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SOCIOTECHNICAL SYSTEMS APPROACH FOR DESIGNING EFFECTIVE PRE-COLLEGE STEM PROGRAMS FOR ADULT STUDENTS

by

IFEOMA EUCHARIA OKECHUKWU

DISSERTATION

Submitted to the Graduate School

of Wayne State University,

Detroit, Michigan

in partial fulfillment of the requirements

for the degree of

DOCTOR OF PHILOSOPHY

2020

MAJOR: INDUSTRIAL ENGINEERING

Approved by:

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Advisor Date

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DEDICATION

To My LORD AND SAVIOR, JESUS CHRIST, my source of inspiration and strength.

To Chukwudi Okechukwu, my son and my partner as my chief editor throughout my Ph.D. journey.

Thank you so much for your relentlessness in your support and selflessness.

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In my opinion, the GET program is an epitome of how customer orientation can be woven into the fibers of a program without compromising the quality. The business model of the GET program is very effective for busy adult students.
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CHAPTER 1: INTRODUCTION

There is an increasingly complex problem of untapped talent for the STEM workforce in the United States (Richey, 2014; Brown, 2012). This talent is largely underserved and underprepared for college (Bettinger and Long). In theory, individuals who graduate from high school should be properly prepared for college, but the reality is that many are not. For this reason, two- and four-year colleges in the U.S. offer remedial education services to over 40% of their freshmen to improve their skills in mathematics and writing (NCES, 2003). Some researchers have shown that fewer than half of these students ultimately complete this remedial education (Campbell, 2016; Bailey, 2008, 2010). Moreover, this is only counting the students admitted to college. Many underprepared high-school graduates do not even meet the standard for admission and must first be re-educated to reach the point where they can handle college courses (Bahr, 2010).

Underprepared students often attempt to return to college years later as adults with a heightened desire to earn college degrees and gain higher-paying employment. Over 50% of college students are 25 years of age and older; these are referred to in the literature as nontraditional students (National Center for Education Statistics, 2002). This category of adult students commonly includes workers who return to college after being unemployed due to fast-changing technology, as well as returning college dropouts (Berker, Horn, & Carroll, 2003). As Soydan observed, “Technological developments in the workplace in the United States have led to a demand for highly skilled laborers in the workforce. Hence, adult students return to college to earn four-year college degrees or obtain certifications in order to meet the demand for highly skilled positions” (Soydan, 2018, p. 1).
Nontraditional adult students (NTAS) frequently struggle to attend college and to persist in completing degrees (Bjordal, 2011). The fact is that most pre-college and college programs (PCSP) are designed with traditional students in mind, and nontraditional students are forced to adapt (Christensen, Johnson, & Horn, 2010; Weise & Christensen, 2014). Literature has revealed that nontraditional students’ pace to earn a degree is slower than traditional students placed into college-level courses (Bettinger and Long, 2005; Adelman, 2006; Bailey, 2009; Complete College America, 2012). The experiences, circumstances and attitudes of nontraditional adult learners are different from those of traditional students, yet colleges continue to feature “traditions and practices that prove ill-suited for adults” (Council for Adult and Experiential Learning, 2005 p. 1). In highlighting the complexity of the life of typical nontraditional students, La France (2008) stated that “the nontraditional learner is faced with numerous life dilemmas, world changes, feelings of inadequacy, difficulty with re-integration, and developmental crises” (p. 35) as they juggle school, employment and family (Day, Lovato, Tull, & Ross-Gordon, 2011; La France, 2008, p. 67).

There are few, if any, dedicated public policies to properly assist these struggling adult students. Some organizations have decided to fill this gap and offer pre-college education to re-educate and prepare students to successfully complete a STEM degree. An example of such an organization is the Detroit-based nonprofit Focus: HOPE, which in the early 1990s took part in establishing a college Engineering Technology degree program (Al-Holou et al., 1998) to increase access for members of disadvantaged communities into better-paid work in growing industries. Unfortunately, while these goals are laudable, programs of this nature have struggled to achieve sustainable improvement of adult student outcomes and have failed to develop proven mechanisms and tools for helping underprepared high-school graduates persist to earn a technical degree. The
Focus: HOPE degree program was suspended in 2011, and finally closed in 2017 (https://www.focushope.edu/).

This research proposes a sociotechnical systems (STS)-based approach to develop a model for the improvement of outcomes for nontraditional adult students in a pre-college or college STEM education service system. (See Figure 1 below for a model of a PCSP). A sociotechnical system approach is a well-known and extensively utilized organizational development technique that involves a dichotomous view of an organization as consisting of interdependent technical (all the non-human components) and social systems (the people), which must be improved in tandem for the optimum performance of the organization (Baxter & Sommerville, 2011; Carayon et al., 2015; Sittig & Singh, 2010). This approach aims at optimizing the relationship between the technical components and the work groups to ensure optimum product or service productions. For a STEM education program, the optimum service would be increased/optimum number of NTAS completing a STEM program. The social system of the STEM program is made up of the large stakeholder base the organization serves (Groff, 2009; Sussman, 2011) – the organization’s staff and the quality of their work life (Trist, 1975; Pasmore, 1988; Rosser, 2004), as well as the perceptions and interactions of students, their families and friends, individual and corporate donors, university partners, employers, management, and the community. The technical system includes the physical infrastructure (equipment) and learning technologies (virtual platforms)—computer machines and computer labs, online learning and management platforms, shop floor and the technical training equipment (where applicable), program supplies, program and organizational structure, climate, and the like. It also includes teaching tools and techniques, the program

---

1 Focus: HOPE suspends job training programs for lack of funding
Detroit-based organization says layoffs coming as well
Posted: 1:47 PM, November 22, 2011
https://www.clickondetroit.com/education/focus-hope-suspends-job-training-programs-for-lack-of-funding
curriculum, and official processes and procedures. From a sociotechnical systems perspective, a college or pre-college STEM program for NTAS is a complex open system (Christensen, Horn, & Johnson, 2008; Christensen et al., 2010; Rouse & Serban, 2011; Tracy & Lyons, 2013). This assessment is based on six factors:

1. The system has many components. These are required to adequately meet the needs of NTAS learners whose “world’s life is complex” (La France, 2008). The system requires multiple subsystems targeted at each critical need for the student to persist through to academic success. In addition to technical academic needs like customized curricula, remediation, and technical skill training for better-paying employment, this population’s non-academic needs also abound. These include employment and its proper coordination with school schedules and school projects, family responsibilities, socioeconomic issues and strategies to ensure non-disruption of education, components that may be dedicated to ensure that skills gaps are adequately filled, components that could ensure customized curriculum to address adult’s learning styles and so forth. The sub-goals that culminate in successful completion of a college STEM degree and the associated subsystems are many. See, for example, a possible model of a pre-college/college STEM program for nontraditional adult learners in figures 1a and 1b in appendix A.

2. The system has a large stakeholder base. This includes the staff at the organization level, program level management, faculty, vendors, and other clients. Externally, this includes the students, their family members, their friends, employers, philanthropists, industry and university partners, pipeline schools (High Schools), local and state government, government agencies, alumni groups, and the community.
Note: The Model above was designed based on literature and the rich experience (over 20 years working with NTAS learners) of the researcher. The components of the PCSP process flow above can be adapted based on the unique characteristics of the NTAS learners in a given program. For example, a nursing program could call for some medical education component that may not be relevant for students pursuing engineering degree. Moreover, the differentiation can be made with the customized curriculum and the associated technology, and the curriculum if adequately designed could be easily adaptable to varying course contents (Goldman, 2017).

3. The system has non-linear interactions. The performance of the system is affected by complex interactions between faculty and students, staff and students, management and students, students and students, the program’s partners and students, and various stakeholder groups and the complex world’s life characteristic of NTAS learners.

4. The system is open to the external environment. The students originate from the external environment, as do many of the components that influence the students’ performance within the system (Moeller, 2010). The funding, public policies, rules and regulations that
influence the administration of the system belong to the external environment. The program receives all program resources from outside the boundaries of the program and supplies the external environments with its product (educated graduates). As has been observed by many researchers of adult students, this population, in addition to having limited social integration on college campuses, is mostly affected by an external environment wherein they enjoy their own social integrations and are influenced by them (Bean & Metzner, 1985; M. J. Bergman, 2012).

5. The financially independent adult learner is complex, and each class has unique characteristics and needs. As a result, the program’s dynamics are unpredictable, and the program’s systems must be adaptable to new demands from external environments. Additionally, many of the NTAS learners’ characteristics, which are strongly interrelated and sometimes interdependent, require multi-dimensional systematized solutions. For example, delayed enrolment to college could lead to full-time employment and financial independence (M. J. Bergman, 2012). Any further delay or dropout from college can also be associated with having young dependent children and increased adult responsibilities, which engender part-time enrolment in and stop-out from college for many NTAS learners. Additionally, a tuition assistance impact could be neutralized because the students does not earn enough for childcare. This suggests that the support services need to be holistic to optimize impact.

6. The system is extremely sensitive to the demands of the external environment (Bean & Metzner, 1985). Although adult learners are motivated to learn for the most part, their emotional and social world can be very unstable and disruptive to their intent to learn (La France, 2008). Unexpected events such as loss of employment, a sick family member,
relationship issues, and so forth. can throw an adult learner out of focus (M. J. Bergman, 2012; Ikegulu, Barham, Farmer, & Roberson, 1999)

Thus, a program that can effectively assist a NTAS to successfully complete degree requirement on time need to be holistic.

Sociotechnical theory is grounded in the principle that a focus on improving only the social or only the technical system alone will hurt the effectiveness of the organization—they must be improved together. The joint optimization of both the social and technical systems of an organization to improve performance has been well-understood in the business and manufacturing world for decades (Baxter & Sommerville, 2011; Carayon et al., 2015; Clegg, 2000; W. Pasmore, Winby, Mohrman, & Vanasse, 2019; W. A. Pasmore, 1988; W. A. Pasmore & Sherwood, 1978a, 1978b; Richey et al., 2014; Trist, 1981) Industry practitioners recognize that improving human interactions in an organization is not very effective if the processes and tools remain inefficient and outdated (Pasmore, 2015). Likewise, striving for highly optimized processes is ineffective if the improvement effort lacks buy-in from management and positive engagement of staff and customers. The social and technical systems of the organization must be optimized in tandem to meaningfully and sustainably improve performance. Traditional education reform research fails to address the interconnectedness and interdependency of the social and technical systems of an education service (Aslan & Reigeluth, 2015; Assidmi, 2015; Banathy, 1993, 2013; Fullan, 2002, 2005, 2009; Khan, 2017; Reigeluth, 1993, 2004; Reigeluth et al., 2015; Weise & Christensen, 2014). A design model grounded in STS principles, on the other hand, will address the optimization of rules, processes, and technology in the education service, the human interactions and perceptions of the staff and students, as well as how these facets of the service work together to improve student’s experience and outcomes.
Although STS design is commonly applied in manufacturing contexts, sociotechnical systems literature commonly refers to services as a possible future area of application of the concept (Pasmore 1988, Travis 1975; Baxter, 2011; Pasmore, 2019). One example study relating to education services is an article by Richey and his colleagues present one example of a study relating to educational services, which proposed a complex sociotechnical systems approach for the reformation of the U.S. educational system and workforce. The authors believe that this approach would offer a holistic perspective that would enable reformers to identify the challenges associated with the preparedness and persistence of STEM students (Richey et al., 2014). Another more recent example is Law, Liang, & Cheng (2017) who used the STS approach to study scaling the development of a collaborative platform for a network of schools for special needs students in Hong Kong. An earlier application of STS principles in educational systems was by Telem (1996) who designed a STS based implementation framework “School Management Information Systems (SMIS)” (p.85) for information technology diffusion in grade schools. None of these studies were aimed at NTAS learners’ college education process.

**Problem Definition: Sociotechnical Systems Gap in Education**

Over many decades of reform efforts to fix the known issues of education service systems, the education community has arrived at many varied solutions. There has certainly been some improvement in specific components of education services, but most of these improvements are not universal and are hardly commensurate with the effort and cost. The solutions have ranged from narrowly-focused, piecemeal efforts to change components of the technical and social subsystems, to more holistic systemic transformation (Banathy, 1993, 2013; Churchman, 1996; Groff, 2009; J. S. Groff, 2013; Joseph & Reigeluth, 2010; Kahn & Reigeluth, 1993; Lopez Zelaya & Barrios Mena, 2013; Martone, 2015; Mital, 2015; Mital, Moore, & Llewellyn, 2014; Mourshed, Farrell, & Barton, 2013; Reigeluth, 1993; Reigeluth et al., 2015; St Clair, 2018; Weise &
Christensen, 2014). An example of an incremental improvement would be the No Child Left Behind policy of President Bush in 2002, which disappointed in its actual impact on student performance. Many reasons were proposed for why it did not work (Mital, 2015), but the reasons cited do not usually include the faulty assumption that the proposed changes aligned with the social dynamics of the administrators and staff tasked with implementing them (Ackerman, 2000). This type of assumption is characteristic of the sociotechnical gap that plagues many isolated and piecemeal changes in education that did not consider the possible negative resultant effects of such changes on the other components of the entire system.

Ackerman (2000) defined the sociotechnical gap as the “divide between what we know we must support socially, and what we can support technically” (p. 179). Physical machines and software can be limiting, and equally limiting are some human-based technologies, which can be prohibitive from a cost, space, time overall logistics standpoint. However, the divide Ackerman is referring to in his definition has more to do with the assumed equality in flexibility, nuances, and context of both the new or improved technology itself and the human responses and activities surrounding it. In other words, proposals in education about some needed “pedagogical or andragogical” or “service delivery methodological” improvement, for example, if not based on participatory decision process that includes employees tasked with implementing the changes is bound to produce less than optimum outcome. It is not surprising that among the stakeholders of academic service provisions, instructors have been perceived to be the most reluctant to embrace innovations in technology for face-to-face classrooms and for online course delivery (Kolowich, 2013, Young, 2010; Allen & Seaman, 2013; Premaux, 2008; Gena McNair-Crews 2015). Literature abounds about the needs of adult learners and the many roles they play while pursuing college degrees (Markle, 2015). According to Markel, the NTAS often suffer from “role strain,” which she described as the challenges that come with multiple roles that are accompanied many
times with conflicting objectives, conflicting timing and conflicting space for their accomplishment. This, in itself, is complex. Some of their characteristics include full-time employment, part-time enrolment, and limited time to juggle adult responsibilities, work and school, yet, many are forced into educational business models that are built for traditional-aged students (MacDonald, 2018; Park & Choi, 2009; Radford, Cominole, & Skomsvold, 2015; Remenick, 2019; Sogunro, 2014). Institutions of Higher Education (IHE), desire improved degree completion rates for this population, but technically, many of them have not been able to design models that fit their goals. Literature abounds with what must be supported socially for better degree completion outcomes for NTAS, but the support seemed technically prohibitive. This is a sociotechnical gap. Sociotechnical gaps could vary from one set of technological innovations to another; vary across context as do the social requirements. However, for better outcomes, these gaps must be understood and strategies designed to greatly mitigate their effects. A sociotechnical systems design approach, which is proposed in this study, is a problem-solving technique that uniquely targets sociotechnical issues and help create shared understanding about holistic change strategies the lack of which engender the socio-technical gap. A mixed method approach used in this study would grant access to the perspectives of the directors, faculty members, students and their family members about the educational experiences of the NTAS in three case programs, so we can learn how best to bridge the sociotechnical gaps. Additionally, the mixed-methods would help determine the relative importance of identified factors that enable better degree completion rate for adult learners.

**Research Goals**

The goal of this research will be to identify and rank social and technical factors that enhance the effectiveness of a STEM program for NTAS learners, and then develop a framework for designing an effective STEM program for these students. Although the scope for this study is
pre-college STEM programs for adult learners, it is hoped that the principles and techniques uncovered in this study could be applied to education service design in general. The findings will contribute useful information for practitioners seeking to increase the degree completion rate of NTAS learners. Additionally, it will increase understanding of how known adult education theory can be applied more effectively in improving outcomes for adult learners. The motivation that inspired this study and an extensive literature review follows below.

**Scope: STEM Programs**

Two factors motivated the study of NTAS pursuing STEM degrees. The first is the prevalence of underserved minorities in the pre-college STEM programs in this study. There is a national shortage of graduates in STEM fields (Hall, Dickerson, Batts, Kauffmann, & Bosse, 2011), less diversity in the STEM workforce in the USA (Tsui, 2007), and the efforts to bridge the gap with the increase of STEM field employment opportunities have yet to significantly improve (CPST, 2007; Lowell & Regets, 2006; Washington Center on Education and the Workforce, Georgetown University, 2010). The college strategy of “pre-college summer bridge programs or transitional programs” for low-income and minority students” is, according to Ackerman (1991), "an established part of the effort to recruit, retain, and graduate a population of students underrepresented in higher education." (Ackermann, 1991, p. 201). These programs have included STEM program recruiting as a major part of their goal. However, most of these efforts are focused on the recruitment of traditional students. Tsui (2007) observed that “supplemental instruction through pre-freshman bridge can effectively narrow a preparation gap that is often caused by

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2 Bridge programs are a cohort-style series of courses, activities, and learning experiences intended to help students “make a smooth transition from high school to college.” In some cases, bridge programs “support students transitioning from one postsecondary institution to another. Some common goals of Bridge programs include enhancing students’ academic skills, orienting students to campus life and culture, helping students develop goals, and developing academic and social networks.” Bridge programs are often residential, and typically take place during the summer before the freshman year.
attendance of impoverished schools with inadequate instruction, poor facilities and equipment, and few positive role models,” (p.557). This could, in turn, increase the enrolment of minorities in STEM fields, who, according to Wilson (2000), tend to be less prepared for rigorous academic programs. One of the cases in this study had about 40% African-American enrolment, the second had over 90%, while the third had 100% African-American graduates. The third case, the Case # 3, has also graduated a significant percentage of minorities.

The second reason for selecting NTAS learners pursing STEM degrees is scope. Because the needs of NTAS learners in college are not necessarily significantly different between STEM and non-STEM disciplines, any factors that could influence their success may also enhance the success of NTAS learners in non-STEM program as well.

Motivation

"A college degree is the surest ticket to the middle class,"

President Obama (2014)

“‘We cannot always build the future for our youth. But we can build our youth for the future.’”

– Franklin Delano Roosevelt (1940)

Drawing from the wisdom of Presidents Obama and Roosevelt, when we fail to build our youth for the future, then we must re-educate them as adults to earn the ticket to, at least, the middle class.

Wage, workforce, and welfare gaps in the U.S. continue to widen between those with a Bachelor’s degree compared to those with a two-year college or a high school credential (Pew Research Center, 2014). Future employment projections through 2020 indicate, furthermore, that the share of all jobs requiring a high school diploma or less will shrink from 41% to 36%, grow for some college or 2-year degrees from 27% to 30%, and grow for bachelor’s degrees and beyond from 32% to 35% (Georgetown University Center on Education and the Workforce, 2013). The
evidence and projections cited above, along with student college aspirations surveys of all groups along race, ethnicity, and socioeconomic levels overwhelmingly favor a Bachelor’s degree as the new baseline for economic security and well-being (College Board, 2013; ACT, 2013).

Thus, free education to improve the earning power of an individual is an investment that has both social and financial benefits for the individual as well as society. The benefits to society include increased earning power for individuals and reduced reliance on government assistance programs. The main reason that was indicated by the students in this study for returning to pursue a Bachelor’s degree in a STEM field was economic independence. Most of those who were receiving government assistance expressed a desire to end their reliance on it as soon as they could, especially for self-dignity.

Nationally, only 37% of all high school students who took the ACT were considered college ready in all four subjects tested, and in Detroit that number is about 3.9%. Only 19% of the adult population in Detroit have earned an associate degree or higher, and 39.3% of the population live at or below the poverty line in 2014. It is clear that innovative solutions are necessary to effectively address these problems and increase the earning power of Detroiter, and other urban cities’ residents as well. The need to establish an effective pre-college STEM a socioeconomic service in Detroit and similar communities across the U.S. cannot be overemphasized.

**Research Development and Data Collection**

Figure 2 below shows a graphic representation of the steps taken in the development of the present research and data collection. Chapter 2 is the quantitative study and Chapter 3 is the quantitative methodology that followed after. Chapters 4 and 5 have the discussion and recommendations for practitioners and researchers, the transfer of the STS concept, and
philosophy and principles in the design the design of educational service calls for ensuring its applicability.

Sociotechnical systems (STS) theory is applicable to organizations that produce either products or services (Pasmore, 1988, 2019). To ascertain its applicability to an education program like the PCSP, this literature review was organized to rationalize characterizing a pre-college/college STEM program (PCSP) for nontraditional adult students (NTAS) as such an organization. We posit that a PCSP for NTAS leaners is an open service system with its associated interrelated, interdependent and interacting social and technical subsystems as they interact with the external environment in which they are embedded, or in the context of the external environment in which they are embedded. The relevance of characterizing an educational service like the PCSP as a service is to ensure, to a large extent, the relevance of STS theory’s principles and assumptions in a sector where there has been little to no operational level application of the STS design approach. A PCSP is an educational service organization, and an open sociotechnical system whose effectiveness is dependent upon many dynamic components. In this review, we discuss service, service systems, service systems design and educational services to enable the characterization of a PCSP as a viable educational service for the use of a STS-based approach. Next, is the presentation of the definition of a nontraditional adult student as used in this study.

Who is a Nontraditional Student in College?

The term nontraditional student is defined in different education literature slightly differently depending on the purpose of the study (Levin, 2007). Some categories are based on age - college students who are 21 or older (Kenner & Weinerman, 2011), 22 years and older (La France, 2008), 25 years and older with a certain educational background and mode of study (Kenner &
Kenner & Weinerman, (2011) referencing Horn and Carroll (1996) ranked the students from minimally nontraditional to highly nontraditional based on how many of seven characteristics a student has. The characteristics are financial independence, being 25 years or older, full-time employment, dependents other than a spouse,
delayed enrolment or part-time enrolment, single parenthood, and lack of a high school diploma (Bjordal, 2011; Kenner & Weinerman, 2011; Mullen, 2016). Collis & Reed, (2016) included first generation students and students with disabilities in their definition of nontraditional student. Choy (2002) defined a nontraditional student more broadly as anyone who

- has financially independence,
- delayed enrolment,
- is employed full-time
- is enrolled part-time enrolment
- has dependents
- is a single parent,
- or has a GED as an alternative to high school diploma.

This broad definition of a nontraditional student by Choy (2002) suggests the possibility of non-adult college and university students who are nontraditional. Levin (2007) included differentiation between the “haves and have-not” as categories of privileges, emphasizing those with “hardship of life woven into their personal accounts of educational experiences.” (p.5). For the purposes of this study, a non-traditional student:

- is an adult college student (Levin, 2007)
- is enrolled only part-time
- is employed full time,
- has many adult responsibilities, and
- wants a two-year or four-year college degree.

These are who we refer to as “NTAS”, meaning Non-Traditional Adult Student, as opposed to simply Non-Traditional Student, which is prevalent in adult education literature.
La France (2008) gave a perspective based on the psychosociological challenges peculiar to these students, such as the students’ academic efficacy, multiple adult responsibilities, diverse challenges, family and personal illness, levels of stress, time constraints, sleep patterns, relationships, support systems, and cognitive ability. Thus, nontraditional students should be viewed more holistically in terms of the issues that define their “life’s world” (La France, 2008). Although Mullen (2016) found that a postsecondary student’s risk of dropping out is positively correlated with the degree of the nontraditional status of the student (Levin 2007), designing a program with the highly nontraditional students in mind would help and not hurt those who are minimally nontraditional. This is because as Mullen found, “minimally, moderately, and highly nontraditional students did not differ significantly on administration, advising, peers, multiple roles, and faculty mattering.” (Mullen, 2016, p. vi). Bjordal, (2011) similarly found that there was no significant difference in the students’ need for adequate service despite the variety in characteristics and life experiences.

Many of the reasons pundits found that pressured traditional students to become nontraditional (Kenner & Weinerman, 2011) seem to underscore the characteristics of NTAS. These include lack of financial resources for college, full-time employment, and lack of critical and analytical thinking skills needed for collegiate course work. Kenner & Weinerman claimed that after either failing to enroll in college immediately following high school or dropping out of college soon after they enroll, these students get employed, but the “non-college graduates’ employment experience does not provide them with the critical thinking skills and particular analytical ability that would be required in the collegiate environment.” (Kenner & Weinerman, 2011, p. 87). Thus, the NTAS return to school underprepared for college-level course work. They are usually underprepared for college level coursework as well as for any highly technical employment because they have not received skill training in post-secondary school. They also
bring with them various learning styles and experiences from employment and life. Because employment requires self-directedness and a willingness to learn by doing, the NTAS has been observed to be more self-directed and self-regulated than traditional students (M. J. Bergman, 2012; Knowles, 1974). The NTAS also bring the experience of the culture of teamwork, and therefore expect a greater opportunity for cooperation between themselves and faculty (Zmeyov, 1998). They have increased expectations for accommodation for missing deadlines (Kenner & Weinerman, 2011). Knowles (1984) suggested that NTAS are usually goal and task oriented and are more intrinsically motivated to learn, based on lessons learned from organizational development. NTS “often feel less prepared for higher education.” (Collis & Reed, 2016, p. 2)

*Is a Pre-College STEM Program (PCSP) for Nontraditional Students a Service?*

The word service is used extensively across a wide range of academic disciplines (Operations Management, Service Science, Service Management, Grid computing, Information Technologies, etc.) with a wide range of meanings to represent a wide range of processes, experiences, opportunities, and pre-requisites (Aurich, Mannweiler, & Schweitzer, 2010; Lovelock & Gummesson, 2004; Sampson & Froehle, 2006; Vargo & Lusch, 2004, 2008). Kotler et.al. (2006) defined a service as “any act or performance that one party can offer to another that is essentially intangible and does not result in the ownership of anything”3 (Kotler & Keller, p. 365). Kotler’s definition excludes services like software delivered in CDs or MP3 format that may be permanently owned by the customer after the purchase. Harvey defines a service simply as "a result that customers want" (Harvey, 1998, p. 1). Lyons and Tract (2013) defined service as “the application of competence and knowledge to create value,” (p. 1) and they agree with other researchers that value is realized through interactions and co-creation within service systems. This

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3 [DOC]Chapter 13: Designing and Managing Services LEARNING ...
ebc.ie.nthu.edu.tw/StudentProject/NTUTProject/Projects/.../kotler13_im.doc
definition captures what happens between educational institutions and their primary customers, the students (Moeller, 2010).

Services are inherently different from goods in multiple ways. The central characteristics of services (Shostack, 1977, 1984) that can influence the design of a service system are Intangibility, Heterogeneity, Inseparability, and Perishability - IHIP (Abdullah, 2006; Fonseca & Pinto, 2014; Parasuraman, Zeithaml, & Berry, 1985; Sampson & Froehle, 2006; Zeithaml, Parasuraman, & Berry, 1985). According to (Parasuraman et al., 1985), the intangibility, heterogeneity, inseparability and perishability characteristics of services must be understood before the quality of a service can be ascertained. Moeller (2010) revealed how the four characteristics of services, IHIP, apply to different aspects of services. Intangibility describes the service offering, heterogeneity and inseparability apply to customer resources, and perishability applies to the facilities of the provider (Moeller, 2010, p. 359). Many service researchers agree with the contextualized characteristics of services. Lovelock (1992) stated that “although services often include tangible actions [...] the service’s performance itself is basically an intangible.” (p.6) The increasing body of literature on services has continued to expand our understanding of how these characteristics apply to different services, and the differing aspects of the same service in the service industry.

Intangibility means that customers do not own any tangible possession from a service process. Most services involve the performance of actions rather than receiving of a physical object—but customers can still classify the service received as good or bad (Bigaeva, 2015). In an educational service, students walk away with intangible value in the form of acquired knowledge, and they can categorize their interactions with instructors and administrators as good, bad or indifferent. Hill (1977) agrees that the transformation of customer resources is what constitutes the core of the service provision process. For education, the process of educating a student is
intangible, and is separate from the teacher or the teaching material (Hill, 1977; Moeller, 2010). The intangibility of services is important since, very often, “this transformation is the reason for the consumption of the service” (Moeller, 2010, p. 362). Also, although Moeller argued that the intangibility of resource transformation is not necessarily unique to services, in a service the customer’s resources, and not the provider’s resources, are processed and transformed. This means that for services like education, the service offerings are dependent on customer resources for completing individualized service.

Heterogeneity refers to the variability of service types, customers, demands and outcomes. This is true of all the sectors in the educational services industry. The primary customers, the students, are diverse in age, learning style, learning ability, ethnicity, gender, socioeconomic status, culture, etc. The heterogeneity inherent in the composition of the student body of an educational organization has engendered some criticism against the idea of designing and delivering educational services through one-size-fits-all model (Carmody, 2009; Christensen et al., 2008; Christensen, Horn, & Staker, 2013; Christensen et al., 2010; Weise & Christensen, 2014). Heterogeneity in services correlates with the high amount of human interaction inherent in most services and human performance (Moeller, 2010; Vargo & Lusch, 2008). “This is a particular problem for services with a high labor content, as the service performance is delivered by different people and the performance of people can vary from day to day” (Wolak, Kalafatis, & Harris, 1998, p. 26), as well as from person to person.

