Student Retention in STEM Career Paths: Primary Influences on the Decision to Stay or Leave

Jennifer Winner
Air Force Research Laboratory
Wright Patterson Air Force Base, Dayton, OH
jennifer.winner.1@us.af.mil

Michael D. Coovert,
University of South Florida
Tampa, FL
coovert@usf.edu

LT Christopher Faxon
United States Air Force
Wright Patterson Air Force Base, Dayton, OH
christopher.faxon@us.af.mil

ABSTRACT

Extracurricular programs for science, technology, engineering and mathematics (STEM) content for middle and high school students are growing in number and are distributed utilizing in-class learning, after school clubs and activities and summer internship programs. It is often the case that anecdotal evidence of an internship program's effectiveness is plentiful but quantitative data to support this evidence is lacking. In this paper we discuss how the existing organizational turnover literature may be leveraged to explore student interest and retention in STEM career paths. This approach was inspired by the summer modeling and simulation (M&S) program conducted by the Air Force Research Laboratory's (AFRL) Gaming Research Integration for Learning Laboratory (GRILL™). We describe the basic features of the GRILL™ program and classify dimensions in behavioral change that have emerged over four years of the program. By interpreting these data through the theoretical framework of retention and turnover, specifically focused on organizational commitment, job satisfaction, fit, stress, and career intentions, we develop a more complete picture of factors associated with student entrance into STEM disciplines, continuance through educational and training programs, and entry into the STEM workforce.

ABOUT THE AUTHORS

Ms. Jennifer Winner is a research scientist with the Air Force Research Laboratory (AFRL) under the 711th Human Performance Wing's Human Effectiveness Directorate, Warfighter Readiness Research Division (711 HPW/RHA). She supports the AFRL's Gaming Research Integration for Learning Laboratory (GRILL™), leading the summer Science, Technology, Engineering, and Mathematics (STEM) program (2011 to present). She has led requirements development for game-based simulation and automated performance systems for use in military training environments. Ms. Winner received her M.S. in Applied Psychology from Arizona State University and her B.A. in Psychology from Wright State University.

Dr. Michael D. Coovert is a professor of industrial/organizational psychology at the University of South Florida. His research at the University of South Florida includes human-systems integration and the impact of technology on individuals and organizations. Dr. Coovert teaches graduate quantitative methods, has authored over 100 scientific publications, delivered 175 presentations, and has directed 40 funded projects. He is a fellow of American Psychological Society, Association for Psychological Science, and the Society for Industrial and Organizational Psychology.

LT Christopher Faxon is a program manager with the Air Force Research Laboratory (AFRL) under the 711th Human Performance Wing's Human Effectiveness Directorate, Warfighter Readiness Research Division (711 HPW/RHA). He supports the AFRL's Gaming Research Integration for Learning Laboratory (GRILL) where he serves as the GRILL's Program Lead for Live, Virtual, and Constructive Simulations. He has served as mentor for the GRILL's 2015 summer program, providing guidance to students and overseeing the various aspects of the STEM program. Lt Faxon received his B.S. in Business Administration and M.A. in Military History and Leadership from Columbia College.

Student Retention in STEM Career Paths: Primary Influences on the Decision to Stay or Leave

Jennifer Winner
Air Force Research Laboratory
Wright Patterson Air Force Base, Dayton, OH
jennifer.winner.1@us.af.mil

Michael D. Coovert,
University of South Florida
Tampa, FL
coovert@usf.edu

LT Christopher Faxon
United States Air Force
Wright Patterson Air Force Base, Dayton, OH
Christopher.faxon@us.af.mil

INTRODUCTION

Extracurricular programs for science, technology, engineering and mathematics (STEM) content for middle and high school students are growing in number and are distributed utilizing in-class learning, after school clubs and activities and summer internship programs. These programs have the potential to inspire students and complement the content students are already receiving in formal classroom settings (National Science Board, 2010). In the case of these programs, anecdotal evidence of the impact on students is often plentiful but quantitative data to support this evidence are lacking. Students' experiences and opportunities for growth and learning within an internship program often depend heavily on the focus of current projects within the team of mentors. As a result, there may not be a readily accessible set of objectives for evaluating and documenting the program's effectiveness, much less ones that will hold up over repeated occurrences of internship occurrences. This paper describes how concepts from the organizational turnover literature can be used to frame the problem of retaining students in the STEM career pipeline and presents a framework for interpreting the impact of summer programs, such as the one conducted at the Air Force Research Laboratory's (AFRL) Gaming Research Integration for Learning Laboratory™ (GRILL™). The ultimate goal of this work is to leverage the investment in the GRILL™ summer program to better understand the factors leading to the retention of students in STEM career pipeline.

