, 2010). Students were able to formulate the conceptual understanding of relational databases and the interdisciplinary knowledge of forensics analytics. Second, simulated learning environments with real-world applications provided adult learners with relevancy and context to solve modern-day problems through the lens of forensic analysis. Third, these automated tutorials provided female students with 24/7 access without location constraints. Further, these cloud-based tutorials helped students learn new software and tools more quickly so that they could focus on establishing data relationships.

Challenge & Conclusion

One challenge is for STEM educators to seek lasting partnerships and to collaborate with external stakeholders (e.g. advisory board, internship sponsors, and employers) to identify job trends and skill requirements; and to improve STEM education. This paper presented a roadmap for interdisciplinary researchers, innovative technologists, industry professionals, and government leaders to work together and shared resource, expertise, and technological infrastructure. Researchers presented strategic R&D processes to integrate a global GIU partnership model, real-world applications, sound theoretical frameworks, strategic andragogy, and cutting-edge technologies in order to create more value-added programs, engaging curricula, career-exploration strategies, and skill-building programs
It is hoped that the positive teaching and learning experiences derived from STEM+FA pilot program will encourage other STEM educators to consider as another way to broaden the STEM participation by female students in order to build a pipeline of skilled and equitable STEM graduates for the highly competitive workforce of today, and into the future.

REFERENCES

Allen, E., & Seaman, J. (2011). Going the distance: Online education in the united states, 2009. Available at http://www.onlinelearningsurvey.com/reports/goingthedistance.pdf

American Association of University Women. (n.d.). Available at http://www.aauw.org/what-wedo/ stem-education/NSF ITEST STELAR. (2015). Available at http://stelar.edc.org/

Basu, A. (2013). Executive edge: Five pillars of prescriptive analytics success. Available at http://analytics-magazine.org/executive-edge-five-pillars-of-prescriptive-analytics-success/

Bell, D. (2011). Learning from second life. *British Journal of Educational Technology*, *40*(3), 515-525.

Bresnick, J. (n.d.). What is the role of natural language processing in healthcare? Available at https://healthitanalytics.com/features/what-is-the-role-of-natural-language-processing-in-healthcare

Brown, J. (2010). New learning environments for the 21st century. Retrieved from http://www.nsf.gov/cgi-bin/good-bye?http://www.johnseelybrown.com/newlearning.pdf

Cheng, J. (2009a) Teaching business courses with innovative technology in the twenty-first century classroom, *Journal of Information Systems Technology & Planning, 2*(1), 66-78.

Cheng, J. (2009b). Cheng, J. (2009). The effects of virtual tutor on MBA hybrid classroom. *International Journal Education Research, 4*(1), 68-77.

Cheng, J. (2013). An interdisciplinary study of cyber security and forensic accounting. *Mustang Journal of Business and Ethics, 5*, 14-22.

Cheng, J. (2014). An quasi-experiment pilot study of teaching and learning with simulation in higher education. *Journal of Information Systems Technology and Planning, 7*(18), 1-27.

Cheng, J., Feng, R. (2016a). A just-in-time model for teaching & learning STEM in virtual classrooms. *Journal of Information Systems Technology and Planning, 8*(19), 83-94.

Cheng, J., Feng, R. (2016b). An evaluation of forensics bridge program for promoting STEM participation. *Journal of Research in Business Information Systems, 9*(9), 81-104. http://www.abis-fbd.org/wp-content/uploads/2016/09/2016JRBIS-1.pdf

Crellin, J., & Karatzpimo. S. (2010). Simulation in digital forensic education. Proceedings from the Higher Education Academy Annual Conference.

Dede, C., Honan, J, Peters, L. (2005). Scaling up success: Lessons learned from technology-based educational improvement. Jossey-Bass: New York.

Deloitte University Press. (2016). Global human capital trends. Retrieved from https://www2.deloitte.com/content/dam/Deloitte/global/Documents/HumanCapital/gx-dup-global-human-capital-trends-2016.pdf

Evans, J., & Lindner, C. (2012). Business analytics: The next frontier for decision sciences. Available at http://faculty.cbpp.uaa.alaska.edu/afef/business_analytics.htm

Fostering learning in the networked world. (n.d.). The cyberlearning opportunity and challenge. Available at www.NSF.gov

Good, J., Howland, K., & Thackray, L. (2008). Problem-based learning spanning real and virtual worlds: a case study in Second Life. ALT-J, *Research in Learning Technology, 16*(3), 163-172.

Grillo, M., & Hackett, A. (2015). What types of predictive analytics are being used in talent management organizations? Retrieved October 7,2018, from http://digitalcommons.ilr.cornell.edu/student/74/

Groff, J. (2013). Technology-rich innovative learning environments. Available at https://www.oecd.org/edu/ceri/Technology-Rich%20Innovative%20Learning%20Environments%20by%20Jennifer%20Groff.pdf

IBM. (n.d.). IBM predictive analytics. Available at https://www.predictiveanalyticstoday.com/ibm-predictive-analytics/

IBM. (2013). Descriptive, predictive, prescriptive: Transforming asset and facilities management with analytics. Retrieved October 7, 2018, from https://www-01.ibm.com/common/ssi/cgi-bin/ssialias?htmlfid=TIW14162USEN

IBM. (2016). Use of workforce analytics for competitive advantage. Retrieved October 7, 2018, from https://www.shrm.org/foundation/ourwork/initiatives/preparing-for-future-hr-trends/Documents/Workforce%20Analytics%20Report.pdf

Ji, S. W., Michaels, S., & Waterman, D. (2014). Print vs. electronic readings in college courses: Cost-efficiency and perceived learning. *The Internet and Higher Education, 21*, 17-24. doi:10.1016/j.iheduc.2013.10.004

Knowles, M. S. (1977). The modern practice of adult education: Andragogy versus pedagogy (eighth ed.). New York: Association Press.