Though variability also exists for goods, there is little to no variability in a provider’s resources that are transformed into products. However, in services like education, the variability in the customer’s resources abound. Within the K-12 education system, where age is the predominate basis for classification, variations in behavior, learning style, intelligence, and rate of learning are mostly ignored (Christensen et al., 2008; Christensen et al., 2013; Christensen et al.,
The case is even worse at the college level, where the main classification is based on prerequisite courses and prior knowledge, which is highly variable from student to student. Colleges admit high school graduates from different schools, different states, and different countries with different K-12 school experiences and quality of education service offerings. However, the course delivery systems of most colleges are a “monolithic batch system” (Christensen et al., 2008, p. 1) operating under the assumption that all high school graduates who met the minimum admission requirements for a particular program have same intelligence, learning style, learning rate, etc.

Inseparability refers to how service products are typically produced and consumed at the same time—consumption cannot be separated from production. This feature is true of instruction: whether real-time in a face-to-face setting, or digital and remotely accessed, the students must be present to consume the service. One of the challenges of this feature of services is capacity management, which becomes increasingly more complex when “human beings serve as resources to be transformed, as opposed to objects” (Moeller, 2010, p. 366).

Perishability refers to when the product disappears or perishes as the service ends. Technology that can store instruction digitally has diminished the perishability of educational services. Some argue that perishability of the outcome is not a suitable reference object to characterize services at all (Moeller, 2010). Perishability of service may not be unique to services (Hill, 1977; Edvardsson et al., 2005) since the perceived utility of the outcome of the transformation is what lingers long after the outcome perishes. It is also true of products because the product is not what remains in the memory of the customers, but the perceived utility of the product. However, productive capacity, the facilities, equipment, and labor that are associated with the production of service, reserved in readiness for the co-production of the service are perishable (Lovelock and Wright, 2001). This point has implications for designing an effective pre-college
program for NTAS since service providers heavily depend on the customers’ resources to produce the service, and the service’s production capacity is perishable, and therefore must be properly managed (Moeller, 2010). Moeller referenced Rust et al. (1996) who also stated that time is the “most perishable component of services capacity,” (365) and recommended that the perishability of customer resources should be managed with yield and price management, as hotel and airlines do. For education, the last date to drop or add a course within a semester is an example of how to manage the customer’s resources.

The characteristics of services also commonly include a lack of standardization, customer co-production (Fritsche, 2011; Grönroos, 2007) high labor-intensiveness (Sampson & Froehle, 2006), and direct and usually face-to-face interaction (Sasser, 1976). These characterize education services as well. Students are co-creators of the value they enjoy. In other words, in educational services the student is a co-producer of his own knowledge or skills. The labor-intensiveness and necessity of face-to-face interaction in educational services is well-documented. And although there is standardization in education services in terms of grade level standards of a curriculum, instructors enjoy a degree of autonomy within their classroom that does not usually come under scrutiny (as evidenced by the rate at which some schools produce students who are underprepared for college or a career). Hence, these established standards could be compromised.

**PCSP as an Open Service System**

In exploring the education of non-traditional adult students as a service, an important aspect of it is the systematization of the components that work together to deliver what the customer, the student, wants. In highlighting the complexity of designing an education program to better serve the target students and better meet the needs of society, Banathy (1991) observed that those who are in a position to bring about the “redesign and transformation of education do not know how to go about it” (p.5). In other words, the staff and managers of educational organizations may lack
both the willingness and the ability to design and implement a more holistic and effective solution. Khan (1995) shared the same concern that the systems design approach to designing an effective program is dependent on the organizational capacity and human capacity to successfully implement the design to function accordingly. He suggests that all the stakeholders be involved in the decision-making and design process, including the faculty and frontline employees that use the technology and interact with the students regularly. It is noteworthy that the educational service system design approach these researchers recommended includes the implementation process as well. They suggested that the plan to implement should include prototyping the restructured educational service concept and experimenting and collecting feedback for revision and improvement.

A common thread in all the definitions of a service system is that a service system is purposefully configured and includes the people (the services providers, customers, and other stakeholders), technology (technical features and artifacts and processes that enable the delivery of the services), and the environment in which the service system is embedded and with which it interacts. These definitions support the notion that a pre-college STEM program is a service system that delivers a number of services to its customers with the student as the primary customer. From a different perspective, an educational service system can be viewed as a business organization where many of the innovations and design approaches that were successful for business services could be successful as well.

An educational service system like a pre-college STEM program (PCSP) for NTAS learners is open because it is usually embedded within a larger organization or directly in a community with which it interacts for survival. Operational resources come from outside the boundaries of the system, and finished products and services leave the system. The program materials and teaching delivery tools are constantly replenished from the outside. Upon graduation,
the students need to be employed or move on to another educational service system for their experience at the pre-college program to be worthwhile. In addition, the students’ life experiences come from outside the system (Bean & Metzner, 1985; M. J. Bergman, 2012) to co-produce the educational service they enjoy. Beyond the interactions within the system are the often unplanned, unanticipated, and sometimes undesired input from the external environment, which are capable of disrupting the smooth operations of the system. The ability of an organization to manage these unexpected demands from the external environment is vital to the effectiveness and sustainability of the organization.

**PCSP and Service Design**

One advantage of viewing an educational service like a pre-college STEM program as a business service is that it highlights the student as the primary customer and the common goal of the system as the student’s success (Kramer, 2001; Nwankwo, 1995; Simons, 2014). This representation emphasizes a mindset that focuses on the needs of the students and their satisfaction when evaluating the quality of educational services (Christensen et al., 2010; Weise & Christensen, 2014). This mindset is not prevalent in traditional educational services, however. The business world, in their competition for increased market share, innovate regularly to be leaders of customer satisfaction, but many schools compete only for enrolment numbers and not in degree completion and job placement for their customers. Currently, many students are non-consumers of the educational services of K-12 and postsecondary institutions, not because they do not want the services, but because the existing business model does not accommodate them (Weise & Christensen, 2014).

This calls for educational service innovation. With an increasing number of NTAS returning to school, but not completing degrees commensurately, there is a need for colleges and universities to rethink their service model. Adaptation to change continues to be an important
success factor for organizations, including colleges and universities. According to Storey & Larbig, (2018), what manifests innovative service ideas is service design with the service concept (service prototype or value proposition) as its central theme, and the customer’s involvement in the process as a critical success factor. For education of the NTAS, there is a need for education service concept transformation, which means adapting an existing service concept to reflect changes in external environment demands, especially from the primary customer (Storey & Larbig, 2018). This move requires extensive knowledge of who the customers are and what their needs are. To better understand the students as the primary customer, the service-dominant logic approach of recognizing the customers as a major source of knowledge outside the organization can provide some insight. This is important because customers have been found to “have an important role in the assimilation and transformation of customer knowledge. Customers help the design team to understand and interpret customer needs and help embody this tacit knowledge within the service concept.” (Storey & Larbig, 2018, p. 111).

These authors described service design as a “human-centered, reflective learning, iterative approach to the creation of new service offerings” (p.101), where value is accumulated or constellated for the customer. Although customers belong to the external environment of the provider’s organization, for educational services they are a critical outside resource. A strategic decision to engage customers would help centralize the customers’ satisfaction as a primary goal, which is the first step to successful service innovation. Involving the customer adequately in the design process is very important, because they have firsthand knowledge of the problem the organization exists to solve, while the organization has more information about possible solutions. Moeller et al. (2010) suggests a co-creation of not only the value, but also the value proposition.

Whether performing disruptive or sustaining innovation (Christensen et al., 2010) customer engagement is critical to success. It “helps identify opportunities, improves the service concept,
pinpoints alternative uses, and at the same time ensures that service offerings are simple enough” (Storey & Larbig, 2018, p. 112), to be readily accepted and understood by the customers.” For colleges and universities, outsourcing this function to an outside firm, or the school’s recruitment department only, reduces the opportunity for faculty and other frontline employees to learn important customer characteristics and needs, hampering the ability of the service design team to have the “insight and thoughtful interpretation” (Storey & Larbig, 2018, p. 112) they need to transform those needs into effective new services. As Storey and Larbig (2018) found, “customer knowledge assimilation has a strong direct influence on success.”

**PCSP and Service System Design**

Understanding the problem-solving activities of service system design and some of its fundamental principles will help guide this study. Gebhart, Baumgartner, & Abeck (2010) highlight the importance of making decisions that represent the service system that is desired, and using design to provide solutions in inherently problematic areas, such as making decisions based on sociotechnical systems philosophy and abiding by those decisions (Gebhart, Baumgartner, & Abeck, 2010). This suggests a sociotechnical system design approach that would take stringent measures to include a definite schedule of specified activities, then use the design to make each of the decisions with care and monitor their impact on emergent service behavior (Gebhart et al., 2010).

Chew (2014) proposed a framework that integrates service-dominant logic and value co-creation principles in the service system for use by businesses to design a more coherent and cohesive business service model. Although Chew’s service system framework that was built from the service concept integrated many design concerns of services, it showed systematic development of a service system from the basic “prototype of service”, the service concept. The service concept is described in literature as the customer's needs and how they are to be satisfied
in the form of the content of the service, the design of the service or “customer’s benefit package”,
or the “what and the how” (Collier & Meyer, 1998; Edvardsson & Olsson, 1996; Goldstein,
Johnston, Duffy, & Rao, 2002). The service concept can be viewed as a commitment of the service
provider to fulfil what the customer wants, as and how it is wanted. The “domain of the customer
needs” (Edvardsson & Olsson, 1996; Goldstein et al., 2002) is considered very relevant for the
design of a quality service system (Goldstein et al., 2002). The service concept is useful to gain
feedback and input from a wider variety of external stakeholders and customers and obtain buy-in
from internal stakeholders (Blank & Dorf, 2012; Chew, 2014).

As an approach to build quality into the service at the design and development stage,
(Edvardsson & Olsson, 1996). (Shostack, 1984) used Blueprinting techniques both to dictate
potential problems, and identify market opportunities. Blueprinting which has also been used
applied to IHE (Bitner, Ostrom and Burkhard, 2012) was described as a rational management
technique that shows the totality of a service flow, highlighting possible ‘fail points’ - meaning,
those stages of the service operations that have a significant probability of generating variance, so
they can be better analyzed, understood, and possibly redesigned. Bitner, and her colleagues used
blueprinting technique to model the service for the transformation of student’s college experience.
Blueprinting highlights the line of visibility of services: the front stage, and the back stage, in
particular, proposing an appropriate approach in designing and managing every stage of a service
process, and this can be of great value for early detection detrimental emergent behavior of the
service system as the interactions increase in delivering services. Ries (2011) detailed how to
quickly develop products or services that customers actually want which leverages learning from
a process of fast iteration of hypothesis, the “minimum viable product/service”, customer
feedback, revision, and launch, as quickly as possible (Ries, 2011). Ries’s approach of quick
launching of a “service prototype” to the real customers cannot be fully implemented in an
education program, but the nimbleness both in decision-making process to adjust and revise or completely change any part of a service concept can be useful for the solution we seek.

**Sociotechnical Systems**

For a good understanding of systems and how best to optimize their performance, some researchers suggest an integrative sociotechnical systems approach (Clegg, 2000; Sussman, 2011). By integrative, they mean an approach that explores multi-disciplinary concepts and core theories relevant to a broad problem space. This allows for “integrative domain knowledge,” which is in-depth understanding of the components and subsystems, both internal and external, to the system of interest. They warn that care must be taken to ensure that the decisions about the design and development of the social and technical aspects of the system are based on well-established facts. A “key aspect of the study of complex sociotechnical systems is to have core, underlying concepts for creating integrated approaches across domains”, (Sussman, 2015 Webinar⁴). Following on Sussman’s suggestion, this study draws from Systems Science, Social Science, Service Systems, Complexity Science, and Education Service and domains. Clegg similarly warned against application and diffusion of STS principles into new systems without ensuring they are established with cross-domain applicability (2000).

This research will apply the principles of systems design to develop an Education Service Systems Design (ESSD) model for the improvement of outcomes for nontraditional adult students in a pre-college STEM education service system. Systems design analysts and researchers believe that complex sociotechnical systems underlie many critical contemporary issues (Sussman (2010, 2011; Sommervelle, 2011), which include the issues of educational service systems in the US. Many researchers have called for a systems design approach to improve education outcomes

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⁴Webinar: “Understanding and Designing Complex Sociotechnical Systems” - Joseph M. Sussman
https://www.youtube.com/watch?v=p09PL7Xog4&t=2434s
(Banathy, 1991, 1992, 2013; Bozkuş, 2014; Churchman, 1996; Forrester, 1990; FOULIDI & PAPAKITSOS, 2018; Fullan, 2009; Groff, 2009; J. S. Groff, 2013; Reigeluth, 2004). However, a systems design approach to designing education service systems has yet to become common, and best practices for applying the approach is not yet well known. Historically, the design of programs to reform education has rested with educators, who generally lack the multiple-disciplinary perspectives needed to effect meaningful change in this type of complex system (Banathy, 1991; Fullan, 2005). Banathy (1991) observed that those who have called for the “redesign and transformation of education do not know how to go about it,” (p.5) and according to Kahn & Reigeluth (1993), a systems design approach to education reformation will require knowledge of “parts of management, finance, governance, learning and instruction, and so on.” (p.38)

To increase the STEM degree completion rate of NTAS, this research adopts a multi-disciplinary approach based on the sociotechnical systems (STS) design methodology. The sociotechnical systems design approach has over six decades of success stories in organizations across various industries, especially technical industries. A sociotechnical system consists of the structure, substructures, technologies and people that make up an organized effort to solve social and technical issues. Sociotechnical theory is grounded in the fundamental principle that a focus on only the social or only the technical system alone will adversely affect the effectiveness of the organization. From a sociotechnical systems perspective, a college/pre-college STEM program for NTAS is a complex open system, because it has a large number of interconnected dynamic components and subsystems that interact in a nonlinear manner with emergent behavior and feedback loops, and it also interacts with its environment (Christensen et al., 2008; Christensen et al., 2010; Rouse & Serban, 2011; Tracy & Lyons, 2013). Its social systems are made up of the large stakeholder base the organization serves (Groff, 2009; Sussman, 2011) – the organization’s staff and the quality of their work life (Trist, 1975; Pasmore, 1988), as well as the perceptions and
interactions of students, their families and friends, individual and corporate donors, university partners, employers, management, and the community. The technical part of the system includes the physical infrastructure (equipment) – computer machines and computer labs, shop floor and the technical training equipment, program supplies, program and organizational structure and climate, etc. It also includes teaching tools and techniques, the program curriculum, and official processes and procedures. In other words, the technical system consists of the technology - the “how” and the “what” that the program provides for its primary customers, the students, and for the organization. Christensen and his colleagues defined technology as “the processes by which an organization transforms inputs of labor, capital, materials, and information into products and services of greater value.” (Christensen et al., 2010, p. 11)

Although STS design is commonly applied in manufacturing contexts, sociotechnical systems literature commonly refers to services as a possible future area of application of the concept (Pasmore 1988, Travis 1975). (Richey et al., 2014) proposed a complex sociotechnical systems approach for the reformation of the U.S. educational system and workforce. The authors believed that this approach would offer a holistic perspective that would enable reformers to identify the challenges associated with preparedness and persistence of STEM students. Another more recent example is Law, Liang, & Cheng (2017) who used the STS approach to study scaling the development of a collaborative platform for a network of schools for special needs students in Hong Kong. An earlier application of STS principles in educational systems was by Telem (1996) who designed a STS based implementation framework “School Management Information Systems (SMIS)” (p.85) for information technology diffusion in great schools.

Research Questions

To identify factors critical for success (FCS) of NTAS learner pursuing a college STEM degree, three questions were asked to guide the study. Understanding the guiding principles, ideas,
thought processes of educators who designed a STEM college program for this population could give insight to what they may have considered important. A reflective thought process for everyone who participated in the design of the program either as a faculty or as a student could also produce more insight into the critical factors of students’ success. The reasons NTAS learners return back to pursue college degrees in STEM, their perceptions of what they need to know before they enroll, their expectations, and possibly who influenced or supported their decision to return to school could all point to some other critical factors that would otherwise escape discovery. The faculty members’ perceptions of how they became NTAS educators, their experiences, and their general attitude toward the cause can also be pointers to the FCS. There is a need also to explore further what aspects of the entire process from enrolment to graduation that were critical to the students’ success. This would include students’ direct interactions with all the program’s social and technical components as well as the influence of internal organizational policies, procedures, and culture and the demands of the external environment. Therefore, this study seeks to answer the following three questions:

1. How do educators go about designing educational programs to benefit NTAS learners? (Koper & Olivier, 2004; W. A. Pasmore, 1988)
   a. What do they think are the principal weaknesses of their program designs?

2. How do NTAS learners and faculty make the decision to become involved with a STEM program? (Bjordal, 2011) (These authors addressed to a varying degree the question of how students initially choose their major (Bjordal, 2011; Maple and Stage, 1991; Montmarquette, et al., 2002; Malgwi, et al., 2005)
   a. What can be learned from an analysis of the events that led to their being involved with the STEM program?
3. What factors cause students and faculty to stay motivated and committed to a STEM program for NTAS learners? (Forsman, Linder, Moll, Fraser, & Andersson, 2014; W. A. Pasmore, 1988)

   a. What do they think are the causes of the breakthroughs and/or challenges they may have experienced?

   The answers to these questions will inform the development of an educational service system design (ESSD) framework. This framework will answer the question of how a practitioner should design and optimize a pre-college or college program for NTAS learners to be successful through a more effective pre-design analysis. Based on literature and over 20 years experience of the researcher, nine main components were identified and included in the proposed ESSD model. These represent the nine areas of an education service system, like a PCSP, that should be well understood to guide the design for optimum outcomes for nontraditional adult students.

Theoretical Background of the Proposed Educational Service Design Framework

A sociotechnical systems approach, educational service systems design framework, is proposed in this study for understanding how it might inform the design of an effective pre-college STEM program for non-traditional adult learners. As the literature review has established, a pre-college STEM program (PCSP) or college STEM program for NTAS learners (CSP), as an educational service system, can be analyzed using the sociotechnical systems (STS) approach. From an STS perspective, every business organization consists of a technical system and a social system. The technical system comprises all the physical equipment, hardware, software, machines, policies, procedures, processes, techniques and tools that enable work (Mumford, 2006; W. A. Pasmore, 1988). The social system consists of the employees and all the human elements that affect how work is done (Mumford, 2006; W. A. Pasmore, 1988). The sociotechnical systems design approach optimizes the performance of an organization through the joint optimization of
both the technical and social systems of the organization. STS reveals that optimizing one and not the other can lead to a less than the desired outcome. Any isolated improvement or redesign of any part of the organization without consideration of the possible adverse impact on other parts of the organization can lead to an undesirable outcome (Leavitt, 1965; Muller, 1989; W. A. Pasmore, 1988; Rabah, 2017; Somerville, 2015; Wang, 2012). This principle has motivated the creation of a model that accurately captures the interconnectedness of the internal and external structure of an educational service organization for NTAS learners.

Since the mid-1960s, organizational development researchers have sought to optimize the performance of an organization by determining the most effective approach and structure for its diagnosis, analysis and change processes (Král & Králová, 2016). Král & Králová compiled a partial list of these researchers (16 researchers), categorized based on the kinds of relationships their organizational components have with one another and how they may influence the structure and processes of the organization. The relationship between the components ranged from interdependence, casualty, factor of, process sequence, or just a frame to the end of improving the task performance, where performance has varying definitions that depend on the philosophical approach to the intended improvement (Leavitt, 1965). For example, Cummings & Worley, (2015) showed interdependence between input; environment, design components; strategy, technology, structure, climate, human resource management, management processes, output, while Senior & Swailes, (2010) showed that structure, environment, strategy, technology, size, culture, creativity, politics, leadership are factors of organizational structure. Similarly, Leavitt’s (1965) represented an organization with four broad interdependent components of task, technology and people, of structure, which must all be accounted for any organizational change to be viable. . Another representation of organizations not included on Král & Králová’s list but with interdependence components was developed by by Sittig & Singh (2015). Sitting & Singh used the eight
components of hardware, software, clinical content, human computer interface, workflow and communication, internal organizational features, external rules and regulations, and measurement and monitoring. Telem used a five-component representation of schools in designing an STS-based implementation framework (1996 p.85).

Each of these researchers used different types and numbers of components for depicting an organization. The number of components used in the representation of an organization was not necessarily dependent on the type of industry or type of organization, but rather on the purpose and the level of the desired change, analysis, restructuring, or redesigning (Král & Králová, 2016; W. Pasmore et al., 2019; W. A. Pasmore, 1988). This makes sense, since no two organizations are identical both in their internal structure and external environmental demands (Abdullah, 2006; Král & Králová, 2016). The internal structure of an organization has been linked to its performance (Germain, Claycomb, & Dröge, 2008; Král & Králová, 2016; W. A. Pasmore, 1988; Rabah, 2017; Wang, 2012; Wyman, 2003). Therefore, understanding the structuring that would best enable optimum output is important for the present study. Structure, Task (process), People, Technology (Leavitt, 1965) have been established to broadly capture everything about the internal structure of both tightly and loosely coupled organizations (Weick, 1976; Pasmore, 1988, Fixsen et al., 2005). Therefore, for the analysis in this study, Leavitt’s four components have been deconstructed more granularly as the desired change requires to derive the proposed ESSD (See Table 1 and figure 3a below for how Leavitt’s change model’s components mapped to ESSD). The ESSD has nine components of goal clarification, measuring and monitoring; Service offering and technology; infrastructure; people; workflow and communication structure flow; and people that were derived directly from Leavitt’s task, structure, technology and people. The other three components of the ESSD are customer orientation factor, socioeconomics factors and external environment that need to be explicitly addressed/accounted for in an educational service environment in order to
highlight the importance of improving the adult learners’ school experience. An important consideration in the present study is the level and depth of analysis needed to be able to meet the goal, which is identifying and ranking critical success factors for NTAS learners who are pursuing college STEM degrees.
CHAPTER 2: QUALITATIVE STUDY

Sociotechnical Systems Approach for Designing Effective STEM Programs for Nontraditional Adult Students – Qualitative Study

Abstract

Society lacks an effective pre-college education service model for helping nontraditional adult learners who are underprepared for college and high-skill careers to obtain a STEM (Science, Technology, Mathematics and Engineering) college education. Moreover, crafting an effective program first requires a good understanding of the problem from multiple perspectives, because the nontraditional student’s life can be highly complex. The problem is not purely technical and cannot be solved with a solution focusing only on traditional education theory. Therefore, a sociotechnical systems approach was utilized in this qualitative study to identify factors that enable this population to successfully complete college STEM degrees on time. The study results suggest that the proposed sociotechnical systems based educational service systems design (ESSD) approach is indeed effective in gaining an understanding that can inform the development of effective pre-college STEM programs (PCSP) for non-traditional adult students. The findings highlight the complex, systemic nature of the problem and several key elements that relate to re-educating underprepared nontraditional adult students to prepare them for college STEM degree programs.

Keywords: Sociotechnical systems, Nontraditional students, Pre-college education

Introduction

There is an increasingly complex problem of untapped talent for the STEM workforce in the U.S. (Richey, 2014). Over 50% of college students are 25 years of age and older; these are referred to in the literature as nontraditional students (Radford et al., 2015). This category of adult
students commonly includes workers who return to college after being unemployed due to fast-changing technology, veterans, as well as returning college dropouts (Berker et al., 2003). As Soydan observed, “Technological developments in the workplace in the United States have led to a demand for highly skilled laborers in the workforce. Hence, adult students return to college to earn four-year college degrees or obtain certifications in order to meet the demand for highly skilled positions.” (Soydan, 2018, p. 1). These nontraditional adult students (NTAS) are largely underserved (NCES, 2014) and underprepared for college (Bettinger, Boatman, & Long, 2013). Two- and four-year colleges in the U.S. offer remedial education services to over 40% of their freshmen to improve their skills in mathematics and English (Bahr, 2012; Campbell, 2016; Hughes & Gibbons, 2018). Fewer than half of these students ultimately complete this remedial education (T. Bailey, Jeong, & Cho, 2010; Hughes & Gibbons, 2018). Moreover, many underprepared high-school graduates and NTAS do not even meet the standard for admission and must first be re-educated to reach the point where they can handle college courses (Hughes & Gibbons, 2018).

The fact is that most pre-college STEM programs (PCSP) are designed with traditional students in mind, and NTAS are forced to adapt (Christensen et al., 2010; Mohammadi, Grosskopf, & Killingsworth, 2019; Weise & Christensen, 2014). The experiences, circumstances and attitudes of nontraditional adult learners are different from those of traditional students, yet colleges continue to feature “traditions and practices that prove ill-suited for adults” (Council for Adult and Experiential Learning, 2005 p. 1).

There are few, if any, dedicated public policies/programs to properly assist these struggling adult students. Some organizations have decided to fill this gap and offer pre-college education to re-educate and prepare students to successfully complete a STEM degree. Unfortunately, while these goals are laudable, programs of this nature have struggled to achieve sustainable improvement of adult student outcomes and have failed to develop proven mechanisms and tools
for helping underprepared high-school graduates persist to earn a technical degree (Mohammadi et al., 2019).

The exploratory study discussed in this paper is based on a sociotechnical systems (STS) approach with the goal to develop a model to improve outcomes for NTAS in a pre-college or college STEM education service system. STS approach is a well-known and extensively utilized organizational development technique that involves a dichotomous view of an organization consisting of interdependent technical (all the non-human components including the physical infrastructure and learning technologies) and social systems (the people), which must be improved in tandem for the optimum performance of the organization (Baxter & Sommerville, 2011; Carayon et al., 2015; Sittig & Singh, 2010).

An STS based framework approach can facilitate a comprehensive pre-design analysis of a learning program for NTAS, because such a program needs to be holistic to effectively assist NTAS to successfully complete degree requirements on time. Sociotechnical theory is grounded in the principle that a focus on improving only the social or only the technical system alone will hurt the effectiveness of the organization—they must be improved together. Traditional education reform research fails to address the interconnectedness and interdependency of the social and technical systems of an education service (Aslan & Reigeluth, 1993, 2015; Banathy, 1993, 2013; Fullan, 2005, 2009; Khan, 2017; Weise & Christensen, 2014). A design model grounded in STS principles, on the other hand, will address the optimization of rules, processes, and technology in the education service, as well as the human interactions and perceptions of the staff and students, and how these facets of the service work together to improve student outcomes.

To increase the STEM degree completion rate of NTAS, this research adopts a multi-disciplinary approach based on STS design methodology. From an STS perspective, a college/pre-college STEM program for NTAS is a complex open system, because it has a large number of
interconnected dynamic components and subsystems that interact in linear and nonlinear manner and it also interacts with its environment (Rouse & Serban, 2011; Tracy & Lyons, 2013). Although STS design is commonly applied in manufacturing contexts, sociotechnical systems literature commonly refers to services as a possible future area of application of the concept ((Baxter & Sommerville, 2011; Clegg, 2000; W. Pasmore et al., 2019; W. A. Pasmore, 1988). One example study by Richey et al. (2014) proposed a complex STS approach for the reformation of the U.S. educational system and workforce. The authors believe that this approach offers a holistic perspective that enables education reformers to identify the challenges associated with preparedness and persistence of STEM students (Richey et al., 2014).

**Sociotechnical Systems Gap in Education**

The STS design approach proposed in this study is a problem-solving technique that uniquely targets sociotechnical issues and helps create shared understanding about holistic change strategies, the lack of which engenders a sociotechnical gap. Ackerman (2000) defined the sociotechnical gap as the “divide between what we know we must support socially, and what we can support technically” (p. 179). This definition refers to the assumed equality in flexibility, nuance, and context of new or improved technology and the human responses and activities surrounding it. For example, the No Child Left Behind policy of President Bush in 2002, which disappointed in its actual impact on student performance, incorrectly assumed that the proposed changes aligned with the social dynamics of the administrators and staff tasked with implementing them (Hursh, 2007). This type of assumption is characteristic of the sociotechnical gap that plagues many isolated and piecemeal changes in education that did not adopt a more holistic approach and consider the possible negative effects of such changes on the other components of the entire system. Sociotechnical gaps must be understood, and strategies must be designed to proactively mitigate their effects.
Future employment projections through 2020 indicate that the share of all jobs requiring a high school diploma or less will shrink from 41% to 36% (Georgetown University Center on Education and the Workforce, 2013). Nationally, less than 38% and (24.4% in Michigan) of all high school students who took the ACT in 2018 were considered college ready in all four subjects tested, and only 27% of the 45% that indicated interest in STEM (nationally) met the minimum requirements (ACT College and Career Readiness Report, 2019). It is clear that innovative solutions are necessary to effectively address these problems. The need to establish an effective pre-college STEM socioeconomic service in Detroit, the research site for this study, and in similar communities across the U.S. cannot be overemphasized.