GRILL™ STEM PROGRAM

The GRILL™, part of the 711th Human Performance Wing's Warfighter Readiness Research Division (AFRL, 711 HPW/RHA) located at Wright Patterson Air Force Base (WPAFB) in Dayton, Ohio, focuses on the integration of game-based technology in United States Air Force (USAF) training environments. The intent of leveraging these technologies is to find affordable capabilities to complement the training capabilities being researched in larger footprint, high-fidelity training systems. The use of modeling and simulation (M&S) is widespread across science and technology disciplines and undergraduate students entering STEM programs of study increasingly encounter the use of M&S in their coursework. A strong foundation of M&S skills is one way of equipping STEM students for success in their early years of study at a university. Since 2011, the GRILL™ has integrated game-based technologies in a full-time summer mentorship environment for high school juniors and seniors and college interns.

The GRILL™ program was initiated in response to a well-documented need to prepare and inspire the next generation of STEM graduates (e.g., Executive Office of the President, 2012; National Research Council, 2010; President's Council of Advisors on Science and Technology, 2010; United States Air Force Chief Scientist, 2010). A workforce comprised of "STEM personnel with the requisite skills to develop, operate, and sustain the high technological Air Force of the future" is a desired end state that is included in the Air Force STEM Workforce Strategy (p. 8, United States Air Force, 2014). A specific goal identified in the strategy is "outreach to increase the local STEM talent pool" (p. 11). The GRILL™ program is one of many such programs being supported by the Air Force Research Laboratory (Negron, DeRaad, Huggins, & Sciabica, 2011).

Students participating in the GRILL™ summer program are recruited from the Wright Scholar Program at WPAFB. During the program students learn to utilize 3D modeling and simulation tools while working in collaboration with the GRILL™ scientists and engineers on project-based applications of these technologies. Often, students have no prior experience with M&S or any of the game engines used during the summer program. Teachers who utilize the M&S technologies in their high school classrooms throughout the year provide input with regard to the activities that most high school students are ready to tackle. As a result, projects undertaken during the summer reflect the capabilities of the high school students and the complexity of the projects and the expectations for the summer students are refined each year. Summer activities are focused on introducing students to the M&S technologies being employed for training research and tools that would assist in the development of the problem-solving and other technical skills relevant to M&S and STEM career paths. We detail yearly summer program enrollment numbers in Table 1.

Table 1: GRILL™ STEM program enrollment by year.

Year	High School Students	Teachers	College Interns	Pre-service Teachers
2011	8	1	-	-
2012	13	7	2	-
2013	13	7	3	-
2014	10	7	8	2
2015	12	7	4	2

Throughout the summer program, high school students are able to successfully utilize the full tool range of M&S tools, from 3D modeling software (e.g., Sketchup, 3ds Max® and Blender) to game engines (e.g., Source, Unity, Unreal) to generate solutions to complex problems. They are able to produce quality 3D models, import them into game engines, and assign physics and modify other parameters enabling users to interact with the objects within a game environment. Furthermore, students are able to successfully incorporate hardware and software into their solutions. This allows them to address challenges using a mixture of both physical and virtual solutions. We illustrate examples of student-generated 3D models in Figures 1 and 2.

Figure 1. Student-generated simulation of an office workspace using photorealistic rendering.

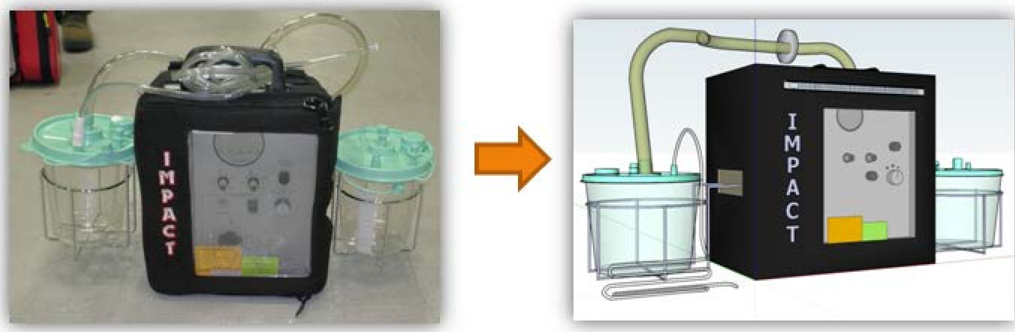

Figure 2. Student-generated model of medical suction pump created from photograph.