Manlow, V., Friedman, H., Friedman, L. (2010). Inventing the future: Using social media to transform a university from a teaching organization to a learning organization. *Journal of Interactive Learning Research, 21*(1), 47-64.

McCreedy, D., Dierking, L. (2013). *Cascading Influences: Long-Term Impacts of Informal STEM Experiences for Girls*. Available at https://www.fi.edu/sites/default/files/cascading-influences.pdf

Millennials' weak skills threaten america's competitiveness. (2015). Available at https://www.ets.org/s/research/30079/asc-millennials-and-the-future.pdf

Mitchell, A., & Benyon, R. (2018). Teaching tip adding intercultural communication to an IS curriculum. *Journal of Information Systems Education, 29*(1), 1- 10.

Momin, W. Y. M., & Mishra, K. (2015). HR analytics as a strategic workforce planning. IJAR, *1*(4), 258-260.

Morales, Cory, & Bozell, D. (2001). A comparative efficiency study between a live lecture and a web-based live-switched multi-camera streaming video distance learning instructional unit. In Proceedings of the 2001 Information Resources Management Association International Conference, Toronto, Canada, 63-660.
National Girls Collaborative Project. (n.d.). Available at https://ngcproject.org/statistics
NSF. (2018). https://nsf.gov/
Office of the Under Secretary for Economic Affairs. (2018). https://www.commerce.gov/doc/office-under-secretary-economic-affairs#1/39/-77
Oklahoma's 2016 STEM report card. Available at https://www.usinnovation.org/state/pdf_cvd/ASTRASTEM-on-Hill-Oklahoma2016.pdf
PWC. (2018). https://www.pwc.com/gx/en/research-insights.html
Rising above the gathering storm: energizing and employing america for a brighter economic future. (2008). The National Academies Press, Washington, D.C. Retrieved on October 7, 2018, from http://www.nap.edu/html/11463/11463_revisions.pdf
Schiller, S. (2011). Practicing learner-centered teaching: Pedagogical design and assessment of a Second Life project. *Journal of Information Systems Education*, *20*(3), 369-381
Top 10 Trends. (2018). https://www.thejobnetwork.com/10-of-the-most-in-demand-jobs-for-2018/
US Bureau of Labor Statistics. (2015). Available at https://www.bls.gov/
US department of education awards grant for UCO transformative learning program https://www2.ed.gov/programs/nfdp/2016awards/npdapp0307.pdf
Waterhouse, S. (2005). The power of eLearning: The essential guide for teaching in the digital age. Boston: Pearson.
Williams, J. (2015). *The 5 Biases pushing women out of STEM*. Available at https://hbr.org/2015/03/the-5-biases-pushing-women-out-of-stem
Women in computer science: Getting involved in STEM. (n.d.). Available at http://www.computerscience.org/resources/women-in-computer-science/
Zhang, D. (2004). Virtual mentor and the lab system-toward building an interactive, personalized, and intelligent learning environment. *The Journal of Computer Information Systems, 44*(3), 35-43.

Appendix A: A STEM+FA Pilot Program Agenda (2018)

	Wednesday (8/1)	**Thursday (8/2)**	**Friday (8/3)**	**Saturday (8/4)**	**Sunday (8/5)**
8:30 AM	***Registration/Check in (Must be signed in by parent/guardian if student are under the age of***				
9:00 AM	SIM#1: 911; Career/R&D at FBI (Gene) in CB-113	OSBI Labs in Edmond (DNA CODIS)	Edmond Police (Randy Payne)	Forensics Science Institute (FSI, Lecture Hall) - by Dr. Creecy (1) DNA, (2) Guided Tour - Foresncis Science Institute, and (3) Blood Testing in Labs	Administer CSI Post-test (CB-107 & 109)
10:00 AM	Virtual reality by CeCE (CB-113)				Team presentations, digital story, refelctive journaling, & Academy graduation (CB-113)
11:00 AM	Dr. Mwongola: AI (CB-113)				
12:00 PM	**Buddy Cafeteria - See UCO Map; Bring meal card to avoid paying cash; Team briefing**				**Adjourn**
1:00 PM	Site Visit: OSBI HQ & Fusion Center (Terrorism)	(1) Crime Scene Investigation (To be announced); (2) Videos of Virtual Interviews (CB-113); (4) Simulation lab (CB-107 & CB-	(1) Digital Forensics (Dr. McCoy); (2) Finger prints (Porterfield); Simulated AFIS Database; (3) Forensics biometrics & cyber security	(1) CODIS (Dr. R. Williams, CB-113), (2) Database & analytics (Dr. T Williams, CB-107); Rotation for the following: (3) SQL - Programming (CB-107); (4) Virtual Interviews	
2:00 PM					
3:00 PM					
4:00 PM					