**Research Questions**

Three questions guided the qualitative study reported in this paper:

4. How do educators go about designing educational programs to benefit NTAS learners?

5. How do NTAS learners and faculty make the decision to become involved with a STEM program?

6. What factors cause students and faculty to stay motivated and committed to a STEM program for NTAS learners?

The answers to these questions can inform the development of an educational service system design (ESSD) framework and can guide the design of effective pre-college STEM programs (PCSP) for non-traditional, undereducated adult students.

**Literature Review and Theoretical Background**

Sociotechnical systems (STS) theory is applicable to organizations that produce both products and services (Pasmore, 1988, 2019). We posit that a pre-college/college STEM program

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(PCSP) for NTAS learners is an educational service and an open sociotechnical system whose effectiveness is dependent upon many dynamic components. The relevance of characterizing a PCSP as a service is to ensure the applicability of STS theory principles and assumptions to educational services.

**Who is a Nontraditional Student in College?**

The term nontraditional student is defined in different education literature slightly differently depending on the purpose of the study (Levin, 2007). For the purposes of this study, a nontraditional adult student is an adult college student (Levin, 2007), is employed full time or has many adult responsibilities, and wants a two-year or four-year college degree. An individual who meets these criteria is a “NTAS”, meaning Non-Traditional Adult Student, as opposed to simply Non-Traditional Student, which is prevalent in adult education literature. La France (2008) gave a perspective based on the psychosociological challenges peculiar to NTAS, such as the students’ academic efficacy, multiple adult responsibilities, diverse challenges, family and personal illness, levels of stress, time constraints, sleep patterns, relationships, support systems, and cognitive ability. Thus, NTAS should be viewed more holistically in terms of the issues that define their “life’s world” (La France, 2008).

Many of the reasons that pressure traditional students to become nontraditional (Kenner & Weinerman, 2011) seem to underscore the characteristics of NTAS. These include lack of financial resources for college, full-time employment, and lack of critical and analytical thinking skills needed for collegiate course work. Kenner & Weinerman claimed that after either failing to enroll in college immediately following high school or dropping out of college soon after they enroll, these students get employed, but the “non-college graduates’ employment experience does not provide them with the critical thinking skills and particular analytical ability that would be required
in the collegiate environment.” (Kenner & Weinerman, 2011, p. 87). Thus, the NTAS return to school underprepared for college-level course work.

**Is a Pre-College STEM Program (PCSP) for Nontraditional Students a Service?**

The word “service” is used extensively across a wide range of academic disciplines with a wide range of meanings to represent a wide range of processes, experiences, opportunities, and pre-requisites (Aurich, Mannweiler, & Schweitzer, 2010; Lovelock & Gummesson, 2004; Sampson & Froehle, 2006; Vargo & Lusch, 2004, 2008). Kotler et.al. (2006) defined a service as “any act or performance that one party can offer to another that is essentially intangible and does not result in the ownership of anything” (Kotler & Keller, p. 365). Lyons and Tract (2013) defined service as “the application of competence and knowledge to create value,” (p. 1) and they agree with other researchers that value is realized through interactions and co-creation within service systems. This definition captures what happens between educational institutions and their primary customers, the students (Moeller, 2010).

Services are inherently different from goods in multiple ways. The central characteristics of services (Shostack, 1977, 1984) that can influence the design of a service system are Intangibility, Heterogeneity, Inseparability, and Perishability - IHIP (Abdullah, 2006; Fonseca & Pinto, 2014; Parasuraman et al., 1985; Sampson & Froehle, 2006; Zeithaml et al., 1985). Intangibility means that customers do not own any tangible possession from a service process. In an educational service, students walk away with intangible value in the form of acquired knowledge, and they can categorize their interactions with instructors and administrators as good, bad or indifferent (Elsharnouby, 2015). The process of educating a student is intangible, and is separate from the teacher or the teaching material (Hill, 1977; Moeller, 2010). The intangibility of services is important since, very often, “this transformation is the reason for the consumption of the service” (Moeller, 2010, p. 362). Heterogeneity refers to the variability of service types,
customers, demands and outcomes. This is true of all the sectors in the educational services industry. The primary customers, the students, are diverse in age, learning style, learning ability, ethnicity, gender, socioeconomic status, culture, etc. Inseparability refers to how service products are typically produced and consumed at the same time—consumption cannot be separated from production. This feature is true of instruction: whether real-time in a face-to-face setting, or digital and remotely accessed, the students must be present to consume the service. Perishability refers to when the product disappears or perishes as the service ends. The facilities, equipment, and labor that are associated with the production of service, reserved in readiness for the co-production of the service are perishable (Lovelock and Wright, 2001).

The characteristics of services also commonly include a lack of standardization, customer co-production (Fritsche, 2011; Grönroos, 2007), high labor-intensiveness (Sampson & Froehle, 2006), and direct and usually face-to-face interaction (Sasser, 1976). These factors characterize education services as well. Students are co-creators of the value they enjoy (Ng & Forbes, 2009). In other words, in educational services the student is a co-producer of his own knowledge or skills (Elsharnouby, 2015). The labor-intensiveness and necessity of face-to-face interaction in educational services is well-documented. In addition, although there is standardization in education services, instructors enjoy a degree of autonomy within their classroom.

**Educational Service Systems Design Framework (ESSD) - Theoretical Background**

Since the mid-1960s, organizational development researchers have sought to optimize the performance of an organization by determining the most effective approaches for diagnosis, analysis and change processes (Král & Králová, 2016). The internal structure of an organization has been linked to its performance (Germain, Claycomb, & Dröge, 2008; Král & Králová, 2016), and understanding the structure enabling optimum output is important for the present study.
Structure, Task (process), People, Technology (Leavitt, 1965) have been established to broadly capture everything about the internal structure of both tightly and loosely coupled organizations (Král & Králová, 2016; Weick, 1976). Therefore, for the analysis in this study, Leavitt’s four components have been deconstructed more granularly as the desired change requires to derive the proposed ESSD.

The proposed ESSD is a nine-component pre-design Model based on the STS principles of joint optimization of the social and technical subsystems of an organization for optimal performance. Table 1 and Figures 3a illustrate how Leavitt’s change model’s components map to ESSD. The nine components of the proposed ESSD are: 1) goals, measurement and monitoring; 2) service offerings and technology; 3) infrastructure; 4) customer orientation; 5) people; 6) socioeconomic and sociocultural component; 7) workflow and communication flow; 8) internal organizational policies, procedures and authority structure; and 9) the external environment. All nine components need to be explicitly addressed in an educational service environment. Each of these components is further described in the next section. Following this description is the contextualization of the components of the ESSD in education.

The proposed ESSD is necessarily complex and detailed because an important consideration in the present study is the level and depth of analysis needed to be able to meet the goal of an educational design that could adequately enable critical success factors for NTAS learners who are pursuing college STEM degrees. Although ESSD still does not fully capture the complexity of relationships between some of the technical components and the social system in an educational service system, it allows for a more granular analysis of these interactions than other existing models.
Table 1: Leavitt’s Four-Component Model of Change Mapped to ESSD Model

<table>
<thead>
<tr>
<th>Leavitt’s Model</th>
<th>Educational Service Systems Design Model</th>
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<tbody>
<tr>
<td>Structure:</td>
<td></td>
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<tr>
<td>Policies and authority systems (PAS)</td>
<td>International organizational policies and procedure</td>
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<td>Communication systems and flow (CSF)</td>
<td>Work and communication flow</td>
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<td>Workflow Systems (WFS)</td>
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<tr>
<td>Technology:</td>
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<tr>
<td>Direct problem solving inventions (PSI)</td>
<td>Technology</td>
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<tr>
<td>Physicals Workspace (WSP)</td>
<td>Infrastructure</td>
</tr>
<tr>
<td>Task:</td>
<td></td>
</tr>
<tr>
<td>Organization’s raison d’etre (ORD)</td>
<td>Goal clarifications, measurement and monitoring</td>
</tr>
<tr>
<td>Organization’s functions (OGF)</td>
<td>Educational service offerings</td>
</tr>
<tr>
<td>People:</td>
<td></td>
</tr>
<tr>
<td>Actors – HR; skills &amp; competencies (HRS)</td>
<td>People and Decision influencers: People, their skills and expertise</td>
</tr>
<tr>
<td>Attitude &amp; behavioral elements (ATT)</td>
<td>People: human elements - behavioral and emotional</td>
</tr>
<tr>
<td>Not included</td>
<td>Socioeconomics components</td>
</tr>
<tr>
<td>Not explicit</td>
<td>Customer orientation</td>
</tr>
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<td></td>
<td>External environmental demands</td>
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</tbody>
</table>

From an organizational development perspective, task and technology are categorized as technical systems of an organization while structure and people constitute the social systems (Alter, 2008, 2015). Because technology in education includes non-machinery entities that are used for service production (Christensen et al., 2010), a knowledgeable faculty belongs to the technical as well as social subsystem of a PCSP. This could be one of the peculiarities of educational service organizations such as two- and four-year colleges. For example, a faculty,
member is one of the technologies that transforms a person from a pupil to a knowledgeable graduate.

In this scenario, the faculty belongs to both the people and technology categories. ESSD enables the analysis of the faculty as both technology and as people, therefore providing a better understanding of the level of influence a faculty-related change can cause in the two components. An analysis of the faculty as technology would focus on knowledge co-production, delivery mechanisms, style, consistency, variety, dimensions of core learning services, and so forth. The faculty as a technology is a firm resource that works with the customer’s resources in the service to co-create value for the student. An analysis of faculty as people would focus on the perceptions, attitude, behavior, and belief systems that could be affected by an introduced change in the design or need to be considered in the design stage.
The ESSD model of an educational service organization is a more detailed consideration of the interconnectedness of the components of an organization. One of the advantages of a more detailed depiction of the organization than Leavitt’s four components is that according to Pasmore (1988), process variances and deviations identified as close to their sources as possible have a better chance of course correction. The nuances of the variation in an element within a component could be missed because its manifestation seemingly came from other elements in the same component. For example, a student as a co-creator of the value of the educational service they experience could be mistaken to have been affected by an internal activity, when what may have influenced the student’s performance was from the external environment (family, friend, employment and so forth). Also relevant is that the focus of Leavitt’s four-component model for organizational analysis for change was not based on a high-touch service like an educational service system where the customer must be present for the service to be experienced. In a technical organization, like in the manufacturing sector, the key equipment and tools are heavy physical machinery that can more easily be analyzed than the human-based processes present in educational service systems. The level of detail necessary for sufficient analysis can also vary between different sectors of the service industry.
Educational Service Systems Design (ESSD) Components

The significant differences between Leavitt’s and the ESSD’s are in the level of analyses and the granularity of the components of both models. Moreover, although not explicit, Leavitt’s model was more for business organizations that comprise components that tend to be more tightly coupled than educational institutions (Weick, 1976). Leavitt used the existing property of the interdependency between the four components of his model as they exist in business organizations to explain the need not to focus only on the components of the organization that need change, but also on the other components as they could be affected by the introduced change. On the other hand, many of the IHEs’ components are loosely coupled (Weick, 1976), but for optimal performance in say, students’ retention and ultimate degree completion, this research posits it that
pertinent (social and technical) components must be tightly coupled together. Thus, the interconnectedness and interdependency of the components of the proposed ESSD premised on the assumption of IHEs as sociotechnical systems could correct both the notion of and the practice of educational Institutions’ attempts to optimize performance with loosely coupled systems of strategies, as well as providing them with a viable tool to use IHEs’ components are loosely coupled, but for optimum performance, targeted subsystems within an institution (Tinto, 2012) must be tightly coupled.

1) Goals Clarification, Measuring and Monitoring

Goals clarification, measuring & monitoring (Choi, Lam, Li, & Wong, 2018) (what must be right for optimum performance to occur) corresponds to Leavitt’s Task of the organization, raison d’être, and the monitoring of goals. The goal and the techniques for monitoring it were all in the same category in Leavitt’s model, but separated in the ESSD for a more detailed analysis of the component, without losing sight of any dimensions. Some aspects of goal monitoring and measurement require adequate clarification and dissemination of the vision and goal of an educational program like a PCSP.

The goals category of the ESSD model also addresses the monitoring techniques to ensure the intended change can occur. For a PCSP, this component ensures the analysis of the central goals and their achievability in terms of volume, rigor, composition, key performance standards, and viability of the monitoring mechanism. This category also ensures the monitoring of other main-goal enablers such as adequate staff levels and staff’s quality of work life. Because the goal of a system drives its design and development, it is very important for educators and consultants who plan to design a pre-college/college STEM program for NTAS learners to understand what the desired outcomes are and how to achieve them more efficiently.
The goals of a PCSP as a STS include the main and sub-goals of organization as a service, the personal goals of the staff as well as any applicable goals of partners. The main goal in this study is efficient graduation of a critical number of adult learners. There are many sub-goals that can contribute to the main goal. An example of a sub-goal is the students’ successful completion of each course that advances them to the completion of the program. The achievement of this sub-goal would require the achievements of specific course objectives according to predetermined standards. Each goal has an associated subsystem whose components primarily target the achievement of that goal. Thus, the goal drives the design and configuration of the system and subsystems. Several of these subsystems for achieving each of the sub-goals might be needed to contribute to an optimum outcome for the NTAS. Other subsystems (sub-goals) contributing to the dream of earning a degree come true for NTAS could be designed to strengthen fundamental skills in math, English, and introductory science, develop independent learning skills, reduce time to graduation, mentor the students on a personal level, and provide opportunities for employment while enrolled. Strengthening fundamental skills in math, English, and introductory science could require a separate remediation subsystem, or adequate review of pre-requisites within the main course. The goal of enabling the NTAS to develop independent learning skills can also be incorporated within main courses through case study scenarios and/or real-world projects. A goal of reduced time to graduation could possibly be included in a PCSP to attract adult learners, since according to some research, NTAS are motivated by the opportunity to complete college faster (M. Bergman, Gross, Berry, & Shuck, 2014; M. J. Bergman, 2012). Providing opportunities for stable employment while enrolled in college could be one of the best ways to ensure adult learner’s stability. Financial instability is one of the biggest problems adult undergraduate students have (Markle, 2015), thus any strategy to enable them to earn more and work less could increase the stability of the students while enrolled. Moreover, increasing the stability of the students while in
school could include establishment of and maintaining a viable workflow and associated communication flow as a sub-goal.

2) Educational Service Offering and Technology

This category represents a combination of two parts of two Leavitt’s components. From Leavitt (1965), this would be an organization’s reason for existence—the production of goods and services and the associated subtasks that go with the production (p. 1144). This implies the goal and the means of achieving the goals were combined in Leavitt’s Task. While the goal of a PCSP should guide the analysis, the service offerings (the value propositions) and the associated technology for fulfilling the proposition maps naturally to Leavitt’s Task, except that the infrastructure aspect of Leavitt’s technology was categorized by itself, so both service offering and technology can be more deeply explored. Additionally, in educational service systems, a “human technology” and a service offering can be the same entity.

Christensen and his colleagues defined technology as “the processes by which an organization transforms inputs of labor, capital, materials, and information into products and services of greater value” (Christensen et al., 2010, p. 11). This definition may suggest heavy machinery that employees use for performing tasks, but it is not limited to hard physical equipment. It also includes soft tools like software and electronic materials, and for an educational service system, technology includes processes, procedures, training and training materials, seminars, books, curriculum, delivery chain, etc. (Christensen et al., 2010). Intellectual knowledge of the faculty, student service professionals, counselors, and so forth. are by themselves “human technology”(Christensen et al., 2010). This category ensures the analysis of everything that properly enables the transmission of educational knowledge to pupils. This category also ensures the analysis of all the educational service offerings (main and sub-goals) of the program and the subsystems designed to achieve them.
The service offering for a PCSP is more than just courses and delivering them. Because of the multiplicity and interdependency of the learning needs and needs while enrolled of the NTAS, an effective PCSP for NTAS is expected to offer many services, both core and supplementary services (Ng & Forbes, 2009), which include adequate relevant support services (Bauman et al., 2004; Remenick, 2019) for their unique needs. Core services are the activities that directly lead to learning, which Ng and Forbes described as “embodied in the learning experience of the student” (p.48). Supplementary services, which play an important role in the core service delivery, include application processes, registration of classes, advising services, academic counseling services, tuition and fees processing, campus facilities including learning laboratories, learning centers, and administrative and support staff helpfulness. The needs of the NTAS while enrolled include earning enough income to be able to take care of their daily expenses, childcare, financial needs for tuition and fees, social and emotional support, and their likes.

It does not seem feasible for one institution to provide all the services that can adequately address the needs of the NTAS learners. Moreover, the failure to address the full spectrum of the complex world’s life of NTAS in college can result in learning failure, which translates to performance failure for the institution. Although postsecondary schools generally do not provide many of the non-academic services that NTAS need to be stable and persist through to graduation, it would be beneficial to understand what the students need and develop strategic partnerships to ensure that the students have access to necessary assistance.

Technology is grouped together with the service offering in ESSD only because each technology employed maps to a given service offering. The advancing world of technology has taken educational services along with it. There are many digital learning materials, learning management systems, and analytics solutions that have increased accessibility, convenience, “big-data” predictive analyses, and options for the students, and better insight into patterns of behaviors for
educators (Choi et al., 2018). Computer laboratories, smart boards, hands-on computer-based learning deliveries, and real-time and offline access to a student’s work online are a few of the technologies that enhance the service co-production. The faculty as a knowledge technology is a peculiarity of the educational service.

3) Infrastructure

The infrastructure category, which was the other part of Leavitt’s technology components, ensures analysis of physical structures and buildings, fixtures and plans, virtual learning platforms, and how best to design them to support optimal performance of the program. Leavitt’s model included physical buildings and key equipment under technology. For a program like a pre-college STEM program (PCSP), infrastructure is more than the physical building and all the other artifacts (Almqvist & Östman, 2006; Conradie, 2014). It is about place making—deliberately creating or adopting a space for the students that enables the collaboration and engagement that are essential for academic performance (Kuh, Cruce, Shoup, Kinzie, & Gonyea, 2008; Wyatt, 2011). For adult students, the ease and comfort of coming from their place of employment to the classroom, or to keep appointments with faculty and staff, is an important factor in how they could perceive the program.

Satisfaction with facilities relates to educational service quality of IHE (Napitupulu et al., 2018). A major part of facilities in education is the different Infrastructure, which includes the physical building that houses the program, the virtual platforms of all learning management systems, the classrooms, learning labs for remedial courses (especially when the remediation is self-paced), science and computer laboratories, and so forth. Virtue learning facilities and the learning management systems are some platforms provided to increase the variety of options for the students as customers.
Effective infrastructure could also include a student’s lounge with some conveniences like coffee, vending machines, dedicated parking, and so forth. A comfortable student’s lounge would be the institution’s strategy to account for the fact that most adults travel to school straight from work, and therefore could be tired, hungry, need to relax a little bit before classes if their schedules permit. Therefore, a PCSP could consider a lounge and other conveniences like a dedicated parking space for the NTAS. This service may not be a core service of learning, but it can increase the chances of having satisfying experiences which could positively influence the co-production behavior of the students (Elsharnouby, 2015).

4) Customer Orientation: Focus on The People the Organization is in Business to Serve

Customer Orientation is not explicit in Leavitt’s model, but is a common knowledge that for-profit businesses do their best to acquire and retain their customers. For a program like the PCSP, focusing on customer orientation (Gazzoli, Hancer, & Kim, 2013; Nwankwo, 1995) as a component ensures that the organization adequately focuses on the students it is in business to serve. The choice to focus on the student as the primary customer helps in prioritizing requirements while designing and managing the program. This component ensures that attention is given to the students not only as a customer, without whom there is no business, but also as the primary customer whose needs are central to the program’s reason for existence.

Student-customer orientation in an education service like the PCSP would need a clear understanding of its sensitivity points, elements of measurements, and operational themes for implementations (Nwankwo, 1995) and actions that constitute customer orientation. Customer orientation in HE is an institution’s business goal centering on meeting the educational goals of students, which include their learning needs and their personal needs while enrolled. Customer orientation in education includes also proactive strategies to identify and manage students’ perceptions, as these can influence students’ behavior and response to following instructions that
lead to better learning outcomes. It would also include adaptation of learning materials like technology (Reigeluth et al., 2015; Smith, 2014), curriculum (St Clair, 2018), learning style, schedules, office hours (Markle, 2015), and learning delivery channels to increase accessibility (Mohammadi et al., 2019; Park & Choi, 2009), ease of use, updated and adequacy for the students.

Customer orientation in education could require an institution-wide mindset shift of every staff member to quickly and promptly adapt or adjust service co-production processes to create the most value for the students (Eador, 2018)°. In education, all adaptations must have one goal only – to co-create the most value for the students. Herein resides the measure of customer orientation (Martensen, Grønholdt, Eskildsen, & Kristensen, 2000) in education: a determination of the value created for the students by the service or modification made to produce the service. The implementation of customer orientation in education would involve education on why customer orientation is necessary, what it is and what it is not, and how to implement it throughout the entire spectrum of services, both core and supplementary. Customer orientation does not mean lowering the academic standards (Mark, 2013) for some students, as it is not about what is delivered, as it is “the manner in which the service was delivered” (Sierra & McQuitty, 2005, p. 392). Lowering academic standard would violate the business goal of delivering on the education goals of the students(Mark, 2013).

Students’ satisfaction is critical in determining educational service quality, which could relate to service outcomes (Schreiner & Nelson, 2013). However, as in businesses, without a deliberate effort to satisfy students by improving service quality, student satisfaction may not happen in an educational service like a PCSP (Gazzoli et al., 2013; Nwankwo, 1995). One advantage of positioning an educational service like a PCSP as a business service is highlighting the student as the primary customer and the core goal of the system as being the students’ success (Kramer, 2001; Nwankwo, 1995; Simons, 2014).
Some researchers frown at the idea of students as customers (Saunders et al. 2014), and consider it controversial (Rutter, et al. 2016) because of the fear of compromise of education standards. Still, many researchers continue to advocate for the notion of IHE as service systems (Bitner, Ostrom, & Burkhard, 2012). Bitner and her colleagues show that viewing IHE as service systems makes them student-focus in their continuous improvements and innovations, in turn improves outcomes and ensures the fulfillment of their other goals of serving the community and society. Students have also been viewed as the core stakeholders of IHE (Maric, 2013; Kettunen, 2015; Bjorkquist, 2009), with staff, faculty, alumni, employers, parents, government, and the community in which the institutions are embedded and society as other stakeholders (Gross and Godwin, 2005). In all of the categorization of college students, these authors agree that students consume the services of IHE and that their satisfaction is essential in determining service quality.

Because students are not commonly regarded as customers, consumers, or stakeholders, customer orientation is not a widely used phrase in education. Terms like student-centeredness, and student orientation are utilized in describing designing lessons or technology that are student friendly - meaning, easy to use by the students. Adopting teaching style or curriculum to suit students’ learning style and educational needs can also mean student-centeredness or student friendliness (Esses, 2019; St Clair, 2018). As in business services, customer orientation (Guilbault, 2016; Nwankwo, 1995) strategies for better customer acquisition and retention could be effective in terms of meeting the expectations of nontraditional students. Bjordal found that nontraditional students’ expectations include a “consumer-oriented approach with some of the same conveniences and services from their colleges as their banks and supermarkets provide, such as no lines, adequate parking, variable hours of operation, high quality, low cost, and informed employees. Of secondary importance were campus climate, student-centeredness, and campus support services.” (Bjordal, 2011, p. 51).
5) People: Who Is Involved and What Influences Their Performance

The people category of the ESSD corresponds to Leavtt’s actors. For a PCSP, it is important to list all stakeholders and identify their interests and how each could affect the system’s performance (Leimer, 2011). Literature reveals a high degree of interaction between the people and the effects the interactions can have on relations, information flow and optimal performance. Therefore, analyses of different pertinent interactions could elicit critical information necessary for effective STS-based design.

People for ESSD means all actors, both internal and external. STS theory and principles were developed with internal organizational employees, mostly because they can be controlled in any design and change management efforts. Because students are intricately connected to the institution and their success depends on their degree of integration into the technical and the social subsystems of the institution, they are included in the people category in the ESSD. In representing a university as a service, Ng and Forbes showed that people, physical evidence (materials, teaching facilities, accommodation, recreational facilities, and the like) and processes contribute to both the core and supplementary services education provide. People include students, academics, administrative and support staff, and processes include facilitation of applications, registration, exceptions, learning activities, as well as social activities. These processes Ng and Forbes (2009) described include people and the relevant technology in working together to co-produce the service delivered to the students. Through the student’s, their significant family member(s) can also be included. For example, engaging students’ family members early in the program to support the students in their efforts could enable social and emotional support from their families.

One of the factors of complexity in a PCSP as a system is the multitude of stakeholders, which can heavily impact system performance. An in-depth understanding of all relevant stakeholders through stakeholder analysis (Donaldson & Preston, 1995) could reveal better ways
to manage varying goals and conflicting objectives (Ramirez, 1999) and hence narrow the range of stakeholders’ system performance expectations (Prell, Hubacek, & Reed, 2009). In the proposed ESSD model, Leavitt’s people category is expanded to include the pertinent stakeholders whose input can enhance the design of a more effective program. As in other services and industries, the primary customer (the student), also referred to as the core stakeholder (Maric, 2013; Kettunen, 2015; Bjorkquist, 2009) is a key element in the design process whose needs and wants provide the main goal of the program.

The personal goals of the staff, which include psychological needs like quality of their work life and inclusion in decisions and processes about the program, are important components of the goals that drive the design of the system (W. A. Pasmore, 1988). For example, literature abounds with findings about faculty’s perceptions and activities’ relationship with students’ academic outcomes (Bean & Metzner, 1985; Berger & Lyon, 2005; Tinto, 2006, 2012; Umbach & Wawrzynski, 2005). As frontline employees in a high-touch service systems like a PCSP for NTAS, the ultimate goal for customer orientation fall on the shoulders of the academic and non-academic staff, and a well-maintained “work agreement” ensures level of motivation and commitment required for shared students’ success vision of the institution (W. A. Pasmore, 1988; Umbach & Wawrzynski, 2005). Such a shared vision can drive the collective engagement of all critical stakeholders (the staff, the students, critical partners and management).

Many involved people are external to the organization. The strategic importance of a PCSP’s partnerships with industry, colleges, college departments, philanthropists, or governments, skill training programs, non-profit organizations and so forth have been highlighted by many who are familiar with the struggles of NTAS (Christensen et al., 2010). This collective-impact strategy have been recommended and adopted by some who found collaboration to be effective in increasing students’ success (Applegate & Fulton, 2016; Austin & Seitanidi, 2012; Gluesing,
Riopelle, Chelst, Woodliff, & Miller, 2008; Polesel, Klatt, Blake, & Starr, 2017; Richey et al., 2014; Santos & Haycock, 2016). For example, students’ financial stability can be enhanced by a partnership employment while attending college as internship, co-ops, or direct part-time or full employment (Berker et al., 2003; Rouvais, Remaud, & Saveuze, 2017). An employment-based partnership can also mitigate schedule conflicts between employment and school that often put pressure on adult students’ attendance and performance (Markle, 2015). For a strong sustainable partnership, design analysis should include key drivers of viable partnerships between education service provider and industry (Gluesing et al., 2008). According to Gluesing et al., these drivers include shared geographic context (proximity considerations), mutual motivation to make the partnership work (the commitment of the partners), mutual commitment for real-world education (commitment of partners to immediate applicability and problem solving), mutual commitment to beat all obstacles, and mutual willingness to commit adequate resources to sustain the partnership.

6) Socioeconomic and Sociocultural Component

Under this category, employability, affordability/scholarships, accessibility/economic support system (Bauman et al., 2004), and shared value creation can be analyzed for pertinent information for designing an effective PCSP. As expressed in the literature review, the re-education of NTAS learners should be viewed as an investment that would benefit the students, government, and society. This category ensures the analysis of every possibility that can enable students to be more stable in school.

Socioeconomics and Sociocultural factors. Socioeconomics and sociocultural component is not included in Leavitt’s change model. This component in ESSD includes all possible financial supports that could be provided to the students to ensure their financial stability while enrolled in a PCSP or college. Two- and four-year colleges assess the students yearly to determine financial aid eligibility. While most low-income students qualify for financial aids, many of the returning
adult students in college may not qualify for financial aids because of previous college loan debt default or other factors like under-enrolment. Assessing the financial status of the students, their skills sets, and employment eligibility, could give insight into how best to assist the students to attend college and still meet their financial responsibilities. Many adult learners could still desire to pursue an undergraduate degree and pay for it from their pocket. For many of these adults, the financial support could be partnership with companies who could give them co-ops, internships, part-time or even full-time employments while they attend school.

Sociocultural issues have become more relevant in education with the increased globalization of students and faculty members in college. Learning styles, choice of words, and meaning of some gestures can vary from one culture and nationality to another. An expression that is acceptable in one culture and nationality could be offensive to another and this can pose a challenge for students or faculty of differing backgrounds. Thus, understanding the cultural backgrounds of students in a cohort could enhance the strategies for improving value co-creation participation of the students.