The focus of projects and the specific M&S tools differ each summer and across project teams as needs change and technology advances (Winner, Puckett, Folkerth, Malone, & Holt, 2014). There are some commonalities, however, that underlie the program each year, which is that students: 1) gain a foundational understanding of what M&S is and how it is utilized across disciplines, 2) gain hands-on experience with M&S tools, creating 3D models and importing them into game engines, 3) have the opportunity to interact with a customer to elicit requirements and present recommendations based on their work, 4) are provided opportunities to work in teams and practice their communication and presentation skills, and 5) assist in the development of challenge problems and tutorials for use by middle and high school teachers and students outside of the summer program.

CONSIDERATIONS FOR PROGRAM ASSESSMENT

The next step for the GRILL™ program is to identify measures to objectively assess the impact of the program in terms of any gains in retention of students in STEM career paths and to attempt to understand the factors that lead to these outcomes. If the measures we employ relate only to the M&S content, our efforts will not benefit the larger community of DoD-supported mentoring programs. Even within the M&S content domain, tools vary and, especially in the case of game engines, technologies are rapidly evolving. Accordingly, basing measures on specific tools or content would lack generalizability outside of the GRILL™ program and would rapidly become obsolete within our own program.

Recent efforts documented in the academic literature have resulted in a number of measurement tools focused on the interest of students in science and technology, such as the student interest in technology and science (SITS) survey (Romine, Sadler, Presley, Klosterman, 2014; Romine & Sadler, 2014), the students' attitudes toward and knowledge of technology questionnaire (Incantalupo, Treagust & Koul, 2014), and the educational and career interest scale (Oh, Jia, Lorentson, & LaBanca, 2014). Attitudinal and interest-focused surveys such as these are an incremental advance in terms of helping to compare instructional approaches and explore methods to both recruit students into and retain them in STEM career paths.

In addition to these emerging instruments, it is beneficial to reflect on the anecdotal outcomes noted over the first four years of the program to explore additional concepts that may be of particular interest for program assessment. The duration of the GRILL™ summer program (full-time for nine weeks) and the open lab setting allows for mentor-mentee collaboration and enables a variety of experiences and significant feedback for mentees. Individual stories of student success provide anecdotal evidence of the effectiveness and outcomes of the program, as observed by teachers and mentors (Winner et al., 2014). Utilizing a qualitative cluster classification, the following dimensions in behavioral change emerged: research skills, persistence, confidence with the use of technology, tolerance for uncertainty and improved overall engagement in the content. Both in our lab and in the high school classrooms in which the M&S content is taught, it is common that students are logging additional hours (i.e. *hours they are not required to work*), so much so that sometimes they must be "firmly encouraged" to leave so that staff can go home for the evening. Anecdotally, it appears students are engaged by both the game engine and 3D modeling technology and the real-world customers and applications, but more work is required to identify and capture data that is sufficient to objectively explain the factors leading students to voluntarily give of their free time to advance their projects.

Self-reports from graduating GRILL™ interns suggest that familiarity with M&S tools assist them in their early engineering coursework, especially in cases where they encounter 3D modeling software. In addition to the development of M&S skills, the GRILL™ program provides opportunities for students to make connections within the STEM and DoD workforce. Mentors introduce students to colleagues in the field, leading to direct transition of students from the GRILL™ program into DoD-related internships during their early undergraduate programs of study. Additionally, mentors support students as they apply and enter undergraduate and graduate programs of study. Students often reach out in the years following their participation in the summer program to request letters of recommendation for college admission and employment in STEM internships. These non-content types of mentor support may be particularly beneficial to students early in their STEM careers in terms of establishing roots within their career field of interest and may also contribute to the retention of students in their program of study.

Adding an assessment of the impact of the mentoring relationship to our qualitative cluster classification scheme (described above), we have a set of six dimensions to use for the systematic gathering of data as we proceed from class to class. The dimensions are: 1. Mentor impact, and changes in: 2. students' research skills, 3. persistence, 4. confidence with the use of technology, 5. tolerance for uncertainty and 6. overall engagement in the content. This framework is not only useful for our purposes but is also general enough to be applicable to other DoD agencies and schools wishing to assess STEM programs.

In addition to developing the structure described above, we are working on placing the retention of STEM students into a larger theoretical context. The reasons an individual enters and persists in a STEM area of education are likely many and varied and we believe a useful framework for considering STEM retention is to consider the broader context of retention and turnover. There is an expansive literature examining organizational turnover and we present highlights of it below.

RETENTION AND TURNOVER IN ORGANIZATIONS

A review of the turnover literature reveals six primary influences on the decision to stay or leave an organization: *organizational commitment, job satisfaction, fit, stress, culture, and career intentions*. We describe five of the areas and tie its relevance to STEM students. (Our references point the reader to a more in-depth discussion of the topic). While these are the major domains of research in influencing an individual to turnover, it is important to recognize these perceptions and attitudes are likely to be highly interactive and dynamic.

Organizational Commitment

Organizational commitment represents an individual's perceived attachment to the organization, and is frequently defined by two dimensions: affective and continuance. Affective commitment represents a positive emotional attachment to and identification with the organization (Allen & Meyer, 1990). Taken in the context of turnover, employees high on affective commitment tend to stay because they desire to stay. Continuance commitment represents the potential losses or opportunities associated with leaving the organization. It typically exhibits weaker relationships with turnover than affective commitment (George & Jones, 2002), and employees high on continuance commitment tend to remain in the organization out of perceived necessity. The correlation between affective and continuance commitment is typically negative (Meyer, Allen, & Smith, 1993; Meyer, Stanley, Herscovitch, & Topolnytsky, 2002).

For STEM students, affective commitment is a positive emotional attachment and identification with their STEM discipline (e.g., engineering, mathematics). Robnett, Chemers, and Zurbriggen (2015) reported this in a longitudinal study of STEM students engaged in scientific research and found that greater levels of research exposure early on led to higher levels of self-identity as a scientist two years later. Continuance commitment reflects the extent to which students continue to take classes in (and relevant to) their discipline, graduate with a degree and take a job in their chosen STEM field. Support for continuance commitment is seen in the work of Shedlosky-Shoemaker and Fautch (2015) who found that students who left the chemistry major had a greater desire to avoid failure. Perez, Cromley, and Kaplan (2015) found that students' belief about their competence and value in a STEM major is negatively related to perceptions of effort and time spent for the major.

Job Satisfaction

Job satisfaction is a job attitude that represents the contentment an individual experiences with his or her job. Turnover intentions and actual turnover are associated with job satisfaction (Allen, 2003; Gerhart, 1990; Levin, Mor, Barak, & Nissly, 2001; Lease, 1998; Mossholder, Settoon, & Henagan, 2005). Job satisfaction is also positively associated with organizational commitment (Heffner & Gade, 2003; Irving, Coleman, & Cooper, 1997), and person-organization fit (Boxx, Odom, Dunn, 1991). Specifically, Janega (2004) argued that job satisfaction indirectly influenced career intentions via organizational commitment. Weiss et al. (2003) agree that organizational commitment is likely to be more proximal to the decision to stay or leave, and that commitment is significantly influenced by satisfaction.

In the STEM education context, job satisfaction is satisfaction with one's coursework and projects. To the extent a student is satisfied with coursework in their major he or she would be less likely to change majors (turnover) and more likely to complete college coursework and graduate.

Fit

The extent to which an individual perceives that he or she fits with an organization is referred to as Person-Organization fit (P-O fit). P-O fit is related to turnover intentions (Chatman, 1991; Verquer et al, 2003), observed turnover (Chan, 1996; O'Reilly, Chatman, Caldwell, 1991), organizational commitment (Vancouver & Schmitt, 1991; Verquer, Beehr, & Wagner, 2003), and job satisfaction (Verquer et al., 2003; Kim, Price, Mueller, Watson, 1996). Personal values may be the most relevant factor in defining an individual's perceived fit with an organization (Finegan, 2000).

In the STEM context P-O fit would be exemplified by personal values a student has and the continuity of those values with the values of the profession (e.g., IEEE, ACM). This is supported by the work of Robnett et al. (2015) (described above) and that from Perez et al. (2015) who report from their research that STEM students engage in greater levels of professional identity development typified by seeking out information relative to their profession.

Similar relevant aspects of fit include Person-Group fit (P-G fit) and Person-Job fit (P-J fit). Person-Job fit, or P-J fit, demonstrates a relationship with organizational commitment, job satisfaction, and intention to quit (Kristof-Brown, Zimmerman, & Johnson,2005). Fit with one's work-group, or P-G fit, also exhibits positive associations with job satisfaction and organizational commitment (Addae & Wang, 2006; Kristof-Brown et al., 2005). Fit for STEM students would be similarly assessed for fit in one's job as a student. That is, the extent to which there is a match between a student and performance on projects and class assignments and their belief in those, there would be a match. Likewise, for STEM student work-group fit assessment, the extent one gets along with other STEM students and faculty there would be positive fit.