7) Workflow and Communication Flow

Workflow and communication flow are included in Leavitt’ change model as part of its structure. This category in a PCSP ensures that the work design, workflow, schedules, assignments management, communication flow, frequency and structure of the program are adequately analyzed for viability and proper guards are set against variance of process and of goals (Antón & Potts, 1998; W. A. Pasmore, 1988; Unertl, Novak, Johnson, & Lorenzi, 2010). This consists of work design, workflow, value chain, schedules, assignment structure and management. This category for services usually involves less physical equipment-based processes and more human-based processes and procedures (Gazzoli et al., 2013; W. A. Pasmore, 1988), especially for a high-touch service like a pre-college STEM program.
Workflow of ESSD refers to all processes of service co-production, both main and supplementary services. Unlike business products that the customer consumes only after its been produced and delivered, learning co-production depends on an effective and efficient flow of the coproduction processes. The simultaneity of the production and consumption of services makes properly aligning the sequence of classes and time allowed for assignments and assessments indispensable for positive learning outcomes. According to Storey & Larbig (2018), viewing students as customers would help the design team to understand and interpret their academic, social, financial and psychological needs and help operationalize this knowledge within the education service (p. 111) as well as analyze how best to couple and deliver them. For example, one of the needs of NTAS learners is time to study. This could be translated into incorporating study time within the regular school schedule and providing a dedicated study room with internet connectivity and school supplies. A coffee table and a vending machine with snacks in or close to the room could enhance the success rate of this “time for study” strategy. This strategy reflects an understanding that the nontraditional student might have little to no time outside school and work to devote to schoolwork. This would embody nontraditional students “valuing convenience and quality” (Bjordal, 2011, p. 51). School-work conflict and school-family conflicts are realities of the complex life of NTAS (Markle, 2015). The workflow in a PCSP could include buffers in either the scheduling strategy or accessibility of previously covered lessons for the NTAS learners to review at their convenience.

There are multiple layered and interconnected communication flows prevalent in education service like a PCSP that ESSD would target. The non-consumption of educational services co-produced by the institution and the students has been identified as being rooted in the cumulative gaps between student’s dynamic expectations and the value delivered to the students by the institutions (Ng & Forbes, 2009). The students can be influenced to modify their expectations
through strategic communication, and whereas the traditional aged students could be more malleable to change their expectations, the adult learners usually return to college with capacity to be influenced mostly by the academic systems only (Bean & Metzner, 1985). An example of modifiable student’s expectation is a change from “vocational relevance to academic excellence” (Bean & Metzner, 1985). Equally important is the opportunity to correct variance close to the source (Passmore, 1988). That means that for efficient workflow, the communication necessary for the delivery needs to flow directly and on time to the point of action. Adequate communication flow enabled by clearly specified channels is necessary to enhance value co-creation behaviors of both the students and the frontline academic and non-academic staff (Eldor, 2019; Elsharnouby, 2015), which could improve learning outcomes.

8) Internal Organizational Structure, Policies and Procedures

This category is included in Leavitt’s model. For a PCSP, it includes clarifying and defining the jobs of people, setting up clearly defined relationships between those jobs with associated authority, responsibility and coordination mechanisms clearly spelled out. The authority structure, workflow and communication flow of Leavitt’s model was deconstructed into two components, organizational structure, policies and procedures as one component, and workflow and communication flow as a separate component in the ESSD. In this category, belong the hierarchical, centralized or decentralized leadership, control at each level, physical breakdown of authority, and the policies and procedures of the organization, and the ways that all of these could influence the performance of a PCSP.

A PCSP could be a stand-alone program for adult learners (Hollenbeck, 2007; Thompson, Turner-Meikeljohn, & Conway, 2000), or it could be a department of an IHE. The dynamics of the organizational policies, procedures, rules, regulations and the structure of authority could vary
between the two PCSPs. The focus of all strategic efforts of the stand-alone PCSP should be on the sustained success of the adult learners, but the PCSP that is a subunit of a bigger institution could be expected to broaden its focus. For example, staff and some technologies could be shared and logistics may not be as freely flowing as in the case of the stand-alone program. Thus, organizational policies, procedures and authority structure can influence the effectiveness of a PCSP in different ways, and therefore would need to be well-understood from the design stage. Student’s perception of policies and procedures of an institution or program could influence their cooperative behavior and ultimately the service’s performance (Elshamouby, 2015). For the effective engagement of staff (Eldor, 2019) and students in the service co-production process, the cooperation of everyone involved is important for success (Ng & Forbes, 2009). Thus, adult-centered policies, rules, regulations and customer-oriented practices can help ensure students are willing to follow the rules and procedures that will lead to better learning outcomes.

9) External Environment

The external environment was not explicitly mentioned in Leavitt’s model, but can be the source of the reason an organization seeks improved task performance through organizational change. The external environment includes government policies and regulations, economic climate, funding availability, geographical distance, politics, and so forth. Analysis of this component could increase understanding on what, if anything, can be done to buffer some of the effects of the external environment on the students’ performance.

The stability of the program is another external influence phenomenon, because funding for most pre-college programs comes directly from philanthropists and corporate donors. Any threat to the continuity of the funds destabilizes students. Therefore, a dedicated subsystem could be included in PCSP to focus on growth and sustainability. Analyzing an organization for external
environmental factors that could impact its effectiveness must be an ongoing effort that shapes the design and improvement of all aspects of the system.

The external environment of a PCSP can be the wider internal organization outside the defined boundaries of a PCSP that is a subunit of the bigger institution. For a stand-alone PCSP, everything outside the legal boundaries of the program constitutes the external environment. Regardless of the type of PCSP, the external environmental places demands on both the adult learners and the program itself both for good (e.g. family support) and sometime adversarial (e.g. family responsibility). External environments have been found to affect adult learners more than internal institutional components (Bean & Metzner, 1985; M. Bergman et al., 2014; M. J. Bergman, 2012). The effects of external environmental demands on the program and on the NTAS need to be well understood to inform the design of more effective programs for this demography.

External environments have been found to affect adult learners more than internal institutional components (Bean & Metzner, 1985; M. Bergman et al., 2014; M. J. Bergman, 2012). The effects of external environmental demands on the program and on the NTAS need to be well understood to inform the design of more effective programs for this demography. Adult learners often have multiple roles, which include family responsibilities, employment, and community membership, and all of these factors exact pressure on adults and influence their retention and learning outcomes (Markle, 2015). Similarly, the external environment can impact the sustainability of a PCSP since some such programs may not be two- or four-year college, and their sustainability could dependent on philanthropy (Falkenburg, 2005; Plonka et al., 2002). Such programs can be affected by market forces and the economic climate of the country.

Perceptions, values, beliefs, desires, intentions and action.

These human elements influence performance regardless of the industry. Humans are the source of creativity and innovation that advance society continuously. However, humans are also
often the source of organizational failures and ineffectiveness. Even in the presence of reliable technology and a technically qualified workforce, well-designed projects and organization have failed because of misalignment of the technical and social systems of the organization (Trist & Emery, 1968). Underlying the nine components identified in this study is a set of soft but influential human elements, which are perceptions, values, beliefs, desires, and intentions, that could lead to decisions to take actions (Wieber, Thürmer, & Gollwitzer, 2015) that can affect a system’s overall performance (Simon, 1956). These elements could provide important pointers to an exploratory analysis in preparation for designing a more effective program for NTAS learners. The perceptions, values, beliefs, desires, intentions and actions of the human operators and managers of the technology can influence motivation and affect performance. Moreover, since students’ resources are part of the input for the transformation process to co-create the value the students enjoy, analysis of these human elements for the students could reveal success factors as well.

**In conclusion.** According to Ng and Forbes, education experience does not have homogeneous pre-determined needs, for institutions to understand the elements of delivering outstanding service, it requires “knowing where systems end and people take over, and respecting the co-creation of the learning experience.” (p.16). This argument by Ng and Forbes (2009) is a gap prevalent in education and service literature, where a clear demarcation is assumed to exist between the systems and the people who operate them. The interconnectedness that underlies the processes between the people and the technical systems of value co-creation and service co-production could be better captured by the ESSD. We argue that understanding the nature of this sociotechnical relationship could enable institutions of higher education to deliver on their promised value proposition. The concept of students as customers, consumers, and stakeholders, although rejected by some researchers, could broaden understanding of how best to increase NTAS learner’s outcomes.
Research Methodology

Qualitative case study methods were used in this exploratory study, which lend themselves to in-depth inquiry and understanding of the observed phenomena, and lay a foundation for the development of a well-grounded theory (Engward, 2013; Maxwell, 2012). The study goals were to identify factors that enhance the persistence of NTAS toward degree completion and to determine the adequacy of the proposed ESSD for a pre-design analysis of a pre-college STEM program for adult learners. This preliminary explorative study is appropriate to precede any future quantitative study of the same phenomena.

STEM Programs Selected for Study

Three STEM programs were selected as cases for the study, and the research questions were designed to elicit information about how and why these programs either met or failed to meet the college degree goals of their NTAS learners (Yin, 2017). Two of the programs selected were designed for NTAS college learners pursing STEM degrees, therefore exhibited “extreme representation” of the phenomenon of interest (Yazan, 2015; Yin, 2015, 2017). Their goals were focused on NTAS, and the strategies employed were believed to be better than their alternatives, to be most affordable for the students, and to best deliver the most accessible options available. Both of these programs have been discontinued. The third program was not necessarily designed for NTAS, but it has enjoyed a sustained success in graduating a significant percentage of adult students.

The three cases chosen for this study provide for examination of comparable contemporary practices within their real-life context (Yin, 1981, 2015, 2017). The case study method requires deep understanding of the phenomenon under investigation (Creswell, 2003) from the perspective of those who either provided or participated in the education to NTAS learners. Thus, the directors,
the faculty members, the students and family members of the students were the interview subjects. The family members of the students were included because their student’s college experience has had an impact on them directly or indirectly. The expectation is that the experiences and perceptions of these stakeholders could highlight likely success and failure points and provide insights for better program design and operation. Two of the three programs are:

Case #1: A pre-college STEM program, which was specifically designed for NTAS and that was believed to possess many of the elements that could enhance NTAS degree completion in a STEM field. The students in Case #1 had the opportunity to earn up to twenty-four college credits while strengthening their academic skills in mathematics, English and science in introductory courses. Case # 1 was selected because it is an extreme representation of the phenomenon of interest (Somerville, 2012; Yin, 2017).

Case #2: The second case, an information systems management program, was also designed for NTAS who transitioned directly to a university upon the completion of postsecondary accredited Information Technology skills training. This college STEM program is designed with NTAS learners in mind. It is like a typical college program, except that the students are all graduates of a local Information Technology training program. The students are recruited as a cohort and managed as a unit. They have individualized needs-based mentoring and support as they take classes at the university toward earning a degree in information management. They also are employed by a multinational company within the same vicinity. It was selected because it is also an extreme representation of the NTAS learning program proposed in this study. The first and the second cases were part of the educational services provided by a prominent nonprofit organization in the U.S.

Case #3: The third case is an operations and leadership program, which is a specialty program for Industrial Engineering students at a prestigious research urban university in the U.S.
Case #3 has over 60% graduation rate for NTAS students who form about 70% of the program enrollees, though it was not specifically designed with NTAS in mind. Case #3 was selected because it has enjoyed sustained success in its graduation rate of NTAS learners.

Posited in this study was that relevant information from the constituents of these programs will provide insight into the key factors that influence student success/failure and guide the design of an effective STEM program for NTAS. Although only one of the programs chosen was still ongoing at the time of the investigation, the students have either completed or are finishing up their education at other colleges and universities. This selection of programs is appropriate, because this study is an evaluative analysis of the cases to discover what has contributed to their success or caused their failures. Most of the students and faculty members of the discontinued programs have joined other colleges and have richer perspectives about their experiences at their previous program which enhanced the richness of the interviews.

**Interview Protocol and Theoretical Background**

Both an extensive literature review and informal individual and group meetings with some constituents of the three programs as well as the components of the proposed ESSD informed the development of the interview protocol. The best level of analysis for a programmatic study directed at NTAS learners is at the system level, therefore, the interview questions focused on the multidimensional and dynamic program components and how they worked or didn’t work together.

The applicable values of STS design methodology for effective organizations and the unique learning characteristics of NTAS learners also served as guidelines for the interviews (Knowles, 1978). The values that were reflected in the interview are as follows: a) In addition to designing programs that fit the goals, the support services (SS) must be congruent to the design for optimum outcome (W. A. Pasmore, 1988); b) regardless of the technological and organizational
changes planned at any given time, “the rights and needs of the employees must be given a high priority as those of the non-human parts of the systems” (W. A. Pasmore, 1988), because they can more directly drive student’s success; c) the decision-making process needs to be participatory, because both adult learners and the faculty take more responsibility for the success of any process or policy when their input is considered (Day et al., 2011); d) it is important to empower employees in the design and policies and to control variance near the source (W. A. Pasmore, 1988); e) Consideration must be given to how adults learn better (andragogical principles) (Knowles, 1978). Additionally, faculty and students ranked elements generated from the interviews and literature in the order of importance in enhancing students’ success using Google Forms.

Research Relationships

The principal researcher managed Case #1 as part of her responsibilities for about seven years until it was discontinued in December 2017, and she was associated with the Case #2 program in an advisory capacity for about five years. At the time of this study, the students and staff of Case #1 and Case #2 were no longer personally connected to the researcher as all had moved on to other schools and employment. The researcher was forthcoming regarding the project and explained that every honest response would lead to a better program in the future, that no answer was a wrong answer, that confidentiality of responses was guaranteed, and that there would be absolutely no retribution towards students expressing their honest perceptions and experiences with the programs, regardless of how negative they might be, nor for choosing not to participate in the research at all.

The researcher brought into this study a rich experience of working with NTAS learners pursuing college STEM degrees both in an academic and non-academic setting. This experience is consistent with the recommendations of Yin (2017) that the investigator have good knowledge of the phenomenon. Being knowledgeable and experienced about the phenomenon under
investigation is advantageous as it makes for easier connections between “emic” perspectives of the research participants and the “etic” perspectives found in literature. However, to reduce possible “bias and clouded judgement” (Patton, 2002, p.50), the researcher maintained a neutral position and tone to lessen the likelihood that the students and other study subjects would feel the need to respond positively to avoid coercion or other negative consequences of study participation. As a step to further reduce bias and confirm accuracy, the transcript of each respondent was sent to each of the respondent for validation of the information captured. The researcher’s personal observations were also, sent to two of Case #1 former staff members for verification and validation of her account of the students’ information.

**Qualitative Data Analysis**

The transcripts of the 43 interviews were analyzed using Atlas.ti, which results in 1,154 codes and 15 networks (with between 5 and 42 codes each). (See the Atlas.ti outputs in Appendix D). In all, 7 directors, 15 faculty members, 6 family members (three spouses, two parents, one sibling) and 15 students were interviewed. (See Table 2 below). The network was designed based on causal, association, and contradictory relationships between the codes (variables)(Creswell & Clark, 2017). For example, the interview data shows that organizational commitment to the programs had causal relationship with the quality of the support network, financial support is associated with other support services, while non-participatory management contradicts faculty’s buy-in and commitment. Additional quantitative data concerning element considered critical for college success were collected from both faculty and students using Google forms.
Table 2: Population & Sampling for Qualitative Study

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</table>

CC: A local Community College – Pre-college STEM Faculty members

Findings
The study findings are organized here according to major themes that emerged from the inductive, qualitative data analysis and also as relevant to the nine components in the proposed ESSD model.

Major Contributions
This study revealed student’s success to be a design outcome. Designing to fit core goals (main business goals and the personal goals of employees). It revealed possible STS gaps in faculty’s job satisfaction and conflicting objectives of work design, capable of influencing their performance, and hence students’ outcome. For example, conflict between course objectives and student’s new knowledge absorption rate. Participatory work design and decisions about their work also influence the job satisfaction of faculty members.

Another contribution is in the consumerization of education service. This study crystalizes education service’s basic abstraction as an academic service concept (value proposition). The
student’s resources integrate into this service concept in the co-creation of the value delivered to the student. The role of the institution through its front-line academic staff like the faculty is that of resources’ integration in satisfactory formats for learning to occur (Sogunro, 2015). Tinto’s interactionist theory of student departure reveals that students who depart due to poor performance did not integrate well into the academic and social systems for learning to occur (Tinto, 1975, 2012). The underlying synergistic latent factors may not be discernible because of the deconstructionist approach of inquiry employed in most earlier studies. However, the systems inquiry nature of ESSD approach premised on joint optimization of the social (mostly internal) and technical (academic) subsystems for optimal performance locates suboptimal performance of the program in the marriage between the subsystems (in the context of its external environment) and not in their individuality. This also highlights the importance of a STS based analysis with a tool like the ESSD and subsequent design implementation.

This research also reveals optimal performance/impact of student support and services (SS) exists in the holism of the academic and non-academic services it provides and facilitates. A holistic SS for NTAS is more than a collection of individual support and services. It is a sociotechnical system that enables NTAS overcome the systemic complexity of barriers (learning needs and needs while enrolled) to persist to degree completion. It was revealed that institutional commitment to the cause of adult education drives this system.

This study reveals how a gap between the institution’s business goals and the student’s learning needs can negatively affect student’s college experience. There is a gap between the institution’s business goals and the learning needs of the NTAS. The faculty’s constraints in adjusting to the perceived students’ learning needs because of targeted course objectives were viewed by the students in this study as a lack of understanding and empathy. An STS systems inquiry methodology of the ESSD revealed this discrepancy in understanding. This gap can
generate a significant degree of mistrust that can hinder integration of the students into the academic systems, which is necessary for learning to occur.

Lastly, we provide a definition of effective pre-college/college program that can guide related future work. The definition: An effective PCSP, as a system designed to fit its core (degree completion) and supplementary goals (faculty and staff personal needs), consists of simultaneously and holistically designed social and technical subsystems with adequate internal buffers to maintain stability against or respond to adverse external environmental demands in pursuit of achieving optimal performance. The supplementary goals are the personal physical, intellectual and emotional goals of the faculty and staff that optimize job satisfaction linked to optimal performance of the program.

The Appendix E provides the qualitative study findings summarized as propositions; Appendix D provides Atlas.ti outputs of the analyses.
Figure 4: Key Factors that enabled Success for NTAS Effective Pre-College / College STEM Program

Five inter-related and interdependent factors that contribute to the viability of a pre-college or college STEM program for nontraditional adult learners

Findings Relevant to the Proposed Conceptual Framework

Analysis according to the proposed educational service systems design (ESSD) model helped to highlight the complex systemic nature of and critical elements that relate to (re-)educating underprepared nontraditional adult students to equip them for success in college STEM degree programs. Moreover, the findings indicate the value of an adequate pre-design program analysis using a framework like the ESSD, so that every subtle nuance, yet critical, element is uncovered and adequately accounted for in the program design. Below is the discussion of the findings as they relate to the proposed ESSD components:
1) Goals Clarification, Measurement and Monitoring

The goals drive the design and configuration of any system, but according to the data, not everyone had the same understanding of student success nor shared a vision for the adult learners, or the definition of an effective program, or whether or not students should be considered to be customers. One of the interview questions asked study participants to explain what they understood by each of these terms, and to explain why they may think students are customers, or products, or process entities ("Stakeholders" and "client" were not included in the options). Most of the directors thought that the students are customers, and only one thought the students are products. However, over 90% of the faculty said that they could “never see students as customers,” but most of the students thought that students should be treated as customers. It will be important in future research to determine whether students who pay their own tuition and fees and who do not receive any financial assistance would describe themselves as customers, products or stakeholders. Goal clarification could ensure a common understanding of these key words that can influence attitudes in the program.

All the students frowned at measurement of the progress of students based on the regular university’s credit system. Some directors thought that adult students should have a different benchmark of measurement. Director Respondent 01 said that “We cannot say we know that these students work full-time, have dependent children, and still expect them to graduate at the same rate as the traditional students”.

One enabler of student success identified in this study was “motivated and committed faculty.” However, when faculty were asked if they were always supported to stay motivated to help the students, the response was mixed. The majority thought they were regularly encouraged by management, though not everyone agreed. One faculty member was angry for almost an entire semester because he thought that management omitted him when some of his colleagues were
recognized for putting in extra hours to help the students. A good monitoring system may have been able to detect that a faculty member was unhappy for that length of time and provide the opportunity to correct the situation.

A good monitoring system and learning analytics (Choi et al., 2018) could be equally important for early detection of problems and intervention for students who are at-risk academically and/or those who exhibit patterns of behavior and performance that could lead to dropping out. As many of the faculty indicated, attendance was a big issue for this category of students.

2) Service Offering and Technology

In evaluating the perceptions of the students and the faculty concerning the services offered by each of the programs, connecting the students to reliable employment was considered important. Some of the students who were not employed by a partner employer wished that it was the case that their employment was connected to the school. The students and faculty members wanted the employment connection for better coordination of school and assignment schedules with student work schedules. Students and directors thought it would be a value added to the employers if some assignments could be employment-based projects. In addition to the other services the college or the university offered, there were three specific services that students in Case Program #3 enjoyed, and the interviewees appraised them to be important to students. The extra services were project-based, industry relevant and immediately useable courses, opportunity for a paid internship at one of the partner employers, and scholarships. Two directors of this program corroborated the students’ responses that the three services seemed to be the attraction points of the program. One of the directors expressed a desire to have all the courses grouped in modules, each of which would lead to an industry-recognized certification that would accumulate into an industrial and systems engineering bachelor’s degree.
Technology offered in the program to both enable and supplement the services provided is capable of influencing students’ perceptions positively or negatively and can lead to different student decisions. The computer, software, teaching materials, and school supplies offered were available in “abundance.” However, the study also indicated that the customer-focused service level needed improvement in some of these areas. For example, tablets were provided for electronic books, but some of the electronics did not function properly, and some students did not have internet at home to be able to access the content of the tablets at home and do their homework. In other words, dysfunctional technology negatively affected workflow.

3) Infrastructure

The physical environment of the program is important to learning. There were two physical space disruptions that occurred within one year in Case Program #1. First, in the second semester, the organization located a class of 30 middle school-age students in a classroom adjacent to the Case Program #1 classrooms. The noise level was high and created distractions during class. Although not all the interviewees remember this specific incident, faculty members recalled that the class sent representation to the service provider’s upper management and appealed that the young students be housed in another classroom farther away, and they got their wish. Another incident was in the third semester of the program, when without warning the organization rented out some of the underutilized classrooms adjacent to the program’s classroom to a tier one supplier of local automakers. Many students expressed dissatisfaction with this encroachment on their learning space. Some students left the program within three weeks of this incident (though it is not clear if this intrusion was the specific reason they left).

4) Customer Orientation: Focus on The People the Organization is in Business to Serve

There was significant evidence in the data to suggest that these programs did not have a program-wide or department-wide customer orientation. As highlighted above, the directors and
their faculty members did not agree on viewing the students as their primary customers; therefore, there did not exist collective staff engagement to improve the students’ satisfaction (Eldor, 2019). It is obvious from the low success rate of these programs that the customer orientation, or lack thereof, might have negatively affected the outcomes (Bean & Metzner, 1985). However, further study of this component could reveal if the outcomes could have been much better than what they are currently. The customers of most educational institutions that are nonprofit are the clients they serve (students), the donors who support them (individual and industry partners), and the volunteers and staff (faculty and administrative) members who help get the work done (Rothschild, 2012). Without the students, there would be no program; therefore, the students need to be satisfied.

5) People – Culture (Beliefs and Values), Students, Staff, Classmates, Family, Friends, Alumni, Universities, and Employers

Students are a central focus of the educational system as well as of this study, how they interact with everyone else within and outside the program from a sociotechnical systems perspective.

The interactions with faculty both within and outside the classroom were mostly viewed as positive. Over 75% of the interviewees said that all the interactions with the all the instructors were excellent, nice and helpful. A few of the students felt the same way about the permanent full-time faculty but did not think that they always got helpful responses from some of the adjunct faculty.

The student network involved the interactions of all the students in the cohort. For example, Case Program #1 was structured into cohorts, and collaborative groups of five students each were formed out of the class of 39 students. There was regrouping by self-selecting that occurred throughout the duration of the program, based either on course offerings or by group projects. Fifty percent of the interviewees expressed dislike for the initial grouping because they were not
comfortable working with strangers, or because of the generational gap expressed by one of the interviewees. All interviewees adjusted quickly and ended up gaining from the interactions with their classmates. As for whether they benefited from the course interaction network, the data showed that every one of the fourteen student interviewees were encouraged to persist to graduation. However, the interviewees also believed that some of the students who dropped out may not have benefited from it.

*The Students and their Friends* - showed that friends who had college degrees were mentioned as very helpful, and those individuals may have influenced the interviewees. Overall, data revealed that the impact of friends did not seem as significant as expected, because some of the interviewees were predisposed for success. Friends who could not adapt to the adjusted availability of the interviewees for socializing stopped communicating with them and naturally drifted away.

*The Students and their Families* - Family showed a very strong connection to the student decision to persist to graduation with as many credits as possible. shows minimal family support influencing the decision to persist is a feeling expressed by about 80% of the interviewees. They expressed that without the level of support they received from their family, they were certain that they would have dropped out of the program.

6) *Socioeconomic and Sociocultural Factors*

A socioeconomic component was included in the study to focus on the affordability of the program and the ability of the students to take care of their daily expenses as adults while in the program. Financial incentive was overwhelmingly a major draw to the programs. Even students in the second case who did not have scholarships but would have loved them all through the program, appreciated the regular need-based increase of their number of hours worked at the industry partner employment. One of the students expressed her gratitude for the employment she got through
school which she said paid her “enough to take care of most of her expenses” (S0205PS). For students in the Case Program #1, over 90% of them stated that they would not have enrolled in the program if they had to pay for it.

Data indicated increased cultural diversity in the classrooms that if not accounted for can disrupt the education of some students and frustrate some faculty members as captured in the statement by Faculty 08 below.

**7) Workflow and Communication Structure**

The study indicated that the education service delivery processes did not optimize their outcomes. The students had negative perceptions of teaching styles when instructors piled topics upon topics without ascertaining that the students had absorbed previous topics. There was evidence in the data of this difficulty in that the faculty did not always coordinate among themselves the amount of homework each gave to the students and the due dates. There was also evidence of absenteeism due to school-work schedule conflicts.

**8) Internal Organizational Policies, Procedures, and Culture**

This finding includes the organizational structure, the policies and procedures, and the student-centric culture. All the participants from the three case programs in this study indicated that, for the most part, the culture was warm and welcoming. Student Respondent 04 captured this: “Everyone was always available to help, and it was easy to get the help …and all the staff seemed to have one agenda of helping the students.” This sentiment was expressed about program staff as well as organizational personnel with whom the students interacted.

The faculty members of Case Program #1 and Case Program #2 did not think that the organizational policies favored faculty members. An example was given by one of them and captured in the following statement: “It appeared like I had to be a manager or assistant manager to get paid well and I don’t want to be a manager. The organization should recognize the work the
faculty members do and adjust their pay scale accordingly. It was discouraging.” (F0102JS). This faculty member had two bachelor’s degrees in English and engineering, and another who expressed a similar sentiment had a Master’s in engineering. The faculty in the Case Program #3 organization did not seem to have the same kinds of problems with pay scale, perhaps because the program was part of a larger, well-established university.


One major external environmental event that negatively impacted the pre-college programs was the loss of sponsorship. Since all the students got some degree of financial assistance for tuition and fees, all of them could have been affected by loss of sponsorship. However, for one of the case programs, the affected department raised funds from other sources to continue the sponsorship. Increased employment hours were arranged for many of the students in the 2nd Case Program. The 3rd Case Program was temporarily suspended. This component is where the customer orientation provides an opportunity for sustainability of a NTAS learner’s program and the finances must be adequately analyzed, with funds assured, before the program can start.

Another component of the external environment that positively influenced the students in two of the case programs was the services of the state Department of Human Services (DHS). DHS was one of the partners of the organization of two of the case programs, and it had an office on the organization’s campus for easy access for the students who needed their services. Those services were acknowledged in the interview as being very helpful.

Recommendations and Suggestions for Further Research

One of the most important concepts about student academic success and persistence in college both for traditional (Tinto 1975, 1993, 1997, 1998) and nontraditional students (Bean
and Metzner, 1985) is the concept of student integration (academic and social). As co-producers of their own education, students need to encounter the educational service concept to enjoy the service. Correlations have been established in literature between degree of integration with the academic service concept and positive academic achievement. In other words, all things being equal, the higher the level of academic and social integration, the higher the intent to persist in college. According to White (2015), “many researchers believe that knowledge is constructed by humans through social interaction) (p. 10). Spady (1970) and Tinto (1975, 1993) used sociological and interactional perspectives, and others, like Bean and Metzner (1985), were more psychological. Regardless of the disciplinary approach, the studies advocate deliberately designed meaningful connections with technologies, faculty and classmates through varying channels of communication and learning (White, 2015; Hesse & Mason, 2005, p.30), in the value co-creation process. What is not yet known is how to increase the engagement and level of interactions between significantly more students with both the formal and informal academic and social service concepts to enhance performance and student persistence to degree completion. The proposed ESSD could increase understanding of student’s non-technical needs that must be addressed in program design for the desired outcome to occur.