As noted by Weiss et al. (2003), it is important to reiterate the dynamic nature of these constructs (P-G, P-J, and P-O) across time. Discrepancies between personal and perceived organizational values may be largest during initial phases of tenure with organization, which suggests generally lower P-O fit. Overtime, the values of new employees may become more closely aligned with perceived organizational values (Burke, 1997; Marin & Gamba, 2003). Similarly, the longer a student is in a STEM concentration, the more likely their perceptions will align with those of the STEM profession leading to greater P-O fit. Ensuring success in gateway STEM courses is one strategy to help lengthen time in the STEM major. Yet the relationships are complex, as we know from Robnett et al. (2015) greater exposure to research leads to higher levels of self-identity as a scientist, but this relationship is mediated by self-efficacy.

Perceived Stress

Workplace stress involves the negative physical and emotional experience that occurs in response to poor fit between job demands and the abilities, resources, or needs of the worker. Perceived stress is associated with higher intent to turnover and lower organizational commitment (Kavanagh, 2005). There is evidence that stress is indirectly related to turnover via organizational commitment (Firth, Mellor, Moore & Loquet, 2004), and that perceived stressors might indirectly predict job satisfaction, morale and commitment (Addae & Wang, 2006; Mobley, 1982).

Dai and Cromley (2014) report on the importance of implicit beliefs impacting performance in STEM courses and early success in gateway course achievement being critical for retention in a STEM major. In STEM education, the goal is not to eliminate stress, rather it is to identify an optimal level of stress and ensure the threshold is not exceeded. Stressors are brought about in a variety of ways, including a poor fit between the demands of the STEM coursework and the knowledge and skills of the student. To the extent there is a lack of fit, excessive stress will develop resulting in students changing their self-efficacy toward performance in STEM coursework, ultimately resulting in them leaving the major (Shedlosky-Shoemaker & Fautch, 2015).

Career Intentions

Career- or turnover-intentions represent an employee's planned course of action regarding the current employment situation. Intentions are often indicative of, but not identical to, observed behavior. Rather they are interpreted as representing the motivated direction of the employee's behavior (Michael & Olmsted, 2002). Career intentions predict observed civilian attrition (Griffeth et al., 2000; Hom, Griffeth, & Sellaro, 1984; Mobley, 1982) Sager, Griffeth, & Hom, 1998; Vandenberghe, Bentein, & Stinglhamber, 2004) and military reenlistment (Chow & Polich, 1980). Career intentions coupled with organizational commitment are considered to offer a relatively reliable indication of future career decisions (Jaros, 1997).

For our STEM students, career intentions are similar to continuance commitment—the desire to continue taking courses in one's STEM discipline and to ultimately have a career in a STEM field. Various social-psychological factors are involved here as well. Interestingly, an individual difference related to a STEM education is an interest in science in general and having an aspiration for a science-related career (Xie, Fang, & Shauman, 2015).

In summary, there is large body of literature on why individuals stay or leave an organization. This literature provides a useful framework for examining why students enter and continue in a STEM field for their education.

ANALYSIS PLAN: NEXT STEPS

Each year, over 200 students apply to the Wright Scholar's program. The application solicits information about the student's academic achievement, involvement in extra circular activities, and leadership positions. From that pool we select 12-15 individuals we believe would be a good match for our STEM simulation and modeling program. Our program is intellectually challenging, demanding much from the student over the course of the summer. To date, all students who have entered the program have successfully completed it. This speaks well for the validity of our selection system.

Upon completing the Wright Scholar's program, students are tracked for several years. We will augment the current tracking system by asking students who are no longer in a STEM field to indicate why. Responses will be classified according to the organizational retention and turnover literature (described above, student left for reasons associated with: *organizational commitment, job satisfaction, fit, stress, and career intentions*).

As reviewed above, we believe there are important psychosocial variables related to retention of students in STEM collegiate education and later entry into STEM occupations. These constructs are those described earlier, especially *self-efficacy* regarding one's: *research skills, persistence, confidence with the use of technology, tolerance for uncertainty and overall engagement in the content*. We begin measuring these constructs starting with next summer's group of Wright Scholars.

Proximal and distal prediction of STEM engagement. We are interested in both short- and long-term prediction with the Wright Scholars. Short-term refers to a student entering a college or university and completing two years in a STEM major. Long-term engagement is a student completing an undergraduate degree in a STEM major and plans to enter a STEM graduate program. Many different predictor variables are available from the student's application (e.g., overall GPA, GPA in STEM courses, membership/leadership in STEM oriented clubs). Similarly we will have predictors available from the psychosocial scales (e.g., self-efficacy toward research skill, self-efficacy toward tolerance for uncertainty). Employing these different predictors, and having a dichotomous criterion (Proximal: completed two years of college in a STEM major; Distal: completion of a STEM degree, entrance in a STEM graduate program) we will develop regression equations and employ discriminant function analysis to identify those predictor variables that determine membership into the STEM/not-STEM groups.

It is important to uncover those factors that lead promising students out of STEM fields. We anticipate using Latent Class Analysis (LCA; c.f. Geiser, 2013; Goodman, 1974;) to place individuals into homogenous subgroups based on why they left STEM. LCA is a statistical method especially useful for analyzing relationships between class membership and external variables (here variables from the application and the psychosocial measures). This will be done for individuals in each of the five turnover groups (*organizational commitment, job satisfaction, fit, stress, and career intentions*) allowing us to develop a unique response profile for students who leave STEM in each group. Once identified, it may then be possible to develop interventions to keep talented individuals in a STEM field.

CONCLUSIONS

We plan to leverage the existing investment in the GRILL™ STEM program to research factors related to the retention of students in STEM career paths. We have developed a framework for interpreting the impact of summer programs on our students. By utilizing our six dimensional scheme along with newly developed questionnaires, we are evolving an approach for gathering data which will be useful not only our purposes but other STEM programs as well. By interpreting these data through the theoretical framework of retention and turnover, we develop a more complete picture of factors associated with student entrance into STEM disciplines, continuance through educational and training programs, and entry into the STEM workforce. The development and retention of STEM students is of utmost importance to the AFRL, DoD and the nation at large. Summer programs such as ours offer a stepping-stone for students into STEM concentrations. Once students enter into a discipline, it is essential we understand the factors associated with retention and progression through the educational pipeline and into STEM careers. The approach we have described will enable us to identify the factors that are critical for ensuring a sufficient workforce

ACKNOWLEDGEMENTS

The authors would like to acknowledge the support received from the following individuals and organizations: Dr. Winston "Wink" Bennett, Mr. Wayne Donaldson, Mrs. Debbie Miller, Mrs. Kim Puckett, the 711th Human Performance Wing's Warfighter Readiness Research Division, the GRILL™ Team, the Wright Scholar Research Assistant Program, and the Wright Brother's Institute. Dr. Coovert's contributions to this manuscript came while he held a National Research Council Associateship Award at the Air Force Research Laboratory. DISTRIBUTION A. Approved for public release: distribution unlimited (Case Number: 88ABW-2015-3275).

REFERENCES

Addae, H.M., & Wange, X. (2006). Stress at work: Linear and curvilinear effects of psychological, job, and organization related factors. *International Journal of Stress Management*, 13(4), 476.

Allen, N.J. (2003). Organizational commitment in the military: A discussion of theory and practice. *Military Psychology, 15*, 237-253.

Allen, N.J., & Meyer, J.P. (1990). The measurement and antecedents of affective, continuance and normative commitment to the organization. *Journal of Occupational Psychology*, 63, 1-18.

Boxx, R., Odom, R. Y., & Dunn, M. G. (1991). Organizational values and value congruency and their impact on satisfaction, commitment, and cohesion: An empirical examination within the public sector. *Public Personnel Management*,

Burke, R. (1997). Organizational tenure and cultural values: Does familiarity breed contempt? *Psychological Reports*, 81, 288-290.

Chan, D. (1996). Cognitive misfit of problem-solving style at work: A facet of person-organization fit. *Organizational Behavior and Human Decision Processes*, 68(3), 194-207.

Chatman, J.A. (1991). Matching people and organizations: Selection and socialization in public accounting firms. *Administrative Science Quarterly*, 36, 459-484.

Chow, W.K., & Polich, J.M. (1980). Models of the first-term reenlistment decision. Santa Monica, CA: RAND (R-2468-MRAL).

Dai, T., & Cromley, J.G. (2014) Changes in implicit theories of ability in biology and dropout from STEM majors: A latent growth curve approach. *Contemporary Educational Psychology, 39*, 233-247.