Most of the findings of this study support what is already known in adult learning and retention research. However, bridging the gap between what is known about factors that enable adult learners’ retention and actual success is still missing (Tinto, 2012). The most important contribution of this study is the Educational Service Systems Design (ESSD) framework for a more comprehensive analysis of a program’s capacity to address the learning needs of its students. The framework can be used for pre-design analysis of pre-college and college programs for NTAS learners. It is also believed to be appropriate for a pre-design analysis of other educational service programs.
The nine-component framework can be best utilized to precede designing a program for NTAS. However, it also can be used to analyze existing programs for potential redesign before a new cohort starts. The nine components are interrelated, interdependent, and must work together for optimal outcomes. They can be grouped into technical and social systems as they interact for the achievement of the common goal of enabling the maximum number of students to complete their degree requirements.

The goal, like a typical vision statement, needs to be clear and well understood by all the staff members. This framework encourages institution-, department- or program-wide vision sharing, because the philosophy of customer orientation cannot be well-executed with only a few people in the organization aware of it. An adequate analysis according to ESSD should guarantee that everyone who is directly and indirectly connected with the students participates in and is aware of the student-centered strategy of the program.

Even worse than not having a clarified goal is not monitoring its progress and making provisions for managing variance as close to the source as possible for continuous improvement. The goal clarification, measurement and monitoring components address multiple areas - the student, the program offerings and its SS, and there are low cost learning analytics systems (Choi et al., 2018) that can be employed to ease this effort. This analysis means understanding the entry characteristics of the students, including their learning needs, then determining how to combine the SS to reinforce one another and meet these needs. This understanding is the key to optimal impact of the student service and what is termed the student service support network (S3N) in this study.

The program also needs to be deliberate about what services to offer, why, and by whom (whether an internal team or external partner). An incoming cohort that needs remediation, for example, may be able to take some general education courses while strengthening their skills in
the other areas. This strategy could keep their motivation and excitement about gaining admission into a college alive while filling any academic skill gaps.

The associated technology for the educational services offered is equally important. Adequate analysis is recommended of not only the physical, technical tools, but also the possible faculty members who will teach and work with the new cohort. This study determined that merely being knowledgeable was not enough to work well with NTAS learners. The staff also needed to understand adult learners and their unique learning needs, and be willing, motivated and prepared to teach adult students. A program can work against its own goals by not properly vetting the staff that is hired to work with the adult students.

Many adults travel from work directly to the class, so analyzing the infrastructure would be important. Understanding the make-up of a new cohort for an existing program or pre-analyzing where and how adults coming from work can “settle down” before or after classes could help to increase engagement and attentiveness in class. Analyzing this component could also ensure that adequate provision is made for a conducive atmosphere for learning, friendly interactions with the faculty and fellow students, as well as space for collaborative studying with classmates.

People, as the driver of the social systems underlying every program, or as human technology, is the most important component of the ESSD, as it cuts across all the other components. This study revealed that people can go beyond the call of duty to ensure the success of a program. People can also choose to do the bare minimum required of them. ESSD can ensure detailed analysis of how the people of the organization could optimally work with the adult learners. The analysis could determine what motivates people in a particular program and how can they be engaged and have the utmost buy-in to the program’s shared vision. Educators and program directors sometimes expect automatic buy-in from staff, but sociotechnical systems philosophy,
and this study, reveal that this is not always the case. Buy-in, especially from front-line employees, must be deliberately established.

As expressed by the directors interviewed in this study, accurate understanding of the socioeconomic and sociocultural diversity of an incoming cohort or program is important. As faculty Respondent 08 stated, “There is only one me, and there are so many cultural viewpoints that I encounter in my classes; some, I know how to approach, and some I don’t. What is acceptable to one person may be offensive to another. It can be challenging…” Determining who needs what and how best to package, the SS is key to achieving maximum impact of the SS. Also, in addition to grants and scholarships, it is important to determine if work-school partnerships that provide students with employment could fulfil the financial needs of some of the students and use this offer of stable employment to motivate student persistence to degree completion.

The analysis to achieve an effective workflow rests with understanding how the schedules of an incoming cohort can be stable for at least an entire semester. One way identified in the study is to work with some employers, but this strategy requires adequate partnership.

Communication flow can be a big issue with adult students who want to know about everything that concerns them as soon as possible. Unfortunately, the data revealed that adult students are not that eager to inform the program about changes on their side. Some of the students in the study frowned at being required to call in if they were going to be absent. Consider if and why knowing whenever a student will be absent is important for their college success. For example, if a partner employed the students, then ensuring that the students develop the right work etiquette could mean that the students are required to call in if they will be absent from class, because it will be required of them in their employment. Also, decide how many channels will be used to disseminate official information to the students. This requirement could be determined through analysis to reduce misinformation or inadequate information.
Analysis also can reveal the level of commitment of the organization. One of the directors expressed frustration about an organization expecting him to make success of the program happen with little to no organizational-level support tools. The ability to monitor progress in that program was greatly hampered. Usually, when commitment is lacking, the students notice it, because they suffer from it. However, they tend to blame it on the front-line staff members with whom they interact with regularly. This blame can create mistrust and discourage student engagement.

Institution or program policy needs to be ascertained to be student-centered to achieve the best outcome for the adult learners. With an understanding that adult learners work and have family responsibilities, setting their curriculum content and timeline to be the same as those who are in school full-time is being unrealistic. Adult learner-centric policy could include a customized curriculum, a clearly set pathway to degree completion, and provision of all support and services to enable the achievement of the work plan.

The culture where adult students feel welcomed everywhere on a college campus can be created beginning at the organizational level. Of course, analysis alone would not create that culture. But understanding the existing culture and identifying how a non-adult-centered culture can be avoided is an important start in creating the right culture for a program. A “psychology of success” talk was instituted in one of the programs where one of the directors met with the students once a week to inspire them and have an open dialogue to ease tension and to learn different and more beneficial ways to evaluate some internal or external events, including personal issues that students didn’t mind sharing. All the students indicated that they enjoyed those sessions. The outcome of an analysis or “scan” of the internal environment was the reason those sessions were started by the director. They helped in managing students’ perceptions about some of the components of the program. From a sociotechnical systems perspective, this is the third dimension of an organization, because its survivability greatly depends on how well the organization is able
to adjust to the demands of the external environment. While retention researchers like Bean and Metzner (1989) and Tinto (1993) found that the external environment was influential for adult learners, it is equally influential for the program or institutions themselves. The implication is that the adult student is pressured from the external environment directly or indirectly because of the external environment’s effect on the organization. The adult’s learners’ interactions with the external environment are complex since there could be many events that they are involved with externally that the institution may never know about and cannot analyze before or after they return to college. For example, one pre-college STEM program student, on his way home from school, lost his backpack, but did not want to share that information because of the possible repercussions. Most of the things in the bag were free supplies he received from the program. He did not have the money to replace the books and other materials and was considering dropping out. The decision was made by the program to replace the books so he could continue; he successfully graduated a few years later. This is an example of how an event in the external environment may not be directly observable, but adequate analysis could allow for a quick program adjustment to manage adverse effects from the external environment. Without extra school supplies, it was obvious that the said student could not have become an engineer today. The sustainability of a pre-college program or a dedicated college STEM program for adult learners needs to be adequately analyzed and necessary measures taken to avoid program-level disruption of their education or adverse effects due to environmental pressure on the program.

This research focused on directors, faculty members, students and the students’ family, but there are other people who work directly with the students whose experience could reveal additional information to update our current understanding. For example, these people could include academic advisors, administrative staff, and partner employers. What additional knowledge do academic advisors need to better assist the adult student? What can be learned from
their interactions with the NTAS learners? How do the administrative staff view adult learners? For the administrative staff, how does their relationship with adult learners affect their attitude when helping them? What do employers think about co-ops, internships and fully employed students who attend college? How can these kinds of partnerships impact their business? How willing are they to support their employees who are adult students in college? There are still many questions to be answered.

This exploratory qualitative study indicates that framing education as a service, especially when pre-college STEM educational programming is directed at non-traditional adult students, is appropriate and may enhance student success. A quantitative empirical study needs to be conducted to further confirm the adequacy of the ESSD for pre-design analyses as well as for analyzing an existing program for viability in producing the desired long-term result of success in a college STEM program.

**Conclusion**

Many factors, themes and possible propositions relating to best practices for NTAS college programs emerged from the data that can be valuable for pre-college and STEM program designers. Moreover, the proposed ESSD is supported to a significant extent as adequate for a pre-design analysis of a PCSP. The in-depth interview of the 43 participants (directors, faculty, students and their family members of the students) revealed comprehensive findings concerning NTAS learner’s perceptions and actual experiences and the components that could enable their persistence through to degree completion. The multiple perspectives provided a more balanced view of a college STEM program for NTAS learners. It can be more effective in enabling a greater success rate among this demographic.
CHAPTER 3: QUANTITATIVE STUDY

Quantitative Analysis

There are two main goals to the second part of the quantitative method used in this research. The first was to empirically test the ESSD pre-design framework for designing an effective pre-college/College STEM program for nontraditional adult students (NTAS) based on a sociotechnical systems (STS) view of a college STEM program, a concept henceforth referred to as sociotechnical education service system (STESS). The second is to determine the effects of the different components of a college/pre-college STEM program, represented here as STESS on the degree completion of the adult learners.

The STS approach has been used for organizational design, change and continuous improvement since the 1980s. It has been used in IT (Palvia, Sharma, & Conrath, 2001), healthcare (Sittig & Singh, 2010, 2015), and the diffusion of IT in educational institutions and platforms (Law, Liang, & Cheng, 2017; Telem, 1996), but has very limitedly been utilized in the operational improvement of education systems. A conceptual model, the educational service systems design (ESSD) framework is proposed. ESSD is a more granular representation of an organization’s internal structure than Leavitt’s (1965) change management model’s four components of task, technology, processes, and people. Although higher education is a service (Ng & Forbes, 2009), but it does not seem to operate as such (Bitner et al., 2012). As advocates of IHE business models to become more service oriented (Eagle & Brennan, 2007; Elshamouby, 2015; Guilbault, 2016; Mark, 2013; Ng & Forbes, 2009) are increasing, hence the preferred terminology in the present study is, educational service systems design (ESSD) and sociotechnical education service systems (STESS), with emphasis on service. (See chapter 2 for extensive literature review of college education for nontraditional learners as a service). It is posited that the ESSD would be a valid and
reliable tool for pre-design analysis if with the lens of STS, a STEM college program for adult learners is depicted as consisting of nine components including the external environment.

The definition of a sociotechnical system is a system that is made up of interdependent and inter-related social and technical systems that interact to enable the achievement of the common goal of the system in the context of the external environment in which the system is embedded (W. Pasmore et al., 2019). The definition suggests that the two subsystems can mediate each other, and that STESS is a higher-order construct (HOC) that is made up of the two subsystems and can possibly mediate their effects on the goal of the system. The social subsystem is made of people, (usually of the internal organization), the authority structure, workflow, communication and all human related processes. The technical subsystem is made up of technology and the goals and business propositions of the organization, and the external environment is everything outside the formal boundaries of the system (Pasmore, 2019). The external environment includes everything that can either directly influence the students and or the system, like employment conditions for the student, and an economic downturn for the system. Thus, the social subsystems can be observed to consist of four components of people, workflow and communication flow, policies and customer orientation philosophy and practices. The technical subsystem consists of goal clarification, measurement and monitoring, service offerings and technology, infrastructure and socioeconomics principles and practice. Therefore, STESS “represents a more general construct of the two formative latent constructs - the social and technical subsystems (J. F. Hair Jr, Sarstedt, Ringle, & Gudergan, 2017). Moreover, each of the two constructs that form STESS represent “more general constructs of the reflectively measured lower order constructs (LOCs)” (Hairs, et al., 2017, p.45) listed above. Since, the social and technical subsystems are formed by first order LOCs, and are therefore, second order latent factors, which implies that STESS is a third order formative latent factor. Some components of the external environment, like the number of hours worked, student’s
family responsibilities and some level of work-school schedule conflicts, and family-school schedule conflicts exert pressure on the students in ways that could negatively affect retention. They are represented in the study as inhibitors that act from outside of STESS and do not form it. As observed by Hair and his colleagues, “the specific LOCs do not necessarily share a common cause but rather form the general HOC”. “A modification in one dimension does not necessarily imply a modification in another. In other words, they do not necessarily covary; rather, each dimension can vary independently of the others” (Barroso & Picón 2012, p. 532 referenced by Hairs, et al., 2017, 11).

Thus, the STESS is modeled in the present study as a third-order construct that is formed by two lower-order constructs of the social and the technical. The eight internal factors make up the social and technical subsystems (in the context of their external environment) and both form the STS and collectively enable students’ degree completion.

| Table 3: A summary of the Sociotechnical Education Service System (STESS) Components |
|----------------------------------------|--------------------------------|-----------------|
| **Summary of the Theoretical Model: The Sociotechnical Education Service System Composition and hierarchy** |
| **Third Order Construct** | **Second Order Constructs** | **First order Constructs** | **Definitions** |
| Sociotechnical education service system (STESS) | Social | People (P) | Who make things work |
| | | Policies (Z) | Institution commitment to the students |
| | | Workflow (W) | Free flow processes and communication |
| | | Customer orientation (C) | Philosophy of student-centeredness |
| | Technical | Goal clarification, measurement and monitoring (G) | Feedback mechanism |
| | | Service Offerings – ((T) | Relevant and quality curriculum and supplementary services |
| | | Infrastructure (I) | Technologies, learning materials and facilities |
| | | Socioeconomics factors (SE) | Financial support strategies |
| External Environment | External Environmental pressures (EE) | Inhibitors of program processes |
Moreover, education, retention researchers found that student success and persistence is a function of their integration into the social and the academic (technical) subsystem of college. Although their social system was more focused on informal interactions and student organizational engagement for traditional age students and outside the class engagement for adult, this study expands the social construct to embrace all that it is in the context of organizational development literature. Because students of IHE are intricately involved with the school in co-producing their own learning, the external environmental enablers were considered under the different internal features where they may fit. For example, the influence of family support was included under the people component of the social system. However, the external environmental pressures and inhibitors were considered to exert influence on the performance of the STS by exerting pressure on the students. The external environmental factors simultaneously exert influence on STS and they must be understood and accounted for in the design of effective college STEM programs.

An empirical study is necessary to understand if and how an STS-based view of institutions of higher education could support the effort of increasing student success and retention. The empirically tested STESS using students’ perceptions of each of the features in the conceptual model followed to understand the entities that contribute to degree completion. The students’ goal commitment (Bean & Metzner, 1985; Tinto, 1975) and student’s satisfaction (Sogunro, 2014, 2015), which have been shown by previous student success and retention research as an enhancer of retention or persistence, were included in the empirical test to understand how they influence the performance of the STESS.

Also, based on the definition of a hierarchical formative construct, STES was determined to be a third order formative construct because of the “operational definition of the conceptual variable”(J. F. Hair Jr et al., 2017). This suggests that the value of the STESS as a third order construct would change if the value of a lower order construct (LOC) like the social or the technical
changes due, “for example, to a change in a respondent’s assessment of the trait being captured by
the LOC” (Hairs, et al, 2017, p. 43). Higher order constructs (HOC) are combinations of several
specific LOCs that represent “more concrete components” that together form the overarching
concept of the HOC.

According to Jarvis et al. (2003), four criteria for determining a construct as formative or
reflective also suggest that the social, technical and STES constructs are formative. Jarvis et al.’s
four criteria are (1) the direction of the causal relationship between a construct and its indicators
(2) whether or not the indicators are interchangeable, (3) whether or not the indicators co-vary (4)
whether or not the clustering of the indicators define any discernible nomological network (Jarvis,

STES is formed by two second-order formative latent factors of social and technical, and
each of the second order factors is formed by four first-order reflective variables. Thus, the first-
order factors reflect their variables instead of their variables forming them. The reflective items
measure each of the variables they reflect.

Research Model
(Figure 5 below shows the conceptual model of the quantitative analyses).

**Hypotheses**

The hypotheses in this study are developed from the lens of the socio-technical system
type (STS) (W. Pasmore et al., 2019; Trist, 1981), and higher education as a service system
(Archambault, 2008; Bitner et al., 2012; Ng & Forbes, 2009).
The primary dependent variable in the study is “retention”, and it is used as a proxy for a financially
independent adult learners’ intention to complete degree. This makes sense, since academics are
usually the primary focus of the NTAS learner in college (Bean & Metzner, 1985; M. Bergman et
Much of the extant attrition-retention research and articles suggest that if an NTAS learner progressively persists, they will complete their degree requirements (Brown, 2012; Lee, Chung, Hashim, & Lim, 2011; Nash, 2015).

**Figure 5: Quantitative Conceptual Model**

Learning outcome was also included as a dependent variable because it is usually a measure of learning service encounter. Many proponents of higher education as service insist on value creation for the delivered service to have been consumed (Gummesson & Grönroos, 2012; Ng & Forbes, 2009), and by value, they mean the outcomes of the learning co-production process. As argued by Gummesson (1998), “if the consumer is the focal point of marketing, value creation is only possible when a good or service is consumed. An unsold good has no value, and a service
provider without customers cannot produce anything.” (p. 247). Extending Gummesson’s argument to the education service, an unconsumed education service means that value creation did not occur for the students (Christensen et al., 2010). In addition, “value for customers is created throughout the relationship by the customer, partly in interactions between the customer and the service provider… the focus should not be on the service produced, but on the customers’ value-creating processes where value emerges for customers and is perceived by them.” (Vargo and Lusch, 2014, p. 11 referenced Gronroos, 2000). The primary function of HE as service providers then becomes the value proposition: “facilitation and support of a value-creating process… rather than simply distributing ready-made value to customers.” (Vargo & Lusch, 2014, p. 11). Thus, it is posited in the present research that if a student is doing well, meaning if value is emerges for a student, that might enhance retention. Thus, the findings in this study could increase the understanding about STESS’s influence on learning outcome.

STES is also a dependent variable in the study as the effects of social and technical and the external environment need to be understood, before proceeding to determine its effects on retention. Therefore, the first hypothesis to examine is:

H1: The Social system positively relates to STESS
H2: The Technical system positively relates to STESS

There are five independent variables with differing numbers of indicators. The variables are the entry characteristics of the students (which include goal attainment commitments of the learner), the external environmental variables, internal environmental variables grouped into social variables and technical variables, and student satisfaction. These variables have previously been investigated and their relationships with retention/persistence was established (Bean & Metzner, 1985; M. Bergman et al., 2014; M. J. Bergman, 2012; Tinto, 1997a, 1997b, 1998, 1999, 2003, 2006). However, these variables have not yet been investigated from a sociotechnical systems
perspective. A sociotechnical systems perspective is necessary to increase the understanding of necessary pre-design analysis for more effective STEM programs for adult learners. The theoretical background of each of the indicator of the dependent and independent variables are briefly described in the next section.

Social and Technical Subsystems Influence on STESS and its Relationship with Retention and Learning Outcome

The first principle of STESS as a service system is that students co-create the value they enjoy in both academic and non-academic services (Bitner et al., 2012; Yi & Gong, 2013). This process of co-creation requires interactions (Prahalad & Ramaswamy, 2004) between the students and the faculty, learning technologies, administrative staff and other components of the service, (Delpechitre, Beeler-Connelly, & Chaker, 2018, p. 11), and these are the social and technical components of the institution, or what Tinto (1975, 1993) refers to as social and academic systems and those who operate them. Together, the social and the technical effect desire outcomes as a unit referred to in the present study as STESS. The act of combining internal and customers’ resources must be a well-coordinated and “satisfying” experience for learning to occur (Sogunro, 2014), and any dissatisfying experience must not negatively impact the quality of the supplementary service delivery (Ng & Forbes, 2009; Vargo & Lusch, 2004). Because these systems are interdependent activities both within systems (social and technical), between their formal and informal components (for core and supplementary service delivery), and between systems, they interact in a variety of ways (Tinto, 1993; Pasmore, 1988). “The core level centers around the learning experience, which is shaped by factors deemed crucial for enabling students to meet their study obligations (Elbernounby, 2015, referenced Clemes, Gan, & Kao, 2008).

Different forms of students’ participation in the process of co-production of education services in IHE relate to students’ satisfaction, retention, and performance/outcomes
Tinto’s seminal study, which highlighted departure (as opposed to retention) as “a longitudinal process of students’ interactions with the academic and the social systems of the institutions” (1975, p.94), showed that students’ integration with the social and academic systems of an institution relates to their persistence, and have varying learning outcomes. From a sociotechnical systems’ perspective, Tinto’s academic systems corresponds to the technical systems, while the social systems correspond to his “social system and those that make them happen.” Tinto added that, to gain a full understanding of the process of departure, “one must take note of the full range of individual experiences which occur in the formal and informal domains of both the social and academic systems of the institution” (1993, p.118). The interactionist theory states that integration of students into the social and technical systems positively relates to student departure (Tinto, 1975, 1993).

The social systems consists of both the formal (interactions with the faculty, classmates and the internal staff members) and informal (extracurricular activities, friendships and relationships outside the classrooms, and so forth.). The social system also include the workflow, communication flow, policies and the philosophies of service provision (Leavitt, 1965; W. Pasmore, Francis, Haldeman, & Shani, 1982; W. Pasmore et al., 2019; W. A. Pasmore & Sherwood, 1978a). The academics offerings and associated technologies(J. Groff, 2013) correspond to technical and contribute to the overall student outcome in the STESS. However, the quality of the integration of students determine the quality of outcomes. Students’ integration serves to enable value co-creation, both academic and social. Whereas, the technical domain for both the traditional age students and the adult learners is usually the same, but the social domain for NTAS learners is smaller within an institution and tend to intercepts with their external social circle (Bean and Metzner, 1985). The adult learner’s social domain within a college consists mostly of relationships formed with the internal social systems (components and actors) who
participate in the formal core educational service and supplementary service delivery. For example, informal relationships formed with faculty, peers, tutors, academic advisers, and other administrative staff members are the cause of service encounters and service co-production. It is also included significant family members, friends, professional organization and employment colleagues.

The entire continuum of the student’s experience includes value-adding and non-value-adding activities, meaning those that contribute directly to learning and those that do not directly relate to learning outcomes. The absence or poor quality of either can cause dissatisfaction, and can negatively influence co-production behavior in the value-adding segments (Ng & Forbes, 2009).

Ng and Forbes categorized these activities as core (those that contribute directly to learning value co-creation) and supplementary (those that do not directly relate to learning outcomes) services of education. The core service is “embodied in the learning experience of the student” (p. 48), whose outcome quality is dependent on both the institution’s and the students’ inputs in the co-production process. The student as a production resource provider and a contributor to the quality, satisfaction and value of the learning co-creation can be understood and managed to bring about better student outcomes (Bitner et al., 2012; Elsharnouby, 2015; Ng & Forbes, 2009).

In representing a university as a service, Ng and Forbes showed that people, physical evidence (materials, teaching facilities, accommodation, recreational facilities, and the like) and processes contribute to both the core service and supplementary services they provide. People include students, academics, administrative and support staff, and processes include facilitation of applications, registration, exceptions, learning activities, and social activities. From a sociotechnical systems perspective, the three elements listed by Ng and Forbes, that contribute to the core and supplementary service of a university constitute the social and technical systems of
the institution. These authors emphasized that the contribution of the processes happens in a mix of the actors (the social) and the materials used in the processes (technical), and the perceptions of the students concerning the quality of their experiences can influence service outcomes, which includes both learning outcome and intention to stay or not. Similarly, Tinto explained, “colleges are systematic enterprises comprised of a variety of linking interactive, reciprocal parts, formal and informal, academic and social. Events in one segment of the college necessarily and unavoidably influence events in other parts of the institution” (1993, p.118).

The effects of supplementary services have been directly linked to students’ dissatisfaction, which can in turn affect service co-production behavior (Elsharnouby, 2015). Sierra and McQuitty (2005) found that in the co-production of service by a frontline employee and their customer, the “what” is not as important as “how” it was produced, meaning that the quality of the interactions between the employees and the customer during that encounter is paramount (Sierra & McQuitty, 2005). This implies that every encounter of the student in the “customer journey” counts toward the net satisfaction (the difference between the positive and negative experiences) and the cumulative learning and knowledge gained and overall performance in college. Therefore, every part of an organization must cooperate for the desired outcome to occur, not isolated entities and activities.

Collective engagement, as an internal organizational policy, is driven by a shared vision of overall student’s success (retention and positive learning outcomes) and must engage personnel involved with everything that concerns the students (Eldor, 2019). IT/technology and any learning analytics staff, financial aid and student’s placement staff, facility design and maintenance staff, administrative staff, and so forth, become willing to invest in how they can use each of their areas to contribute to achievement of the institution’s or department’s goal of student satisfaction, retention, and performance.
The second principle of the service-dominant logic of co-creation leveraged in this study is that the student, as the consumer of HE, is treated as a resource (operant) critical to achieving the desired outcome. In the words of Vargo and Lusch (2014), the student becomes “primarily an operant resource (co-producer) rather than an operand resource (‘target’) and can be involved in the entire value and service chain in acting on operand resources.” (Vargo & Lusch, 2014, p. 11). Operand resources are “resources on which an operation or act is performed to produce an effect… and operant resources are employed by providers to act on operand resources (and other operant resources.” (Vargo & Lusch, 2014, p. 2). According to these authors, IHE do not just deliver prepackaged knowledge to students with a manual on how to consume as much as they each need, which is the prevalent goods-dominant mindset. This service-dominant principle forces IHE to insist on the value-creation processes, because only when value is created for the students was the delivered service consumed.

Therefore, the role of the student is twofold—firstly as a production resources provider and secondly as a contributor to the quality, value, and satisfaction which they perceive from the resultant services (Ng & Forbes, 2009). Moreover, the learning experience is emergent, it is unstructured (Vargo & Lusch, 2014), and as Ng and Forbes added, it is hedonic. Thus, the students determine the value they get and must participate by engaging in the co-production process. However, because of the reflection of and the impact of the outcomes of the co-production process on the IHE's service performance, strategies must be geared toward increasing the quality and quantity of students' participation in the co-production process. Therein, is the value of a viable STESS.

For the levels and intensity of engagement to define the entire continuum of the students' college experience, the social systems (formal and informal) and the technical systems (academic and non-academic) need to be designed to correspond to the degree of engagement required. One
of the sociotechnical systems design principles is for the support of supplementary functions to align with the goals of the system (Passmore, 1988).

The concept of co-creation of value or co-production of services supports the long-held principle of learning that all "learning begins with students' engagement" (Shulman, 2005, p. 38), referenced by (Groccia, 2018). This implies that the first step towards enhancing students' experiences that could enhance academic performance, satisfaction, and retention starts with engaging the students in relevant academic and social activities on the three levels of "doing, feeling, and thinking" (Groccia, 2018, p. 14).

One of the implications of the three levels of purposeful engagement of the students and alignment of support services is a well-coordinated, collective engagement (Eldor, 2019) of the academic staff (the faculty and the academic advisers), and the administrative staff needs to be collective. Collective engagement (CE) here means every staff member who interacts with the students, regardless of how infrequent, become a team player in a conscious deliberate and voluntary adaptation of work assignment and tasks to engage the students on the three levels whenever applicable, to enrich the students' experience with each encounter. Collective engagement is defined in service as "a strong willingness to holistically invest physical, emotional, and cognitive energies in the organization's business goals" (Eldor, 2019, p. 2). Eldor found that collective engagement enables a value-creation capacity at an organizational level that maps "shared vision directly to service performance" (p.1). The keyword in Eldor's quote from above is "shared," which is equivalent to visions of retention and positive learning outcomes constructed by a participatory decision-making process (Pasmore, 1988), and service performance can include improved retention.

The shared vision of an institution could be within a department of a dedicated program with a focused goal and curriculum. However, collective engagement would call for a shared vision
of enhanced overall student experiences in the longitudinal process of interaction throughout the duration of their education in the institution - STESS. Therefore,

H₁: The Social subsystem positively relates to the viability of STESS

H₂: The Technical subsystem positively relates to the viability of STESS

The hypotheses about STESS and the DVs are in the Dependent Variable section below. The present study seeks to determine if and how each of the components may contribute to the overall program performance in facilitating increased graduation of adult learners in STEM program. A brief description of each of the four components of each of the subsystems of STESS follows below.