Executive Office of the President, National Science and Technology Council (2012). *Coordinating Federal Science, Technology, Engineering, and Mmathematics (STEM) Education Investments: Progress Report*, February 2012.

Finegan, J.E. (2000). The impact of personal and organizational values on organizational commitment. *Journal of Occupational and Organizational Psychology*, 73, 149-169.

Firth, L., Mellor, D. J., Moore, K. A., & Loquet, C. (2004). How can managers reduce employee intention to quit? *Journal of Managerial Psychology, 19*, 170-187.

Geiser, C. (2013). *Data analysis with Mplus*. New York: The Guilford Press.

George, J.M., & Jones, C.R. (2002). *Understanding and managing organizational behavior* (3rd ed). Upper Saddle River, NJ: Prentice Hall.

Gerhart, B. (1990). Voluntary turnover and alternative job opportunities. *Journal of Applied Psychology, 75*(5), 467-476.

Griffeth, R.W., Hom, P.W., & Gaertner, S. (2000). A meta-analysis of antecedents and correlates of employee turnover: Update, moderator tests, and research implications for the next millennium. *Journal of Management*, 26, 463-488.

Goodman, L.A. (1974). Exploratory latent structure analysis using both identifiable and unidentifiable models. *Biometrika, 61*, 215-231.

Heffner, T.S. & Gade, P.A. (2003). Commitment to nested collectives in Special Operations Forces. *Military Psychology*, *15*, 209-224.

Hom, P. W., Griffeth, R. W., & Sellaro, C. L. (1984). The validity of Mobley's (1977) model of employee turnover. *Organizational Behavior and Human Performance, 34*, 141-174.

Incantalupo, L., Treagust, D. F. & Koul, R. (2014). Measuring student attitude and knowledge in technology-rich biology classrooms. *Research in Science and Education,* Downloaded 10 June, 2015, DOI 10.1007/s10956-013-9453-9.

Irving, P. G., Coleman, D. F., & Cooper, C. L. (1997). Further assessments of a three-component model of occupational commitment: Generalizability and differences across occupations. *Journal of Applied Psychology, 82*(3), 444-452.

Janega, J.B. (2004). U.S. Navy Sailor retention: A Model of continuation intentions and behavior. University of Memphis, Memphis, TN.

Jaros, S. (1997). An assessment of Meyer and Allen's (1991) three-component model of organizational commitment and turnover intentions. *Journal of Vocational Behavior*, 51, 319-337.

Kavanagh, J. (2005). *Stress and performance: A review of the literature and its applicability to the military* (TR-192-RC). Santa Monica, CA: RAND.

Kim, S., Price, J.L., Mueller, C.W., & Watson, T.W. (1996). The determinants of career intent among physicians at a U.S Air Force hospital. *Human Relations*, 47, 947-976.

Kristof-Brown, A.L., Zimmerman, F.D., & Johnson, E.C. (2005). Consequences of an individual's fit a work: A meta-analysis of person-job, person-organizaiton, person-group and person-supervisor fit. *Personnel Psychology*, 57, 281.

Lease, S. H. (1998). Annual review, 1993 – 1997: Work attitudes and outcomes. *Journal of Vocational Behavior, 53*, 154-183.

Levin, A., Mor, Barak, M.E., & Nissly, J.A. (2001). Antecedents to retention and turnover among child welfare, social work, and other human service employees: What can we learn from past research? A review and meta-analysis. *Social Service Review*, 625-661.

Marin, G., & Gamba, R.J. (2003). Acculturation and changes in cultural values. In K.M. Chun, P.B. Organista, & G. Marin (Eds.), *Acculturation: Advances in theory, measurement and applied research* (pp. 83-93). Washington, DC: American Psychological Association.

Meyer, J., Allen, N., & Smith, C. (1993). Commitment to organizations and occupations: Extension of the test of a three-component conceptualization. *Journal of Applied Psychology*, 78, 538-551.

Meyer, J. P., Stanley, D. J., Herscovitch, L., & Topolnytsky, L. (2002). Affective, continuance, and normative commitment to the organization: A meta-analysis of antecedents, correlates, and consequences. *Journal of Vocational Behavior, 61*, 20-52.

Michael, P.G., & Olmsted, M.G. (2002). Affective organizational commitment, retention intent, and retention behavior: Investigation of a structural model. *Paper presented at the annual meeting of the Society for Industrial and Organizaitonal Psychology, Toronto, Canada.*

Mobley, W.H. (1982). *Employee turnover: Causes, consequences and control*. Reading, MA: Addison-Wesley Publishing Company.