The Social Subsystem components

People (Interactions 1-10)

The people variable corresponds to Leavitt’s actors. For a PCSP or College STSM program, identifying, and understanding how each member of the people component could affect the system’s performance (Leimer, 2011) was important in the present study. The people variable is made up of all the people that influence students’ degree completion, which include the faculty, academic advisors, financial aid officers, management, employers, professional organizations, friends, family, and peers. Because students are intricately connected to the institution and their success depends on their degree of integration into the academic (technical) and the social subsystems of the institution (Tinto, 1975, 2012), they are included in the people category in the ESSD. In representing a university as a service, Ng and Forbes (2009) showed that people, physical evidence (materials, teaching facilities, accommodation, recreational facilities, and the like) and processes contribute to both the core and supplementary services education provides. The people include students, academics, administrative and support staff, and processes include facilitation of
applications, registration, exceptions, learning activities, as well as social activities. These processes Ng and Forbes (2009) described include people and the relevant technology working together to co-produce the service delivered to the students.

Many involved people are external to the organization. Through the students, significant family members can also be included because they provide support (Bauman et al., 2004) and sometimes pressure on the students. For example, engaging students’ family members early in the program to support the students in their efforts could enable social and emotional support from their families (Bauman et al., 2004).

The strategic importance of a PCSP’s partnerships with industry, colleges, college departments, philanthropists, or governments, skill training programs, non-profit organizations and so forth have been highlighted by many who are familiar with the struggles of NTAS (Christensen et al., 2010). This collective-impact strategy has been recommended and adopted by some who found collaboration to be effective in increasing students’ success (Applegate & Fulton, 2016; Austin & Seitanidi, 2012; Gluesing et al., 2008; Polesel et al., 2017; Richey et al., 2014; Santos & Haycock, 2016). For example, students’ financial stability can be enhanced by partnership-based employment while attending college as internships, co-ops, or direct part-time or full-time employment (Berker et al., 2003; Rouvrais et al., 2017). An employment-based partnership can also mitigate schedule conflicts between employment and school that often put pressure on adult students’ attendance and performance (Markle, 2015). As in other services and industries, the primary customer (the student)(Guilbault, 2016), also referred to as the core stakeholder (Bjørkquist, 2009; Guilbault, 2016; Kettunen, 2015; Marić, 2013), is a key element in the design process whose needs and wants provide the main goal of the program.

Various stakeholders in society and policymakers increasingly judge the performance of higher education institutions by their graduation rates (T. R. Bailey, Calcagno, Jenkins, Kienzl, &
Leinbach, 2005). Thus, it makes sense to translate students’ intent to graduate as a program’s positive performance.

Other external environment pressures of IHE are stakeholders with their increased demand for accountability and budgetary transparency. However, the present study is a scan of the program performance from the student’s perspectives, and the demands of the society and policy makers on the institutions may not be obvious to the students.

In emphasizing the importance of the internal program staff, Liefner (2003) stressed that when external performance measures influence the internal allocation of budgets, institutions should guide against jeopardizing the empowering of their staff because, according to him, “the long-term success of the institution depends on the qualifications, aptitudes, and motivations of employees, which, in turn, influence student outcomes” (p.28). Moreover, the performance of a system is related to the decisions people make about how to use the system (Simon, 1956). Therefore, people collectively contribute to the overall performance of the STS through the social system.

Policies (Policies 1-6): Organizational structure, policies and procedures

The authority structure, workflow and communication flow of Leavitt’s model was deconstructed into two components in the proposed ESSD: organizational structure, policies and procedures as one component, and workflow and communication flow as a separate component (See table 1 for a complete mapping of Leavitt’s model components to the ESSD). For the design of a focused college STEM program or a PCSP, this category would include clarifying and defining the jobs of people and setting up clearly defined relationships between those jobs with associated authority, responsibility and coordination mechanisms clearly spelled out. In this category belong the hierarchical, centralized or decentralized leadership, control at each level, physical breakdown of authority, and the policies and procedures of the organization. How the policies are perceived by the students could influence the performance of the PCSP, as found in the qualitative study in
Chapter Three above. How these policies influence the performance of the program as a stand-alone program for adult learners (Hollenbeck, 2007; Thompson et al., 2000), or as a department of an IHE, was of interest in the present study. The dynamics of the organizational policies, procedures, rules, regulations and the structure of authority could vary between the two PCSPs. The focus of all strategic efforts of the stand-alone PCSP should be on the sustained success of the adult learners, but the PCSP that is a subunit of a bigger institution could be expected to broaden its focus. For example, staff and some technologies could be shared and logistics may not be as freely flowing as in the case of the stand-alone program. Thus, organizational policies, procedures and authority structure can influence the effectiveness of a PCSP in varying ways, and therefore would need to be well understood from the design stage. Students’ perception of policies and procedures of an institution or program could influence their cooperative behavior and ultimately the service’s performance (Elsharnouby, 2015). For the effective engagement of staff (Eldor, 2019) and students in the service co-production process, the cooperation of everyone involved is important for success (Ng & Forbes, 2009). Thus, adult-centered policies, rules, regulations and customer-oriented practices can help ensure students are willing to follow the rules and procedures that will lead to better learning outcomes and decision to complete their degree.

**Workflow and Communication Flow (Workflow 1-5)**

As mentioned earlier, the workflow and communication flow are included in Leavitt’ change model as part of its structure. This category in a college STEM program or a PCSP ensures that the work design, workflow, schedules, assignments management, communication flow, frequency and structure of the program are adequately analyzed for viability and proper guards are set against variance of process and of goals(W. A. Pasmore, 1988; W. A. Pasmore & Sherwood, 1978a). This consists of work design, workflow, value chain, schedules, assignment structure and
Table 1: Leavitt’ Change Management Model Components Mapped to the ESSD

<table>
<thead>
<tr>
<th>Leavitt’s Model</th>
<th>Educational Service Systems Design Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structure:</td>
<td></td>
</tr>
<tr>
<td>Policies and authority systems (PAS)</td>
<td>International organizational policies and procedure</td>
</tr>
<tr>
<td>Communication systems and flow (CSF)</td>
<td>Work and communication flow</td>
</tr>
<tr>
<td>Workflow Systems (WFS)</td>
<td></td>
</tr>
<tr>
<td>Technology:</td>
<td></td>
</tr>
<tr>
<td>Direct problem solving inventions (PSI)</td>
<td>Technology</td>
</tr>
<tr>
<td>Physicals Workspace (WSP)</td>
<td>Infrastructure</td>
</tr>
<tr>
<td>Task:</td>
<td></td>
</tr>
<tr>
<td>Organization’s raison d’etre (ORD)</td>
<td>Goal clarifications, measurement and monitoring</td>
</tr>
<tr>
<td>Organization’s functions (OGF)</td>
<td>Educational service offerings</td>
</tr>
<tr>
<td>People:</td>
<td></td>
</tr>
<tr>
<td>Actors – HR; skills &amp; competencies (HRS)</td>
<td>People and Decision influencers: People, their skills and expertise</td>
</tr>
<tr>
<td>Attitude &amp; behavioral elements (ATT)</td>
<td>People: human elements - behavioral and emotional</td>
</tr>
<tr>
<td>Not included</td>
<td>Socioeconomics components</td>
</tr>
<tr>
<td>Not explicit</td>
<td>Customer orientation</td>
</tr>
<tr>
<td></td>
<td>External environmental demands</td>
</tr>
</tbody>
</table>

management. This category for services usually involves less physical equipment-based processes and more human-based processes and procedures (Gazzoli et al., 2013; W. A. Pasmore, 1988), especially for a high-touch service like a pre-college STEM program.

Workflow in the ESSD framework refers to all processes of service co-production, both for main and supplementary services. Unlike business products where the customer consumes only after the product has been produced and delivered, learning co-production depends on an effective and efficient flow of the co-production processes. The simultaneity of the production and
consumption of services makes properly aligning the sequence of classes and time allowed for assignments and assessments indispensable for positive program performance in enhancing retention and learning outcomes. According to Storey & Larbig (2018), viewing students as customers would help the design team to understand and interpret their academic, social, financial, and psychological needs and help operationalize this knowledge within the education service (p. 111) as well as analyze how best to couple and deliver them. For example, one of the needs of NTAS learners is time to study (Storey & Larbig, 2018). This could be translated into incorporating study time within the regular school schedule and providing a dedicated study room with internet connectivity and school supplies and/or making some services available at times that are convenient for the students (Bjordal, 2011). School-work conflicts and school-family conflicts are realities of the complex life of NTAS (Markle, 2015). The workflow in a PCSP could include buffers in either the scheduling strategy or accessibility of previously covered lessons for the NTAS learners to review at their convenience.

The non-consumption of educational services co-produced by the institution and the students is rooted in the cumulative gaps between student’s dynamic expectations and the value delivered to the students by the institutions (Ng & Forbes, 2009). The students can be influenced to modify their expectations through strategic communication. While traditional-aged students could be more malleable to change their expectations, the adult learners usually return to college with the capacity to be influenced by the academic systems only (Bean & Metzner, 1985). An example of modifiable student expectations is a change from “vocational relevance to academic excellence” (Bean & Metzner, 1985). Equally important is the opportunity to correct variance close to the source (Passmore, 1988). That means that for efficient workflow, the communication necessary for the delivery needs to flow directly and on time to the point of action. Adequate communication flow enabled by clearly specified channels is necessary to enhance value co-
creation behaviors of both the students and the frontline academic and non-academic staff (Eldor, 2019; Elsharnouby, 2015). Doing so could improve the program performance. Therefore, this research hypothesized that workflow contributes to the STS performance through the social system.

**Customer Orientation (CustomerO 1-6)**

Customer Orientation is not explicit in Leavitt’s model, but it is generally accepted that for-profit businesses do their best to acquire and retain their customers. For a program like the PCSP, focusing on customer orientation (Gazzoli et al., 2013; Nwankwo, 1995) as a component ensures that the organization adequately focuses on the students it is in business to serve. The choice to focus on the student as the primary customer helps in prioritizing requirements while designing and managing the program. This component ensures that attention is given to the students as the primary customer whose needs are central to the program’s reason for existence.

Student/customer orientation in an education service like a college STEM program or a PCSP would require a clear understanding of sensitivity points, elements of measurements, and operational themes for implementations (Nwankwo, 1995) as well as actions that constitute customer orientation. However, the present study focuses on ascertaining if customer orientation in a college STEM program or a PCSP is significant. Customer orientation in education would include proactive strategies to identify and manage students’ perceptions, as these can influence students’ behavior and willingness to follow instructions that lead to better system performance. It would also include adaptation of learning materials like technology (Reigeluth et al., 2015; Smith, 2014), curriculum (St Clair, 2018), learning style, schedules, office hours (Markle, 2015), and learning delivery channels to increase accessibility (Mohammadi et al., 2019; Park & Choi, 2009), and ease of use. Customer orientation in education could also imply an institution-wide mindset shift of every staff member quickly and promptly adapting or adjusting service co-
production processes to create the most value for the students (Eador, 2018). In education, all adaptations must have one goal only – to co-create the most value for the students. Herein resides the measure of customer orientation (Martensen et al., 2000) in education: a determination of the value created for the students by the service or modification made to produce the service. Customer orientation does not mean lowering the academic standards (Mark, 2013) for some students, as it is not about what is delivered but rather “the manner in which the service was delivered” (Sierra & McQuitty, 2005, p. 392). Thus, quality academic should be the hallmark of a customer orientation in a college program. Lowering academic standards would violate the business goal of delivering on the education goals of the students (Mark, 2013).

Students’ satisfaction is critical in determining educational service quality, which could relate to service outcomes (Schreiner & Nelson, 2013). However, as in businesses, without a deliberate effort to satisfy students by improving service quality, student satisfaction may not happen in an educational service like a PCSP (Gazzoli et al., 2013; Nwankwo, 1995). One advantage of positioning an educational service like a PCSP as a business service is highlighting the student as the primary customer and the core goal of the system as being the students’ success (Kramer, 2001; Nwankwo, 1995; Simons, 2014).

Some researchers frown at the idea of students as customers (Saunders et al. 2014), and consider it controversial (Rutter, Roper, & Lettice, 2016) because of the fear of compromise of education standards. Still, many researchers continue to advocate for the notion of IHE as service systems (Bitner et al., 2012). Bitner and her colleagues show that viewing IHE as service systems makes them student-focused in their continuous improvement and innovation, which in turn improves outcomes and ensures the fulfillment of their other goals of serving the community and society. Students have also been viewed as the core stakeholders of IHE (Maric, 2013; Kettunen, 2015; Bjorkquist, 2009), with staff, faculty, alumni, employers, parents, government, and the
community in which the institutions are embedded and society as other stakeholders (Gross & Godwin, 2005; Whisman, 2009). In all the categorizations of college students, these authors agree that students consume the services of IHE and that their satisfaction is essential in determining service quality.

Because students are not widely regarded as customers, consumers, or stakeholders, customer orientation is not a commonly used phrase in education. Terms like student-centeredness and student orientation are utilized in describing designing lessons or technology that are student-friendly. Adopting teaching style or curriculum to suit students’ learning style and educational needs can also mean student-centeredness or student-friendliness (Esses, 2019; St Clair, 2018). As in business services, customer orientation (Guilbault, 2016; Nwankwo, 1995) strategies for better customer acquisition and retention could be effective in terms of meeting the expectations of nontraditional students, and hence enhance the program’s performance. Bjordal found that nontraditional students’ expectations include a “consumer-oriented approach with some of the same conveniences and services from their colleges as their banks and supermarkets provide, such as no lines, adequate parking, variable hours of operation, high quality, low cost, and informed employees. Of secondary importance were campus climate, student-centeredness, and campus support services.” (Bjordal, 2011, p. 51).

The present study hypothesizes that the perceived customer-oriented behaviors and activities contribute to the STS performance by positively influencing retention and students’ learning outcomes.

In summary, the variables and the social system that contain them indirectly and directly respectively, positively influence the overall STS (program) performance.

H1a: Social system positively relate to Retention.

H1b: Social system positively relate to LOUT
H$_{1c}$: The people component individually and collectively positively influences the social system.

H$_{1d}$: Organization’s student-centered policies positively relate to the social systems.

H$_{1e}$: Perceived customer oriented staff behaviors and activities positively relate to the social system.

H$_{1f}$: Workflow and communication flow positively relate to the social systems.

**Technical Subsystem components**

The technical construct is made up of four lower-level variables as well, and the research shows that each contribute to performance of the STS. The four variables are goal clarification, measurement and monitoring (GoalCMM), service offerings and associated technologies (Course), infrastructure (Infrastr) and socioeconomic factors. (SES)

**Goal Clarification, Measurement and Monitoring (GoalCMM 1-4)**

Goals clarification, measuring and monitoring (Choi et al., 2018) (what must be right for optimum performance to occur) corresponds to Leavitt’s Task of the organization, *raison d’etre*, and the monitoring of goals. The goal and the techniques for monitoring it were all in the same category in Leavitt’s model, but separated in the ESSD for a more detailed analysis of the component without losing sight of any dimensions. Some aspects of the goal monitoring and measurement require adequate clarification and dissemination of the vision and goal of a college STEM or a PCSP. The GoalCMM can be viewed as the central nervous touch point of the STS located within the technical system because it defines the reason for the existence of the system and the basis for all the other functions of the other components. Thus, it clarifies, measures and monitors the systems goals, dictates deviations from goals, strategies and tactics for their realignments.

The goals category of the ESSD model also addresses the monitoring techniques to ensure the intended change can occur for timely feedback and informed necessary adaptation of revision.
Because the goal of a system drives its design and development, it is very important for educators and consultants who plan to design a pre-college/college STEM program for NTAS learners to understand what the desired outcomes are and how to achieve them more efficiently. It implies that the suboptimal performance of the systems can be traced back to the GoalCMM directly or indirectly. Directly could mean that it fell short of providing accurately the needed timely feedback, and indirectly if it did so, but the “people” did not adjust the systems accordingly. Thus, providing clear pathway to degree completion (M. Bergman et al., 2014; M. J. Bergman, 2012), regular feedback, and variance correction mechanisms could enhance student’s learning outcomes and thereby improve the program performance. These authors found that adult learners appreciate programs that enable faster degree completion. To regularly scan and incorporate “the voice of the students” on how best to provide quality service (Storey & Larbig, 2018) could improve outcomes as well. That highlights the need for regular feedback so that both the program and the students can adjust at the micro, personal and unit levels and correct the variances as necessary. Without feedback through regular monitoring and updates, the entire systems performance could be hampered.

From the students’ perspective, regular feedback from the faculty and academic advisors with regard to degree completion target met, and things of that nature could positively influence the performance of the STS.

**Service Offering (course 1 - course 5)**

This category represents a combination of two parts of two of Leavitt’s components. From Leavitt (1965), this would be an organization’s reason for existence—the production of goods and services and the associated subtasks that go with the production (p. 1144). (For details, see chapter three above).
The core and associated technology services offered are usually the main focus of educational service systems and rightly so. Quality curriculum (St Clair, 2018) and knowledgeable (Johnsrud, 2002) staff (academic and non-academic) have been previously shown to interest students in general and adult in particular. However, additionally, the adult learner has been shown to be drawn to course that seemed relevant and relatable to their career interests (Maher, 2004; St Clair, 2018) and intellectually stimulating. “Relevance connects learning with reality. Generally, adult learners perceive learning as a means to an end and, therefore, value learning experiences only if they are relevant and applicable to their needs.” (Sogunro, 2014, p. 29).

Sogunro found eight factors from a study of 203 university students that motivate adult learners in college, namely: quality of instruction, quality of curriculum; relevance and pragmatism; interactive classrooms and effective management practices; progressive assessment and timely feedback; self-directedness; conducive learning environment; and effective academic advising practices (p. 22). This means ensuring that the core educational service offering (academics) is perceived as useful, relevant and can be “applied immediately.”

While the goal of a college STEM program or a PCSP should guide the analysis, the service offerings (the value propositions) and the associated technology for fulfilling the proposition maps naturally to Leavitt’s task component, except that the infrastructure aspect of Leavitt’s technology was categorized by itself, so both service offering and technology can be more deeply explored. Additionally, in educational service systems, a “human technology” and a service offering can be the same entity, as in the case of a knowledgeable faculty member.

Christensen and his colleagues defined technology as “the processes by which an organization transforms inputs of labor, capital, materials, and information into products and services of greater value” (Christensen et al., 2010, p. 11). This definition may suggest heavy machinery that employees use for performing tasks, but it is not limited to hard physical
equipment. It also includes soft tools like software and electronic materials, and for an educational
service system, technology includes processes, procedures, training and training materials,
seminars, books, curriculum, delivery chain, and so forth (Christensen et al., 2010). Intellectual
knowledge of the faculty, student service professionals, counselors, and so forth, are by themselves
“human technology” (Christensen et al., 2010). This category ensures the analysis of everything
that properly enables the transmission of educational knowledge to pupils. This category also
ensures the analysis of all the educational service offerings (main and sub-goals) of the program
and the subsystems designed to achieve them.

The service offering for a PCSP is more than just courses and delivering them. Because of
the multiplicity and interdependency of the learning needs and needs while enrolled of the NTAS,
an effective PCSP for NTAS is expected to offer many services, both core and supplementary
services (Ng & Forbes, 2009), which include adequate relevant support services (Bauman et al.,
2004; Remenick, 2019) for their unique needs. Core services are the activities that directly lead to
learning, which Ng and Forbes described as “embodied in the learning experience of the student”
(p.48). Supplementary services, which play an important role in the core service delivery, include
application processes, registration of classes, advising services, academic counseling services,
tuition and fees processing, campus facilities including learning laboratories, learning centers, and
administrative and support staff helpfulness. Directly or indirectly, any needed service not
provided could negatively affect the program’s performance in enabling NTAS to complete their
degree. Although postsecondary schools generally do not provide many of the non-academic
services that NTAS need to be stable and persist through to graduation, it would be beneficial to
understand the magnitude of the effects the services offered could enhance the program’s
performance. Thus, the present research hypothesized that the core service offerings in terms of
the relevance to interests and how intellectually stimulating the courses are positively influence
the performance of the STS.

**Infrastructure (Course 6-11)**

The infrastructure category, which was the other part of Leavitt’s technology components, ensures analysis of physical structures and buildings, fixtures and plans, virtual learning platforms, and how best to design them to support optimal performance of the program. Leavitt’s model included physical buildings and key equipment under technology. For a college STEM program/a pre-college STEM program (PCSP), infrastructure is more than the physical building and all the other artifacts (Almqvist & Östman, 2006; Conradie, 2014). It is about place making—deliberately creating or adopting a space for the students that enables the collaboration and engagement that are essential for academic performance (Kuh et al., 2008; Wyatt, 2011). For adult students, the ease and comfort of coming from their place of employment to the classroom, or keeping appointments with faculty and staff, is an important factor in how they could perceive the program. Bjordal found that nontraditional students’ expectations include “…adequate parking, variable hours of operation, high quality, low cost, and informed employees…” (Bjordal, 2011, p. 51). The technologies needed to enhance teaching and learning are included under infrastructure. The ESSD proposes analyzing educational services together with its associated technology to avoid any form of oversight. However, for understanding the impact of infrastructure in general in the present empirical study, they are grouped together. The advancing world of technology has taken educational services along with it. There are many digital learning materials, learning management systems, and analytics solutions that have increased accessibility, convenience, “big-data” predictive analyses, options for the students, and better insight into patterns of behaviors for educators(Choi et al., 2018). Computer laboratories, smart boards, hands-on computer-based learning deliveries, and real-time and offline access to a student’s work online are a few of the
technologies that enhance the service co-production. Enhancing teaching and learning may seem easier and better with the ubiquitous availability of technology, however, its specific effects in enhancing the performance of a college STEM program as an STS need to be established. Future research can then explore the different aspect of college infrastructure that are most critical in enhancing student success and retention.

Effective infrastructure could also include a student’s lounge with some conveniences like coffee, vending machines, dedicated parking, and so forth. A comfortable student’s lounge would be the institution’s strategy to account for the fact that most adults travel to school straight from work, and therefore could be tired, hungry, need to relax a little bit before classes if their schedules permit. Therefore, college STEM programs could consider a lounge and other conveniences like a dedicated parking space for the NTAS. This service may not be a core service of learning, but it can increase the chances of having satisfying experiences which could positively influence the co-production behavior of the students (Elsharnouby, 2015). Elsharnouby found that positive learning co-production behaviors of students lead to improved learning outcomes.

Literature abounds that shows that technology can have positive influence of the performance of the an STS (J. Groff, 2013; Martone, 2015). This leads to the hypothesis that infrastructure positively, but indirectly influences the performance of the STS.

**Socioeconomic (SES 1-2)**

Assessing the NTAS learners’ learning needs and needs while in college was found in the quality study to be critical for designing effective college/pre-college STEM programs for NTAS. The socioeconomic status of the students assessment aimed at revealing the employability, affordability/scholarships, accessibility/economic support system (Bauman et al., 2004), capacity to participate in a shared value creation with a possible school based employment, can lead to
informed program design or management. As expressed in the literature review, the re-education of NTAS learners should be viewed as an investment that would benefit the students, government, and society. This category ensures the analysis of every possibility that can enable students to be more stable in school.

A socioeconomic and sociocultural component is not included in Leavitt’s change model. This component in ESSD includes all possible financial supports that could be provided to the students to ensure their financial stability while enrolled in a PCSP or college. Two- and four-year colleges assess the students yearly to determine financial aid eligibility. While most low-income students qualify for financial aids, many of the returning adult students in college may not qualify for financial aids because of previous college loan debt default or other factors like under-enrolment. Assessing the financial status of the students, their skills sets, and employment eligibility, could give insight into how best to assist the students to attend college and still meet their financial responsibilities. Many adult learners could still desire to pursue an undergraduate degree and pay for it out of pocket. For many of these adults, the financial support could arise from partnerships with companies that could provide co-ops, internships, part-time or even full-time employments for NTAs while they attend school.

Providing opportunities for stable employment while enrolled in college could be one of the best ways to ensure an adult learner’s stability. Financial instability is one of the biggest problems adult undergraduate students have (Markle, 2015), thus any strategy to enable them to earn more and work less could increase the stability of the students while enrolled, and hence improve their degree completion.

Low SES students have been found to be less likely to persist to degree completion. Moreover, an institution’s financial viability positively correlates with persistence to graduation (Titus, 2009).
The socioeconomic and sociocultural component belongs in the technical system for two reasons. First, the considerations of the socioeconomic status of a student and to determine the student’s probability to complete a degree, if every other variable is held constant, is purely technical because the assessments are about palpable facts and figures. Secondly, if financial support is determined to be appropriate, the physical fund disbursed is technical. For example, although, the students can use the funds for social activities, but financial aids received by the student are physical. It has also been established in literature that adult students need financial support to complete their college degrees, but sometimes desire coordination between their employment and their school to prevent work-school schedule conflicts. Evidence was found in the qualitative portion of this study that college/industry partnership-based employment could increase chances of persistence to degree completion which implies STS performance. Therefore, it is concluded that supporting the SES status of an adult learner positively relates to the programs’ performance.

In summary, the hypotheses for the technical system are as follows:

- $H_{2a}$: The technical system as a unit positively relate to Retention
- $H_{2b}$: The technical system as a unit positively relate to LOUT
- $H_{2c}$: The goal clarification, measurement and monitoring positively relate to the technical system
- $H_{2d}$: The core academic offerings relate positively to the technical system.
- $H_{2e}$: The learning enhancing infrastructure positively relate to the technical system.
- $H_{2f}$: The adult-centered socioeconomic strategies positively relate to the technical system

**External Environment**

It is important to mention that the viability of STESS as sociotechnical system phenomena is always in the context of the pressures or demands of the external environment. In the present study, the external environment pressures ($ExPressure$), is modeled as a representation of the
number of hours worked per week and the family responsibilities of the students while in school. The hypotheses therefore, are based on the assumptions that the external environmental pressures are capable of influencing student’s retention and academic performance. (Berker et al., 2003; Markle, 2015). Thus,

H₃: External environmental pressure (ExPressure) has a negative relationship with STESS

H₃a: External environment pressure has a negative relationship with Retention.

H₃b: External environment pressure has a negative relationship with LOUT.

The Dependent Variables

Retention (DegComplt 1-5)

Retention is used as a proxy for the student’s intention to complete a degree instead of persistence. This distinction is necessary, because the goal of institutions to retain students until they obtained a desired degree in as short, a period as possible can be different from the goal of an adult learner. An adult learner may or may not be enrolled in a college for a degree, and they may or may not have the goal of enrolling for consecutive semesters even when they want a degree. However, for a NTAS learner pursuing a STEM degree, it is more efficient for them to enroll in consecutive semesters until degree completion. Most adult learners who return to college to pursue STEM degrees do so for economic reasons—to improve their earning power. Given stable external environmental demands or family responsibilities and number of hours of employment, completing their degree on time so they can start earning more is the only option that most aligns with an adult learner’s desire to earn a college STEM degree. Therefore, it would be an important retention strategy for IHE to design adult programs that enhance retention and faster degree completion.
Additionally, colleges assisting NTAS learners to continue to enroll until degree completion has the potential to enhance task performance, as it lessens the possibility of the students forgetting prerequisite concepts learned previously. The target of the college to graduate more of their NTAS learners requires a different approach. The STS approach proposed in this study would allow designers of adult STEM programs to analyze not only the social or the academics and the associated technologies, but also the sociotechnical issues. For instance, technically speaking a faculty member can be very knowledgeable in his field, and may also have been well trained for effective delivery of the subject matter. However, as an individual, the faculty member may hold a philosophy that adult learners pursuing college degrees are a waste of time. In such a case there could be a reluctance to adjust to proven teaching techniques aimed at adult learners’ learning styles. NTAS learners failing a course in such a hypothetical situation would not be a technical issue, but a sociotechnical gap problem.

*Learning Outcomes (LOUT 1-5: LOUT 1-3 = Rate of Progress*)

Positive learning outcomes progressively lead to degree completion if all other variables are held constant. Moreover, a step before degree completion is a series of positive learning outcomes. Therefore it is a given that learning outcomes would lead to degree completion, thus this study focuses on the STESS performance in positively increasing learning outcomes of the students. Since positive learning outcomes are antecedent for degree completion, it can be assumed that activities that enable degree completion are mediated by learning outcomes so as to positively contribute to degree completion.

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*Rate of progress = (average no. of credits earned per semester) X (average no. of semesters enrolled per year)*
Similarly, retention can be assumed to have a positive relationship with learning outcome, since some motivating factors that lead to retention can influence improved performance. Therefore:

H₄a: A college STEM program as a STESS positively relates to Retention of NTAS learners.

H₄b: A college STEM program as a STESS positively relates to LOUT of NTAS learners.

H₄c: The STESS’s effects on Retention is greater than the sum of the individual effects of social and technical subsystems on Retention.

H₄d: The STESS’s effects on the LOUT is greater than the sum of the individual effects of social and technical subsystems on the LOUT.

**The Mediators**

**Student’s Goal and Institution Commitment (GoalCommt 1-4)**

Goal and institutional commitment are constant features in the student success and retention literature and were included in the present study as system performance mediators, which can also completely mediate the effects of the system. Tinto (1975) model assumed that they can be mediated by the system, but their effects in mediating the performance of the system could be greater. It was presented as an independent entry characteristic of the students and as a dependent variable that can be modified by the college experience.

This research views students’ goal commitment as a phenomenon that could be mediated by the system, but a critical driver of adult learners’ persistence, as the qualitative study in chapter two revealed. Adults, compared to traditional-age students, are more likely to weather through challenges in a program to complete their degree, and goal commitment seems to be a catalyst. The values and motivations of the students fluctuates and change throughout the college continuum, as was found in the quantitative study in chapter two, but the inner desire and drive to earn a college degree does not seem to change very easily. For example, if a student does not have
the funds to complete their education at a given time, they could reduce the number of credits they complete within a period, or even drop out, but eventually return to college to fulfill that commitment.

**Student’s Satisfaction (SATF1 -16)**

The satisfaction construct in line with STS principles covered every aspect of a program, not just one global idea of being satisfied with the overall program. Learning is said to occur when students feel satisfied with the learning co-creation encounters. That actually suggests that one global overall satisfaction with a program could be useful for some evaluation, but is at best vague in understanding student’s satisfaction about their experiences in a college program. If they learn when satisfied, one could infer that an antecedent of learning is satisfaction. Elsharnouby (2015) found that students are more likely to cooperate and carry out instructions in learning co-production processes that lead to better outcomes if they are satisfied. Similarly, Sogunro also referenced Kahler, Morgan, Holmes, and Bundy (1985), who stated that “Learning is influenced by whether it brings satisfaction or annoyance to the learner and that a thing learned is strengthened if the result is satisfying, and weakened if the result is annoying” (Sogunro, 2014, p. 29). Moreover, since “Intrinsically motivated students use more effective learning strategies, prefer challenging tasks, enjoy their classes more and show sustained student involvement (T. H. Bailey & Phillips, 2016, p. 2), as opposed to extrinsically motivated students who tend to do what is required to avoid some repercussions. Therefore, lesson plans and activities that specifically target students’ satisfaction within the knowledge creation interactions are more likely to result in learning, which in turn increases the chances of the student completing their degree.

Thus, it is hypothesized that satisfaction with different aspects of the program communally and cumulatively contribute to the overall performance of the STS.

H$_{5a}$: Student’s goal commitment mediates the effects of STESS on Retention
H₃₅: Student’s goal commitment mediates the effects of STESS on LOUT
H₅₅: Students satisfaction mediates the effects of STESS on Retention
H₅₆: Student’s satisfaction mediates the effects of STESS on LOUT

Learning Outcomes and Retention as mediators:
H₆₅: LOUT (Learning outcomes) positively relate to Retention
H₆₆: LOUT mediates the effects of STESS on Retention
H₆₇: Retention positively relate to LOUT
H₆₈: Retention mediates the effects of STESS on LOUT

**Entry Characteristics**

Some demographic elements were included in the study to ensure that the population of interest was sampled. The demographic elements included were age, gender, race, number of children, high school performance, and whether one’s parents attended college or not. Except for the number of children, the other elements appeared in most of the persistence models for traditional age students and for nontraditional adult learners (Bean & Metzner, 1985; M. Bergman, Gross, Berry, & Shuck, 2014; M. J. Bergman, 2012; Ikegulu, Barham, Farmer, & Roberson, 1999). The background elements, like high school performance, have been found to relate to academic performance of a student (Pascarella & Terenzini, 1980). The value of including some key entry characteristics could point to the quality of the educational service the learners receive (Elsharnouby, 2015). One of the major differences between product and service production is that the quality of the customer input can influence the quality of the service they receive. Therefore, ensuring homogeneity of the sample was a key quality control measure of the present study. This also points to an important reason to design specific programs with dedicated technical and social systems to meet specific needs. While the goals of traditional age students and the adult students in a STEM program could be the same (to earn a STEM degree), their input in the co-production
of that education could be different because of differing characteristics and learning needs (Bean & Metzner, 1985; Tinto, 1975). This in turn could produce differing quality of educational outcomes. Researchers are invited to test the model with different segments of higher education students. This could be the most viable argument against forcing NTAS learners into the college-degree-completion business model for traditional age students.

**Research Methods**

*Research Design and Measure Instrument*

The quantitative instrument has 86 items of measure for seven variables drawn from instruments with acceptable psychometric scores of four main attrition/retention studies. The list of items and their sources are presented in Table 13 on Appendix A. The instruments, which were used for most of the variables and elements, were: The College Student Experience Questionnaire (CSEQ) (Pace & Kuh, 1998), The Adult Learning Survey (ALS) (Bergman, 2012; 2014), College Persistence Questionnaire (CPQ) (Davidson, Beck, & Milligan, 2009), and Adult Priority Survey (APS) (Noel-Levitz, 2003).

The measures of satisfaction from most of these studies were too narrow to meet the objectives of this study, and Noel-Levitz’s 50-item measure for satisfaction, on the other hand, was too long. Noel-Levitz’s instrument has 50 items that measured students’ level of importance as well as the level of satisfaction for each of the elements being measured. Because the focus of this study includes determining the effects of the social and technical variables on the adult learner’s persistence, a more granular measure of elements of each system needed to be determined. Therefore, a review of attrition-retention studies was used to determine other viable items for each of the elements of the social system as well as the technical systems variables.
The instrument in the present study has four main sections: the entry characteristics with demographic and student commitment elements, the external environmental variables (number of hours worked, financial status, outside encouragement, the internal environment, and IHE commitment to the learner variables), the social system elements (customer orientation, people, SES, workflow and communication flow, and policies and procedures), and the technical systems variables (goal clarification, measuring and monitoring, service offerings and technology, infrastructure, Financial assistance). The third section included learning outcomes, student’s satisfaction, and persistence.

All items measuring all the elements of the variables were drawn from the aforementioned literature except the satisfaction variable. The 16 items for this construct were drawn from many surveys of student’s satisfaction and service quality in IHE. (Baumgart & Johnstone, 1977; Bean, 2005; M. J. Bergman, 2012; Billups, 2008; Dagavarian, 1993; Davidson, Beck, & Milligan, 2009; J. Douglas, McClelland, & Davies, 2008; J. A. Douglas, Douglas, McClelland, & Davies, 2015; Fisher, 1991; Hammer, Grigsby, & Woods, 1998; Ikegulu et al., 1999; Napitupulu et al., 2018; Park & Choi, 2009); and the Survey of Adult Learners' Retention in Postsecondary Vocational Programs" (SALR-PVP)(Ikegulu et al., 1999)). See Table 13 in the Appendix F for a full list of all the items and their sources.

Except for minor changes in the language made to a few of the items, over 90% of the items were developed and previously used by different researchers of students’ retention in college student service quality and satisfaction questionnaires. For example, “my courses were intellectually stimulating”, was rephrased to read “my courses made me think in different ways that I enjoyed”.

Although, the items were previously used for assessing students’ behaviors towards learning and overall experience in college, in the present study the items were used to assess
students’ perceptions of the different aspects of their college STEM programs—we use the same items, but with a different focus and discoveries because of the different unit of interest. The items were re-arranged to fit the constructs in the present study, and this new arrangement was pre-tested to determine suitability in fitting the conceptual model. An extensive literature review and the interviews of about 43 students in the qualitative study where the model was first conceptualized all culminated in the final questionnaire.

The instrument included 11 items about demographic information, 4 items for self-reporting learning outcomes (LOUT), 5 items about their intention to complete degree (DegComp), 4 items about their goal (GoalCommt) and institution (InsCommt) commitments and 16 items that cover their satisfaction (SATF) about different aspects of the their STEM program.

The other items on the instrument were: external environment – 9 items, but 1 was not used; Socioeconomic variable (SES) – 2 items; Goal clarification, measurement and monitoring (GoalCMM) - 4 item; Service offering and associated technology and infrastructure (Course) – 11 items; the quality of interactions with people in the program (Interaction) – 10 items, workflow and communication flow (Workflow) -5 items; customer orientation (CustomerO) – 6 items; and Organizational policies (Policies) – 6 items.

The learning outcome (LOUT) questions were reduced to 3 after computing for their rate of progress by multiplying LOUT 1 (the average number of credit hours completed per semester) by LOUT 2 (the number of semester the student enroll for classes in a year). The items were self-reported grade point average at the time of this study (GPA) and whether the respondent performed as well as they expected.

The student’s satisfaction (SATF 1-16) about the different aspect of their STEM program covered the following: the faculty - 2 items; the other academic and administrative staff - 2 items; general staff – 2 items; courses and assessment options with frequency of progress tracking and
feedback – 3 item; class registration options – 1; financial policies – 2 items; safe and updated learning technologies and facilities – 3 items; and schedule conflict resolution - 1 item.

The Qualtrics software was used to design and distribute the questionnaires electronically to individuals through college faculty members, peers, family and friends. Qualtrics forced the completion of every item. Hard copies of the questionnaire were also distributed to students and to the general public in public events. Pizza and granola bars were offered to students in the classrooms after completing the questionnaires.

**Survey Administration and Participants**

The population was any financially independent two-year or four-year college students who worked, enrolled in a STEM (science, technology, engineering and mathematics) related course or program, or graduated recently and lived in the US.

Because the electronic copy of the questionnaire was posted on social media, there was no record of how many people actually saw or accessed it. However, Qualtrics captured everyone who attempted at least one item before they discontinued. The questionnaire was sent out between July 19th and October 30th, 2019. By the October 30th, Qualtrics recorded 154 as completed, and 36 of them were not up to 80% filled out and were deleted. There were also 405 items that were collected manually from local community colleges, local universities, local churches, and several community and cultural events. Electronic copies were also sent to family and friends and they were asked to send to anyone who may fit the target population. Eight copies of the 405 were rejected for not meeting the minimum requirements to be included in the analysis.

After data screening where 4 more cases were deleted, the remaining 512 were from 6 distinct two-year colleges, and 30 four-year colleges across the US, but the bulk came from five campuses of one local two-year College and one local four-year college. Among those removed from the completed questionnaires were students aged 18-24 who worked less than 20 hours per
week, because they do not qualify as financially independent. There were 244 university and 268 community college students, with 64 graduates who attended undergraduate education as adults. 74 students from ages 18-24 were included because they worked while attending college. 18 of the 512 did not declare their major, but the rest were either STEM or STEM-related.

There were a few outliers of concern, which resulted in removing 4 of the cases mentioned above. Each had all 1s or all 5s, or were removed based on the dictates of the attention grabber interaction item #10.

Table 4: The hierarchical buildup of the STESS

<table>
<thead>
<tr>
<th>Measurement of Hierarchical Constructs</th>
<th>Summary of the Theoretical Model: The Sociotechnical Education System Composition and hierarchy</th>
<th>Definitions</th>
<th>No. of Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Third Order Constructs (Formative)</td>
<td>Second Order Constructs (Formative)</td>
<td>First order Constructs (Reflective)</td>
<td></td>
</tr>
<tr>
<td><strong>Social</strong></td>
<td><strong>Technical</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Sociotechnical education service system (STESS)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>People</td>
<td>Policies</td>
<td>Institution commitment to the students</td>
<td>6</td>
</tr>
<tr>
<td>Policies</td>
<td>Workflow</td>
<td>Free flow processes and communication</td>
<td>6</td>
</tr>
<tr>
<td>Workflow</td>
<td>Customer orientation</td>
<td>Philosophy of student-centeredness</td>
<td>6</td>
</tr>
<tr>
<td>Customer orientation</td>
<td>Goal clarification, measurement and monitoring</td>
<td>Feedback mechanism</td>
<td>4</td>
</tr>
<tr>
<td>Technical</td>
<td>Service Offerings</td>
<td>Relevant and quality curriculum and supplementary services</td>
<td>5</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>Infrastructure</td>
<td>Technologies, learning materials and facilities</td>
<td>6</td>
</tr>
<tr>
<td>Socioeconomics factors</td>
<td>External Environment</td>
<td>Financial support strategies</td>
<td>2</td>
</tr>
<tr>
<td><strong>External Environment (Reflective)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mediating Variable (Reflective)</td>
<td>Mediating Variable</td>
<td>Goal &amp; Institution Commitment</td>
<td>4</td>
</tr>
<tr>
<td>Satisfaction</td>
<td>Dependent Variables</td>
<td>Satisfaction</td>
<td>16</td>
</tr>
<tr>
<td>Retention</td>
<td>Learning Outcome</td>
<td>Retention</td>
<td>5</td>
</tr>
<tr>
<td>Learning Outcome</td>
<td></td>
<td>Learning Outcome</td>
<td>3</td>
</tr>
</tbody>
</table>

**STESS, a third-order construct formed by the social and technical second-order constructs.**

The social construct consists of four first-order variables - people, policies, customer orientation and workflow. The technical consists of goal clarification, measurement and monitoring, service offering and technology, infrastructure, and socioeconomic factors.
Table 5: Quantitative Study Sample Characteristics

<table>
<thead>
<tr>
<th>Age</th>
<th>18-24: 32%</th>
<th>25-34: 37%</th>
<th>35-44: 16%</th>
<th>45-54: 12%</th>
<th>&gt; 55: 4%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Female: 49%</td>
<td>Male: 51%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>College type</td>
<td>University: 48%</td>
<td>Community College: 52%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hours worked</td>
<td>10-20: 14%</td>
<td>21 -30: 32%</td>
<td>31 - 60: 54%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of Dependents</td>
<td>At least one: 60%</td>
<td>None: 40%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>512</td>
</tr>
</tbody>
</table>

Data Analysis and Results

**Measurement Model**

The SPSS was used for descriptive statistical analysis of the data, but the component-based analyses tool of the SmartPLS 3 was used for all measurement and structural analyses for two reasons. First, the variables involved seemed too large for SPSS and AMOS and Partial Least Squares tools are more suitable for large variables (Joreskog, 1982), and secondly, Amos, a covariance-based tool, does not have adequate features for formative constructs (Hair, et al., 2017).

The partial least square (PLS) method was more adequate for the reasons given above about the nature of the constructs and of the model. Many empirical studies are being done with PLS because of its flexibility in calculating and managing a large number of varying control, mediating, and moderating variables much better and faster than its competitors. Moreover, Wetzels et al. (2009) recently argued that “PLS path modeling can also be used for hierarchical models with formative constructs or a mix of formative and reflective constructs” (p. 189), as is the case in the present study (Afthanorhan, 2014; Wetzels, Odekerken-Schröder, & Van Oppen, 2009).

The measurement tested for indicators’ reliability, convergent reliability, internal consistency and discriminant validity. As most of the first-order variables in the study were reflective, the Cronbach’s alpha, rho A, (Dhilon-Goldstein), composite reliability and average variance extracted (AVE) were assessed. For indicators not having unidimensionality reliability issues, they need to meet the minimum measure of Cronbach’s alpha > 0.05 (Cronbach, 1970).
This tests how the indicators in a scale relate to each other. Nunnaly, (1975) recommended the use of rho-A because it is believed to be a more reliable measure of the items also (J. Nunnally & Bernstein, 1967). Both Cronbach’s alpha and rho_A were tested, although further testing was based on CR measures as some researchers found it to be reliable than the rho_A measures (Peterson & Kim, 2013). The convergent validity measures the comparison between the average variance extracted (AVE) and the proportion of variance explained in a factor analysis. The AVE measure is between 0 and 1, and acceptable score is AVE > 0.5 (Bagozzi & Yi, 1988). The AVE of some of the variables was below the acceptable level of 0.5 or higher (J. C. Nunnally, 1994). However, all AVE scores of the indicators were significant at the p-value <0.05.

Most of the loadings of the items were acceptable—at least 0.3 for large sample size, but mostly 0.5 and above (Gaskin, 2017). The out loadings of a few of the items were low, but significant. Therefore, an empirical support exits to retain the indicator. Also, literature reveals that an important consideration before removing any item from a formative constructs content validity, which could become a concern if an indicator is removed (J. F. Hair Jr et al., 2017). Moreover, the outer loadings of all the first-order variables were significant at p-value less than 0.000 (See Table 11 in Appendix I). Additionally, the sizes of the effects of the first-order variables were equally significant at p value < 0.01 (see Table 7 below). Besides, if the sizes of the effects were not substantial, the result demonstrates the value of the indicators and their constructs in the higher-order formative variables.

All the indicators met the minimum required scores of 0.7 for composite reliability (CR) (Straub, Boudreau, & Gefen, 2004), (CR of 0.6 or higher and not above 0.9) (H. HAIR JR, 2014) are also acceptable. A table summary of the output in Table 6 below. However, to ensure that the internal consistency thresholds were met, the HTMT was used, the result of which is also in the appendix. All the first-order constructs showed sufficient discriminant validity, including the
variance inflation factors (VIF) of less than 3.3 (Kock & Lynn, 2012) because the loadings for each factor were much stronger than any cross loadings. (See Tables 5 below).

**Table 6: Measurement Model - Reliability and Validity Summary**

| First-Order Variables | C. α | Rho_A | CR | AVE | VIF - Max | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|-----------------------|------|-------|----|-----|----------|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. CourseNet          | 0.61 | 0.64  | 0.78 | 0.49 | 1.56     | 0.698 | |
| 2. Customer           | 0.71 | 0.73  | 0.81 | 0.47 | 2.52     | 0.385 | 0.68 |
| 3. ExPressure         | 0.61 | 0.78  | 0.79 | 0.58 | 1.25     | 0.006 | -0.1 | 0.76 |
| 4. Faculty            | 0.74 | 0.74  | 0.83 | 0.49 | 2.29     | 0.426 | 0.66 | 0.05 | 0.7 |
| 5. FamilyNFr          | 0.71 | 0.73  | 0.84 | 0.63 | 1.22     | 0.415 | 0.16 | -0.03 | 0.2 | 0.79 |
| 6. GoalOMM            | 0.67 | 0.67  | 0.8  | 0.5  | 1.58     | 0.406 | 0.6  | -0.09 | 0.5 | 0.21 | 0.71 |
| 7. GoalCont           | 0.49 | 0.40  | 0.75 | 0.5  | 1.27     | 0.249 | 0.25 | 0.1  | 0.35 | 0.21 | 0.23 | 0.7 |
| 8. Infrastr           | 0.66 | 0.69  | 0.79 | 0.43 | 1.79     | 0.399 | 0.57 | 0.05 | 0.53 | 0.22 | 0.44 | 0.31 | 0.66 |
| 9. LOUT               | 0.46 | 0.50  | 0.68 | 0.46 | 0.199    | 0.199 | 0.21 | 0  | 0.24 | 0.19 | 0.37 | 0.14 | 0.68 |
| 10. OPeople           | 0.7  | 0.71  | 0.81 | 0.46 | 1.98     | 0.479 | 0.63 | 0.07 | 0.58 | 0.22 | 0.56 | 0.2  | 0.45 | 0.08 | 0.68 |
| 11. Policies          | 0.63 | 0.67  | 0.77 | 0.41 | 1.71     | 0.316 | 0.59 | 0.05 | 0.49 | 0.19 | 0.44 | 0.26 | 0.47 | 0.15 | 0.47 | 0.64 |
| 12. RETN              | 0.81 | 0.82  | 0.87 | 0.57 | 0.211    | 0.199 | 0.21 | 0  | 0.24 | 0.19 | 0.37 | 0.14 | 0.68 |
| 13. SATF              | 1    | 1     | 1   | 1   | 1.48     | 0.342 | 0.41 | 0.02 | 0.5 | 0.19 | 0.35 | 0.4  | 0.36 | 0.37 | 0.33 | 0.34 | 0.39 | 1 |
| 14. SERVOOffr         | 0.78 | 0.76  | 0.85 | 0.53 | 1.75     | 0.427 | 0.59 | 0.01 | 0.65 | 0.2 | 0.52 | 0.4  | 0.53 | 0.26 | 0.47 | 0.45 | 0.38 | 0.43 | 0.73 |
| 15. SES               | 0.4  | 0.54  | 0.67 | 0.37 | 1.22     | 0.246 | 0.38 | 0.04 | 0.38 | 0.11 | 0.31 | 0.17 | 0.38 | 0.04 | 0.37 | 0.43 | 0.21 | 0.26 | 0.32 | 0.61 |
| 16. SchConfli          | 0.59 | 0.63  | 0.83 | 0.7  | 1.23     | -0.02 | 0.06 | 0.43 | 0.04 | -0.03 | 0.04 | 0.08 | 0.09 | 0.05 | -0.01 | 0.05 | -0.02 | -0 | -0.01 |
| 17. Technology         | 0.71 | 0.72  | 0.84 | 0.64 | 1.98     | 0.356 | 0.55 | 0.03 | 0.24 | 0.53 | 0.27 | 0.61 | 0.15 | 0.51 | 0.45 | 0.28 | 0.35 | 0.57 | 0.34 | 0.01 | 0.8 |
| 18. Workflow           | 0.78 | 0.8   | 0.84 | 0.48 | 2.26     | 0.384 | 0.65 | 0.13 | 0.67 | 0.19 | 0.58 | 0.35 | 0.36 | 0.31 | 0.52 | 0.57 | 0.4  | 0.54 | 0.61 | 0.51 | 0.05 | 0.53 | 0.69 |

Discriminant Validity: the bolded numbers on the major diagonal are the square roots of the AVE. Each value should be greater than all other values in its row and column.

The CR values of 0.6 or greater, but not more than 0.9 were met.

Not all the items met the AVE threshold of 0.5 or greater.

**Note:** These measures are based on the internal consistency of the items, which formative constructs are expected to possess (Hair, et al., 2017)

Cross loadings of the items were also examined to ensure that each item loaded more on the construct they identified with than any other constructs. The average variance shared between each construct and their respective measures should be greater than the variance shared between the where they belong, and other constructs in the model (Compeau, Higgins, & Huff, 1999).
measure assumes internal consistency between indicators of the items of a construct, but literature advises that caution should be exercised in eliminating any item where some of the constructs are formative.

By nature, minimal overlapping is expected of formative variables, because the indicators that form them represent different aspects of the general concept the construct defines (Hair, et al., 2017). In discriminant validity testing, the subjective independence of every indicator on its construct is assessed, and can be done by examining the cross loadings of the items to ensure that the difference between the major loadings is 0.2 or greater (Chin, 2010). The present study utilized the Heterotrait-Monotrait (HTMT) ratio of correlations to observe a measure of HTMT > 0.9 (Henseler, Ringle, & Sarstedt, 2015). The HTMT threshold of 0.9 or less was met.

The common Method bias testing was accessed by calculating the variance inflation factors (VIF) of the variables (Knok, 2015). The calculation, which was done in the present study by running the Basic Algorithm of the SmartPLS, generated the VIF values of the variables (Kock & Lynn, 2012). None of the variables showed a VIF score greater than 0.4 (Hair et al., 2017). Since all the items and the latent variables were not higher than the minimum VIF value of 4.0 (Hair et al., 2017; Kock, 2015); therefore, the model is CMB free. Kock & Lynn (2012) “proposed the full collinearity test as a comprehensive procedure for the simultaneous assessment of both vertical and lateral collinearity” (Kock, 2015, P.7).

The multi-collinearity testing revealed that all the first order formative constructs VIF scores were between 1.079 and 2.795. The two second-order construct of social and technical VIF values range from 1.530 to 2.335 and 1.245 – 1.746 respectively. The VIF scores of STESS range from 1.032 to 3.25 all of which are less than the acceptable value of 4.0 (Hair et al., 2010). According to Hair and his colleagues, the VIF value not exceeding 4.0 is considered acceptable
(Kock & Gaskins, 2016). The measures of the inner VIF should be < 3.3 to determine no CMB issues, and discriminant validity was achieved as well.

**Structural Model**

Based on the definition of sociotechnical system (Pasmore, et al., 2019), HOC and formative constructs (Hair, et al., 2017), the STESS was conceptualized as a third-order construct formed by two-second order constructs of social and technical subsystems that consists of eight first order latent variables, as presented in Table 4 above.

Analysis of the structural model was done in four stages:

**Step 1:**

The effects of the Social, and Technical second order constructs on STESS was assessed, first by assessing the effects of the first-order latent variables on each of them. See Table 7 for the effects of first order factors on the Social and Technical Constructs.

The strength and the significance of the effects of all the relationships between IV and DVs are accessed through the path coefficient generated by both the basic PLS algorithm and the Bootstrapping analysis (Ringle, Da Silva, & Bido, 2015). The $R^2$ value, which is the coefficient of determination, gives the value of the total variance explained on the DV by all the IVs predicting it, $R^2$ for the Social, and the Technical constructs were .999 meaning that all the components fully explained the variance in these constructs.

**Step 2:**

Next was assessing the possible independent effects of the Social and the Technical constructs on Retention and LOUT without STESS. (See Table 8a and Figure 6a below for the results). The effects of the Social on both Retention and LOUT are significant ($b = 0.191$, $t = 0.239$, at $p=0.019$; and $b = 0.239$, $t = 2.456$ at $p= 0.014$, respectively). The effects of the Technical construct on retention was significant, but not for LOUT ($b =0.252$, $t = 2.944$, at $p = 0.003$, and $b$
= 0.067, t = 0.639, and p = 0.523 respectively). The Retention’s $R^2 = 0.158$ was significant, but LOUT’s $R^2 = 0.074$ was not.

**Table 7: The Effects the First Order Latent Variables on the Social and Technical Constructs**

<table>
<thead>
<tr>
<th>Path Coefficients of Social and Technical Directly on Retention and LOUT (Without STESS)</th>
<th>Dependent Variables</th>
<th>Path Coefficients</th>
<th>t-Stat</th>
<th>$t$-Square/Effect Size</th>
<th>Hypotheses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RETN: $R^2 = .183$</td>
<td>LOUT: $R^2 = .093$</td>
<td>Social</td>
<td>Technical</td>
<td></td>
</tr>
<tr>
<td>Course Network</td>
<td>0.126***</td>
<td>10.47</td>
<td>5.049***</td>
<td>Supported</td>
<td></td>
</tr>
<tr>
<td>Customer Orient</td>
<td>0.227***</td>
<td>20.52</td>
<td>7.453***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Faculty</td>
<td>0.224***</td>
<td>20.996</td>
<td>8.296***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Family N Friends</td>
<td>0.069***</td>
<td>5.623</td>
<td>2.745**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other People</td>
<td>0.251***</td>
<td>20.91</td>
<td>7.172***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Policies</td>
<td>0.155***</td>
<td>12.847</td>
<td>6.612***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Workflow</td>
<td>0.232***</td>
<td>20.713</td>
<td>8.069***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Goal CMM</td>
<td>0.252***</td>
<td>17.594</td>
<td>2.929***</td>
<td>$H_{1e}$ - $H_{1f}$ : Yes</td>
<td></td>
</tr>
<tr>
<td>Infrastructure</td>
<td>0.282***</td>
<td>21.032</td>
<td>2.853**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Service Offering</td>
<td>0.374***</td>
<td>21.873</td>
<td>3.048**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technology</td>
<td>0.251***</td>
<td>23.238</td>
<td>3.803**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SES</td>
<td>0.133***</td>
<td>10.506</td>
<td>2.68**</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*ns: not significant; *$p < 0.05$; **$p < 0.01$; ***$p < 0.000$; RETN: Retention LOUT: Learning Outcome; Stat: Statistics

All the first-order variables significantly relate to their second-order constructs at $p < 0.000$

**Step 3:** The introduction of STESS into the Model

The next step was to test the effects of the Social and Technical and their components on STESS first without Retention and LOUT: The effects of Social on STESS were significant with $b = 0.594$, $t = 39.214$, $p = 0.000$. The effects of Technical on STESS were also significant with $b = 0.448$, $t = 31.209$; $p = 0.000$. After Retention and LOUT were added to the model, the effects of STESS on Retention was significant with $b = 0.425$, $t = 9.811$ $p = 0.000$, and the effects of STESS on LOUT was also significant with $b = .296$, $t = 7.099$, $p = 0.000$. The effects of STESS on both
Retention and LOUT are higher than the sum of the individual effects of Social and Retention on each of the dependent variables of Retention and Learning outcome (LOUT).

**Figure 6a: Effects of Social and Technical Subsystems on Retention and Learning Outcome**

**Figure 6b: Effects of Social and Technical Subsystems on STESS**
(SATF: Satisfaction has only one item – Student’s satisfaction with their intellectual growth. 
ExPressure has three items – one no. of hours worked item, and two family responsibilities items)

Specific indirect effects of Social on Retention: \( b = 0.253, t = 10.182, p = 0.000 \)
Specific indirect effects of Social on LOUT: \( b = 0.176, t = 7.291, p = 0.000 \)
Specific indirect effects of Technical on Retention: \( b = 0.192, t = 8.802, p = 0.000 \)
Specific indirect effects of Technical on LOUT: \( b = 0.133, t = 6.629, p = 0.000 \)

The significance and strength of the indirect effects of Social and Technical under STESS are much stronger than without STESS. For example, without STESS, Social direct effects on Retention: \( b = 0.191, t = 2.359, p = 0.000 \) for LOUT, \( b = 0.239, t = 2.456, p = 0.000 \) and the direct effects of Technical on Retention \( b = 0.252, t = 2.944, p = 0.000 \), for LOUT \( b = 0.067, p = 0.639 \)-not significant (ns).