Mossholder, K. W., Settoon, R. P., & Henagan, S. C. (2005). A relational perspective on turnover: Examining structural, attitudinal, and behavioral predictors. *Academy of Management Journal*, *48*(4), 607-618.

National Research Council (2010). Examination of the U.S. Air Force's Science, Technology, Engineering, and Mathematics (STEM) Workforce Needs in the Future and Its Strategy to Meet Those Needs.

National Science Board (2010) Preparing the next generation of STEM innovators: identifying and developing our nation's human capital. Retrieved 10 Jun 2015, from http://www.nsf.gov/nsb/publications/.

Negron, R., DeRaad, C. A., Huggins, M. T., & Sciabica, J. (2011). Air Force Research Laboratory Investments in Science, Technology, Engineering, and Math Education. *Astropolitics*, *9*(2-3), 193-212.

Oh, Y. J., Jia, Y., Lorentson, M. & LaBanca, F. (2014). Development of the educational and career interest scale in science, technology, and mathematics for high school students. *Research in Science and Education*, Downloaded 10 June, 2015, DOI 10.1007/s11166-012-9430-8.

O'Reilly, C.A., Chatman, J., & Caldwell, D.F. (1991). People and organizational culture: A profile comparison approach to assessing person-organization fit. *Academy of Management Journal*, 34, 487-516.

Perez, T., Cromley, J. G., & Kaplan, A. (2014). The role of identity development, values, and costs in college STEM retention. *Journal of Educational Psychology, 106(1),* 315-329.

President's Council of Advisors on Science and Technology (2010). Report to the President, Prepare and Inspire: K-12 Education in Science, Technology, Engineering, and Math (STEM) for America's Future, September 2010.

Robnett, R. D., Chemers, M.M., & Zurbriggen, E.L. (2015). Longitudinal associations among undergraduates' research experience, self-efficacy, and identity. *Journal of Research in Science Teaching*, Downloaded 9 June, 2015, DOI 10.1002/tea.21221.

Romine, W. & Sadler, T. D. (2014). Measuring changes in interest in science and technology at the college level in response to two instructional interventions. *Research in Science and Education,* Downloaded 10 June, 2015, DOI 10.1007/s11165-014-9452-8.

Romine, W., Sadler, T. D., Presley, M., & Klosterman, M. L. (2014). Student interest in technology and science (SITS) survey: development, validation, and use of a new instrument. *International Journal of Science and Mathematics Education*, *12*, 261-283.

Sager, J.K., Griffeth, R.W., & Hom, P.W. (1998). A comparison of structural models representing turnover cognitions. *Journal of Vocational Behavior*, 53, 254-273.

Shedlosky-Shoemaker, R., & Fautch, J. M. (2015). Who leaves, who stays? Psychological predictors of undergraduate chemistry student's persistence. *Journal of Chemical Education, 92*, 408-414.

United States Air Force (2014). *Bright Horizons 2.0, the Air Force STEM Workforce Strategy*. Washington D.C.: Department of Defense.

United States Air Force Chief Scientist (2010). Report on Technology Horizons: A Vision for Air Force Science & Technology during 2010-2030, vol. 1 (AF/ST-TR-10-01-PR), May 2010.

Vancouver, J.B., & Schmitt, N.W. (1991). An exploratory examination of person-organization fit: Organizational goal congruence. *Personnel Psychology*, 4, 333-353.

Vandenberghe, C., Bentein, K., & Stinglhamber, F. (2004). Affective commitment to the organization, supervisor and work group: Antecedents and outcomes. *Journal of Vocational Behavior*, 64, 47-71.

Verquer, M. L., Beehr, T. A., & Wagner, S. H. (2003). A meta-analysis of relationsbetween person-organization fit and work attitudes. *Journal of Vocational Behavior*,63, 473-489.

Xie, Y., Fang, M., & Shauman, K. (2015). STEM education. *Annual Review of Sociology, 41*, 19.1-19.27. doi: 10.1146/annurev-soc-071312-145659.

Weiss, H.M., MacDermid, S.M., Strauss, R., Kurek, K.E., Le, B., & Robbins, D. (2003). Retention in the armed forces: Past approaches and new research directions. *Military Family Research Institute, Purdue University*.

Winner, J., Puckett, K., Folkerth, L., Malone, A., Holt, J. (2014, December). Modeling and simulation challenge problems in high school classrooms and internships: Lessons learned. Paper presented at the Interservice/Industry Training, Simulation, and Education Conference, Orlando, FL.