Therefore, the t-statistics of STESS (9.811) is more than the sum (5.303) of the t-statistics of Social (2.359) and Technical (2.944) constructs’ effects on Retention. Similarly, the t-statistics of STESS (7.099) is more than the sum (3.095) of the t-statistics of Social (2.456) and Technical (0.639) constructs’ effects on learning outcome. (See Tables 6b below)

The implication of this result is that STESS provides a platform of interaction that multiplies the effects of Social and Technical constructs on Retention and learning outcome for NTAS by a factor close to 2. The magnitude and the significance of the multiplier influence of STESS on the social and technical systems are not yet known. However, the result here supports hypotheses H_{4c} and H_{4d} (H_{4c}: The STESS’s effects on Retention is greater than the sum of the individual effects of social and technical constructs on Retention; and H_{4d}: The STESS’s effects on the LOUT is greater than the sum of the individual effects of social and technical constructs on the LOUT).
Table 8a: Effects of Social and Technical Factors on STESS

<table>
<thead>
<tr>
<th>Path Coefficients of Social and Technical on STESS with External Environmental Pressure on Schedule Conflicts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Independent Variables</strong></td>
</tr>
<tr>
<td>---------------------------</td>
</tr>
<tr>
<td>Social</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Technical</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>STESS</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>ExPressure</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Schedule Conflict</td>
</tr>
</tbody>
</table>

*ns: not significant; *p < 0.05; **p < 0.01; ***p < 0.001; RETN: Retention; LOUT: Learning Outcome; Conflict: Work - School and Family –School Schedule Conflicts; NT: Not Tested. N/A: Not applicable

A number of conclusions could be drawn from the result above, but future research should retest the effects of these constructs to confirm or disprove the conclusion in the present study.

1. The social system needs the technical systems to exert significant effects on both Retention and LOUT.
2. The Technical system needs the social system to exert significant effects on both Retention and LOUT.
3. STESS, the abstraction of the interaction between the social and technical systems positively mediates the effects of the social and technical systems.
4. The effects of STESS are greater than the sum of the individual effects of social and technical systems.
Further studies are needed to understand better the effects of the first order variables on the dependent variables through the HOCs. However, as shown in Table 7 in Appendix I, all the first-order constructs have significant indirect effects on Retention with t-values that ranged from 3.45 to 21.81, and all at \( p < 0.001 \) level. Their indirect effects on LOUT are inconclusive since some of the variables mediating their effects on the dependent variables do not have significant effects on the DVs. For example, the Technical construct does not significantly predict LOUT. Thus, it could not be a reliable mediator.

**Step 4**

The effects of the STES on the two dependent variables of intent to graduate and learning outcomes were assessed directly by running the bootstrapping analyses of the model as built. However, to determine the effects of satisfaction, goal commitment, external environmental pressure on STES, the repeated indicator approach – a two-step approach of PLS was utilized (Hairs, et al., 2017). First, latent factor scores were generated from the basic PLS algorithm. Then those scores were used to create a new data set forming a simple, but representative model for further analysis. This was necessary, because higher order constructs have \( R^2 \) values close to 1. This means that the variables that form them explain close to 100% of their variance (Hairs, et al., 2017), and there does not exist any room for testing a predictive effect of any latent variable on the higher order construct.

Therefore, two ways to assess higher order formative constructs (Hairs, et al., 2017) are:

a) Test to determine if indicators have significant effects on the latent variables. Assess the significance of the regression weight, direct and indirect, specific and total effects. The t statistics and the p-value \( < 0.05 \) for a 95% confidence interval would suffice. A strict \( p < 0.05 \) can be used, but because it can be detrimental to remove any item in a model that involves formative constructs, \( p < 0.09 \) can be used (Gaskin, 2017).
b) Secondly, Examine the VIF, which should be at most 0.4 (Hair, et al., 2010) (but Gaskin suggests VIF not higher than 5) for a good result, to determine indicators that are discriminant and that they are not overlapping, but uniquely representing different aspects of the construct.

![Figure 7a: Simplified Research Model of STESS with Mediators](image)

Model fit: SRMR = 0.042 and NFI = 0.946.

The f-square measure of the size of the effect that each indicator can exert on their construct was also utilized to determine that, although all the indicators showed significant effects on STES, the effect on the system can be assumed to be greater than others (Hairs, et al., 2017). Tables 8c and 8d below contains the result of that analysis - the result of the effects of external environmental pressure on goal commitment, satisfaction, retention and learning outcome for three categories of students based on the number of hours of employment per week.
### Table 8b: Mediating Effects of STESS, Goal Commitment and Satisfaction

<table>
<thead>
<tr>
<th>Path Hypothesized</th>
<th>Direct Effects</th>
<th>( t ) Statistics</th>
<th>( f^2 / \text{Effect Size} )</th>
<th>( R^2 )</th>
<th>Total Effects</th>
<th>( f^2 / \text{Effect Size} )</th>
<th>Hypotheses Supported</th>
</tr>
</thead>
<tbody>
<tr>
<td>STESS -&gt; RETN</td>
<td>0.425</td>
<td>9.811***</td>
<td>3.924***</td>
<td>0.183**</td>
<td>9.811***</td>
<td>Significant</td>
<td>H0: Yes</td>
</tr>
<tr>
<td>Social -&gt; RETN</td>
<td>0.191</td>
<td>2.312*</td>
<td>1.062 ns</td>
<td>0.183**</td>
<td>2.312*</td>
<td>ns</td>
<td>H0: Yes</td>
</tr>
<tr>
<td>Social -&gt; STESS -&gt; RETN</td>
<td>0.253</td>
<td>10.355***</td>
<td>3.084***</td>
<td>0.183**</td>
<td>3.084**</td>
<td>ns</td>
<td>H0: Yes</td>
</tr>
<tr>
<td>Technical -&gt; RETN</td>
<td>0.252</td>
<td>2.894**</td>
<td>1.333 ns</td>
<td>0.183**</td>
<td>2.894**</td>
<td>ns</td>
<td>H0: Yes</td>
</tr>
<tr>
<td>Technical -&gt; STESS -&gt; RETN</td>
<td>0.19</td>
<td>8.883***</td>
<td>3.139***</td>
<td>0.183**</td>
<td>3.139***</td>
<td>Significant</td>
<td>H0: Yes</td>
</tr>
<tr>
<td>STESS -&gt; LOUT</td>
<td>0.286</td>
<td>7.099***</td>
<td>3.084***</td>
<td>0.183**</td>
<td>3.084**</td>
<td>ns</td>
<td>H0: Yes</td>
</tr>
<tr>
<td>Social -&gt; LOUT</td>
<td>0.239</td>
<td>2.497*</td>
<td>1.137 ns</td>
<td>0.183**</td>
<td>2.497*</td>
<td>ns</td>
<td>H0: Yes</td>
</tr>
<tr>
<td>Social -&gt; STESS -&gt; LOUT</td>
<td>0.176</td>
<td>7.322***</td>
<td>3.139***</td>
<td>0.183**</td>
<td>3.139***</td>
<td>Significant</td>
<td>H0: Yes</td>
</tr>
<tr>
<td>Technical -&gt; LOUT</td>
<td>0.067</td>
<td>0.658 ns</td>
<td>No Mediation</td>
<td></td>
<td>No Mediation</td>
<td>ns</td>
<td>H0: No</td>
</tr>
<tr>
<td>Technical -&gt; STESS -&gt; LOUT</td>
<td>0.133</td>
<td>6.648***</td>
<td>0.658 ns</td>
<td></td>
<td>No Mediation</td>
<td>ns</td>
<td>H0: No</td>
</tr>
</tbody>
</table>

\( f^2 \): effect size is calculated by \((full\ R^2 – Partial\ R^2)/(1- full\ R^2)\) (Mathieson et al. 2001). Effect sizes of 0.02, 0.15 and 0.35 respectively indicate small, medium and large effects (Cohen, 1988). + STESS mediates the effects of social and Technical factors on Retention and learning outcome

**Four steps in establishing mediation:** (Kenny, 1986; Judd and Kenny 1981; James and Brett, 1984).

1. **If** \( Y = \text{RETN} \), \( X = \text{STESS} \), \( M = \text{GoalComm} \), **the following must be true:**
2. \( X \) variable predicts; \( X \) predicts \( M \);
3. \( M \) variable predicts \( Y \);
4. Then, \( M \) can be tested to determine if it mediates the effects of \( X \) on \( Y \).
Effects of the External Environmental Pressure:

The effects of the external environmental pressure (ExPressure) was assessed. ExPressure’s effect on STESS was significant, though the size of the effect was not significant (See Table 8b above). The b = -0.118, t = 2.802, p = 0.006. However, ExPressure does not have significant effects on Retention and learning outcome. The effects of ExPressure on Work-School and Family-School schedule conflicts (SchlConflt) was then tested. ExPressure had significant negative effects on the SchlConflt and the size of the effect was significant as indicated by the f-square t-score. However, SchlConflt did not have significant effects on RETN and LOUT.

Table 8c: External Environmental Pressure

<table>
<thead>
<tr>
<th>Path Hypothesized</th>
<th>Direct Effects</th>
<th>t- Statistics</th>
<th>f² Effect Size</th>
<th>R² Total Effects</th>
<th>f²</th>
<th>Hypotheses Supported</th>
</tr>
</thead>
<tbody>
<tr>
<td>ExPressure -&gt; STESS</td>
<td>-0.118</td>
<td>2.802**</td>
<td>1.158 ns</td>
<td>-0.085</td>
<td>1.823 ns</td>
<td>H3: Yes</td>
</tr>
<tr>
<td>ExPressure -&gt; RETN</td>
<td>0.037</td>
<td>0.939 ns</td>
<td>ns</td>
<td>0.04</td>
<td>0.878 ns</td>
<td>H2: No</td>
</tr>
<tr>
<td>ExPressure -&gt; LOUT</td>
<td>-0.029</td>
<td>0.697 ns</td>
<td>ns</td>
<td>-0.012</td>
<td>0.251 ns</td>
<td>H2: No</td>
</tr>
<tr>
<td>ExPressure -&gt; SchlConflt</td>
<td>-0.426</td>
<td>11.259***</td>
<td>4.623***</td>
<td>0.182***</td>
<td>-0.427</td>
<td>11.243***</td>
</tr>
<tr>
<td>SchlConflt -&gt; STESS</td>
<td>0.02</td>
<td>0.411 ns</td>
<td>ns</td>
<td>0.008</td>
<td>0.154 ns</td>
<td>H3: No</td>
</tr>
</tbody>
</table>

ns: non-significant; *p < 0.05; **p < 0.01; ***p < 0.001

f²: effect size is calculated by (full R² – Partial R²) / (1- full R²) (Mathieson et al. 2001). Effect sizes of 0.02, 0.15 and 0.35 respectively indicate small, medium and large effects (Cohen, 1988)

Thus, ExPressure had negative effects on all the other DVs except STESS and the RETN of students who worked over 30 hours per week.

Similarly, ExPressure did not have significant effects on RETN or LOUT. This result seems counter intuitive because the number of hours worked per a week has been found to have a negative influence on the education of working adult students in college in previous research (Berker, 2003). Further research would be needed to explore the effects of external environmental pressure on retention and learning outcomes. Cluster analysis showed that the only group affected by external environmental pressure were students who worked over 30 hours per week.
Table 8d: Effects of External Environmental Pressure on Three Groups of Students Based on Number of Hours Worked

<table>
<thead>
<tr>
<th>Path</th>
<th>Group 1 (Worked 10-20 Hrs.)</th>
<th>Group 2 (Worked 21 – 30 Hrs.)</th>
<th>Group 3 (Worked 31 - 60 Hrs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Original Sample</td>
<td>T Statistics</td>
<td>Original Sample</td>
</tr>
<tr>
<td>ExPressure -&gt; GoalComm</td>
<td>0.699</td>
<td>0.859 ns</td>
<td>0.129</td>
</tr>
<tr>
<td>ExPressure -&gt; LOUT</td>
<td>0.037</td>
<td>0.356 ns</td>
<td>-0.001</td>
</tr>
<tr>
<td>ExPressure -&gt; RETN</td>
<td>-0.021</td>
<td>0.179 ns</td>
<td>0.066</td>
</tr>
<tr>
<td>ExPressure -&gt; SATF</td>
<td>0.072</td>
<td>0.684 ns</td>
<td>0.056</td>
</tr>
<tr>
<td>ExPressure -&gt; STESS</td>
<td>-0.171</td>
<td>1.228 ns</td>
<td>-0.078</td>
</tr>
<tr>
<td>ExPressure -&gt; SchlConfI</td>
<td>-0.214</td>
<td>1.733 ns</td>
<td>-0.43</td>
</tr>
<tr>
<td>GoalComm -&gt; LOUT</td>
<td>0.277</td>
<td>1.992*</td>
<td>0.304</td>
</tr>
<tr>
<td>GoalComm -&gt; RETN</td>
<td>0.402</td>
<td>2.889**</td>
<td>0.316</td>
</tr>
<tr>
<td>GoalComm -&gt; STESS</td>
<td>0.066</td>
<td>0.528 ns</td>
<td>0.185</td>
</tr>
<tr>
<td>RETN -&gt; LOUT</td>
<td>0.23</td>
<td>1.911 p = 0.056</td>
<td>0</td>
</tr>
<tr>
<td>SATF -&gt; LOUT</td>
<td>0.139</td>
<td>0.791 ns</td>
<td>0.25</td>
</tr>
<tr>
<td>SATF -&gt; RETN</td>
<td>0.035</td>
<td>0.239 ns</td>
<td>0.157</td>
</tr>
<tr>
<td>SATF -&gt; STESS</td>
<td>0.523</td>
<td>4.039**</td>
<td>0.302</td>
</tr>
<tr>
<td>STESS -&gt; LOUT</td>
<td>0.025</td>
<td>0.153 ns</td>
<td>-0.113</td>
</tr>
<tr>
<td>STESS -&gt; RETN</td>
<td>0.136</td>
<td>1.004 ns</td>
<td>0.2</td>
</tr>
<tr>
<td>SchlConfI -&gt; GoalComm</td>
<td>0.022</td>
<td>0.149 ns</td>
<td>0.064</td>
</tr>
<tr>
<td>SchlConfI -&gt; SATF</td>
<td>0.038</td>
<td>0.296 ns</td>
<td>0.109</td>
</tr>
<tr>
<td>SchlConfI -&gt; STESS</td>
<td>0.037</td>
<td>0.306 ns</td>
<td>0.009</td>
</tr>
</tbody>
</table>

ns: non-significant; *p < 0.05; **p < 0.01; ***p < 0.001

The effects of ExPressure on the STESS, LOUT, and the SchlConfI for the students who worked over 30 hours per week, were significant, with STESS’s information same as above. The direct effects:

ExPressure -> STESS: b = -0.137, t = 2.206, p = 0.027

ExPressure -> RETN: b = -0.001, t = 0.009, p = 0.993 (not significant)

ExPressure -> LOUT: b = -0.138, t = 2.213, p = 0.027

The effects of the external pressure for the complete set of data: ExPressure -> STESS: b = -118, t = 2.802, at p = 0.048).

For the student group who work over 30 hours per week: b = -0.176, t = 2.290, p = 0.022, which is significant, but the effects of ExPressure was not significant for the other groups. Since this group
constituted over 50% of the all the cases in study, it can be concluded that ExPressure was more likely to affect students who work more than 30 hours per week than those who do not.

SchlConflt as an element of the ExPressure had significant negative effects on the RETN of the same group of students, but no effect on all the other DVs in the model. (See Tables 8b and 8c above).

**Testing Mediating Effects**

According to Baron and Kenny, (1986), to test the mediation effects of any variable, it is important to ensure that the mediators (M) have significant effects on the dependent variables, and that the independent variables have significant effects on the M. Thus, If Y = RETN, X = STESS; M = GoalCommt, then the following must be true:

X variable predicts Y significantly, otherwise there does not exist significant effects to mediate. X predicts M significantly also, otherwise, M could neutralize the effects the X usually would have on Y without a clear understanding whether the effects of X were being fully mediated or that any other thing was going on. Thirdly, ascertain that M significantly predicts Y, because M cannot mediate what it cannot predict. Finally, M can be tested to determine if it mediates the effects of X on Y. (Kenny, 2008).

As shown below, GoalCommt, SATF and STESS were eligible can be tested for mediating effects, if any, because they all have significant effects on the DVs, and STESS had significant effects on GoalCommt and SATF.

**Goal Commitment (GoalCommt) and Satisfaction (SATF) as Mediators**

The effects of STESS on Retention and LOUT through GoalCommt and SATF:

**Direct effects After the Mediators were introduced into the Model:**

STESS -> RETN: $b = 0.214, t = 4.068, p = 0.000$ (significant).
STESS -> LOUT: b = 0.05, t = 0.996 < 1.96, and p = 0.525 (not significant). However, the effects of STESS on LOUT for students who work 31 or more hours per week was significant, with b = 0.18, t = 2.37 at p = 0.018. (See Table 8c below).

**Specific Indirect Effects:**

STESS -> GoalCommt -> RETN: b = 0.117, t = 4.614, p = 0.000 (significant)

STESS -> GoalCommt -> LOUT: b = 0.11, t = 4.494, p = 0.000 (significant).

STESS -> SATF -> RETN: b = 0.079, t = 2.488 at p = 0.013 (significant)

STESS -> SATF -> LOUT: b = 0.135, t = 4.434 at p = 0.000 (significant)

**Total Effects:**

Total effects of STESS on GoalCommt, SATF, RETN and LOUT:

STESS -> GoalCommt: b = 0.441, t = 11.663, p = 0.000

STESS -> SATF: b = 0.557, t = 16.271 at p = 0.000

STESS -> RETN: b = 0.422, t = 10.101 at p = 0.000

STESS -> LOUT: b = 0.296, t = 6.935 at p = 0.000

**Total effects of GoalCommt and SATF on RETN and LOUT:**

GoalCommt -> STESS: b = 0.246, t = 5.802, at p = 0.000

GoalCommt -> RETN: b = 0.328, t = 6.557, p = 0.000

GoalCommt -> LOUT: b = 0.263, t = 5.522, p = 0.000

SATF -> STESS: b = 0.446, t = 11.000, p = 0.000

SATF -> RETN: b = 0.248, t = 5.150 at p = 0.000

SATF -> LOUT: b = 0.266, t = 5.531, at p = 0.000

The significance and the strength of the effects of STESS on RETN without the mediators were as follows: b = .425, t = 9.811 at p = 0.000 and that of LOUT was b = 0.286, t = 7.099 at p = 0.000. (See Table 8b above).
The effects of STESS on RETN and LOUT were significant and the size of the effects were equally significant before the mediators were introduced. The indirect effects of STESS on RETN through GoalCommt were still significant, but reduced, and the direct effects of STESS on LOUT was not significant. Therefore, GoalCommt partially mediates the effects of STESS on RETN, but fully mediates the effects of STESS on LOUT.

For SATF, the effects of STESS on RETN were significant. That is, the direct effects of STESS on RETN after GoalCommt and SATF were introduced were significant as indicated above, but with reduced weight before mediators were introduced. The effects of STESS on RETN were $b = .425$, $t = 9.811$ at $p = .000$, and after SATF and GoalCommt were introduced, the effects were $b = .214$, $t = 4.082$ at $p = 0.000$. The indirect effects of STESS on RETN through SATF were significant as shown above (STESS -> SATF-> RETN: $b =0.079$, $t=2.488$ at $p=0.013$ (significant)). Similarly, the indirect effects of STESS on LOUT through SATF was significant (STESS -> SATF-> LOUT: $b =0.0135$, $t=4.434$ at $p=0.000$ (significant)), but the direct effects of STESS on LOUT was not significant as stated above. Therefore, SATF partially mediates the effects of STESS on RETN, but fully mediates the effects of STESS on LOUT (Baron and Kenny, 1986).

The direct effects of STESS on LOUT after the mediators were introduced do not mean that goal-committed and satisfied adult learners’ learning outcomes could improve without direct influence of STESS on their performance. However, it could mean that driven adult learners who are satisfied with their intellectual growth drive their own learning outcome.

This finding agrees with the research that suggests that learning actually occurs when students are satisfied (Sogunro, 2014, 2015).

In conclusion, GoalCommt and SATF mediate the effects of STESS on RETN and LOUT, therefore supporting H$_{5a}$ to H$_{5d}$.
The effects of SATF and GoalCommt on STESS as the mediator:

Similarly, the mediating effects of SATF and GoalCommt on STESS’s effect on RETN and LOUT were assessed. Tinto (1975) suggested that the institutions could influence the student’s goal commitment, which can in turn influence their learning outcome. The satisfaction item used as the moderator in the present study was student’s intellectual growth. There were two main reasons for this choice. First, most of the other satisfaction items loaded with their related components. For example, whether or not a student is satisfied with the teaching strategies of faculty members loaded with other items in the instrument that addressed faculty members. The second reason the item about intellectual growth was used as a proxy for their satisfaction of the program was that it globally represented the chief reason adult learners return to college – to enhance their intellectual and employment skills for prospective higher paying jobs.

As was shown above, GoalCommt had significant direct effects on STESS, RETN and LOUT. Additionally, SATF had significant effects on STESS, RETN and LOUT.

The direct effects of GoalCommt on RETN was still significant with STESS as a mediator with $b = 275, t = 5.456$ at $p = 0.000$ and its effects on LOUT with $b = 238, t = 4.712$ at $p = 0.000$ were also significant. The specific indirect effects of GoalCommt on RETN and LOUT through STESS were as follows:

GoalCommt -> STESS -> RETN: $b = 0.01, t = 0.816, \text{at } p = 0.415$ (not significant)

GoalCommt -> STESS -> LOUT: $b = 0.053, t = 3.111, \text{at } p = 0.002$

Thus, STESS partially mediated the effects of GoalCommt on LOUT, but fully mediated the effects of GoalCommt on RETN.

Similarly, the direct effects of SATF on RETN was still significant with STESS as a mediator with $b = 151, t = 2.651$ at $p = 0.008$ and its effects on LOUT with $b = 237, t = 4.225$ at $p$
The specific indirect effects of SATF on RETN and LOUT through STESS were as follows:

\[
\text{SATF} \to \text{STESS} \to \text{RETN}: b = 0.097, t = 3.789, \text{at } p = 0.000
\]

\[
\text{SATF} \to \text{STESS} \to \text{LOUT}: b = 0.018, t = 0.812, \text{at } p = 0.417 \text{ (not significant)}.
\]

Thus, STESS fully mediated the effects of SATF on LOUT, but partially mediated the effects of SATF on RETN.

The result of modeling STESS as a mediator supports Tinto (1975) that the goal commitment of students can be influenced by their experience in college. Moreover, student’s satisfaction with their intellectual growth could increase the students’ interest in a college program and hence ultimately improve learning co-production behavior. This phenomenon needs to be studied further for increased understanding of the construct.

\textbf{Variance Explained by the Independent variables (IVs) on the Dependent Variables (DVs) (See Tables 6a and 6b)}

The \(R^2\) of STESS from ExPressure = 0.007\% (not significant) (where \(R^2\) is the measure of the variance explained by the predicting variables - \(R^2\) further shows the strength of the effects the IVs have on the DVs).

The \(R^2\) of SchlConflt from ExPressure = 29.3\%

The \(R^2\) of GoalCommt from STESS = 19.8\%

The \(R^2\) of SATF from STESS = 30.8\%

The \(R^2\) of RETN = 27.3\% (from 3 IVs –mostly from STESS, GoalCommt and SATF, as ExPressure and SchlConflt did not show significant effects on the DVs)

The \(R^2\) of LOUT from STESS = 9.3\%, (but 20.6\% from the 3 IVs)
The $R^2$ of RETN from STESS = 18.3% before the other latent variables were introduced; implies that STESS explained over 67% of the total variance of the 27% of the three IVs on Retention. The variance explained by STESS on LOUT was only about 5%, and 19% by all the 3 IVs.

The $R^2$ with STESS as a mediator:

The $R^2$ of STESS from GoalCommt, SATF and ExPressure = 50.6%

The $R^2$ of RETN from STESS, GoalCommt, and SATF = 30.7%

The $R^2$ of LOUT from STESS, GoalCommt, and SATF = 22.8%

The variance explained for STESS, RETN and LOUT increased with STESS as a mediator, implying that student’s GoalCommt and SATF could add to the viability of STESS in improving the retention and learning outcome for adult learners pursuing STEM degrees in college.

Retention (RETN) and Learning outcome (LOUT) as Mediators

Table 9: Effects of Retention and Learning Outcome as Mediators

<table>
<thead>
<tr>
<th>Path Hypothesized</th>
<th>Direct Effects</th>
<th>$t$-Statistics</th>
<th>$f^2$ Effect Size</th>
<th>$R^2$</th>
<th>Total Effects</th>
<th>$f^2$</th>
<th>Hypotheses Supported</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOUT -&gt; RETN</td>
<td>0.037</td>
<td>0.879 ns</td>
<td>ns</td>
<td>0.04</td>
<td>0.879 ns</td>
<td>H6b : No</td>
<td></td>
</tr>
<tr>
<td>RETN -&gt; LOUT</td>
<td>0.041</td>
<td>0.833 ns</td>
<td>ns</td>
<td>0.041</td>
<td>0.833 ns</td>
<td>H6c : No</td>
<td></td>
</tr>
</tbody>
</table>

Hypotheses $H_{6a}$ and $H_{6b}$: The mediating effects of RETN and LOUT cannot be tested since they are not significant predictors of each other

$ns$: non-significant

The possible mediating effects of RETN and LOUT were tested:

LOUT did not have significant effects on RETN and RETN did not have significant effects on LOUT, which indicates that they cannot mediate the effects of STESS on each other (Baron and Kenny, 1986). Thus, Hypotheses $H_{6a}$ to $H_{6d}$ were not supported. See Table 10 above for the result. See Table 10 for the summary of all the hypotheses tested in the present study.
Table 10: Result of the Hypotheses Tested

<table>
<thead>
<tr>
<th>Hypothesized Paths</th>
<th>Hypotheses Supported</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>The Effects of the Social and Technical Factors on STESS</strong></td>
<td></td>
</tr>
<tr>
<td>$H_1$: The Social system positively relate to STESS</td>
<td>Yes</td>
</tr>
<tr>
<td>$H_2$: The Technical system positively relate to STESS</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>The Effects of Social Components on the Social Factor</strong></td>
<td></td>
</tr>
<tr>
<td>$H_{1a}$: Social system positively relate to Retention.</td>
<td>Yes</td>
</tr>
<tr>
<td>$H_{1b}$: Social system positively relate to LOUT</td>
<td>Yes</td>
</tr>
<tr>
<td>$H_{1c}$: The people component individually and collectively positively relate to the social system.</td>
<td>Yes</td>
</tr>
<tr>
<td>$H_{1d}$: Organization’s student centered policies positively relate to the social systems.</td>
<td>Yes</td>
</tr>
<tr>
<td>$H_{1e}$: Perceived customer oriented staff behaviors and activities positively relate to the social system.</td>
<td>Yes</td>
</tr>
<tr>
<td>$H_{1f}$: Workflow and communication flow positively relate to the social systems.</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Technical Components on the Technical Factor</strong></td>
<td></td>
</tr>
<tr>
<td>$H_{2a}$: The technical system as a unit positively relate to Retention</td>
<td>Yes</td>
</tr>
<tr>
<td>$H_{2b}$: The technical system as a unit positively relate to LOUT</td>
<td>No</td>
</tr>
<tr>
<td>$H_{2c}$: The goal clarification, measurement and monitoring positively relate to the technical system</td>
<td>Yes</td>
</tr>
<tr>
<td>$H_{2d}$: The core academic offerings relate positively to the technical system.</td>
<td>Yes</td>
</tr>
<tr>
<td>$H_{2e}$: The learning enhancing infrastructure relatively relate to the technical system.</td>
<td>Yes</td>
</tr>
<tr>
<td>$H_{2f}$: The adult-centered socioeconomic strategies positively relate to the technical system</td>
<td>Yes</td>
</tr>
<tr>
<td>Hypotheses</td>
<td>Hypotheses Supported</td>
</tr>
<tr>
<td>------------</td>
<td>----------------------</td>
</tr>
<tr>
<td><strong>External Environmental Pressure's Effects on STESS</strong></td>
<td></td>
</tr>
<tr>
<td>$H_3$: External environmental pressure (ExPressure) has a negative relationship with STESS</td>
<td>Yes</td>
</tr>
<tr>
<td>$H_{3a}$: External environment pressure has a negative relationship with Retention.</td>
<td>No</td>
</tr>
<tr>
<td>$H_{3b}$: External environment pressure has a negative relationship with LOUT.</td>
<td>No</td>
</tr>
<tr>
<td>$H_{3c}$: External environmental pressure negatively relate to students schedule conflicts</td>
<td>Yes</td>
</tr>
<tr>
<td>$H_{3d}$: Student schedule conflicts negatively relate to STESS</td>
<td>No</td>
</tr>
<tr>
<td><strong>Goal Commitment and Satisfaction As Mediators</strong></td>
<td></td>
</tr>
<tr>
<td>$H_{5a}$: Student’s goal commitment mediates the effects of STESS on Retention</td>
<td>Yes</td>
</tr>
<tr>
<td>$H_{5b}$: Student’s goal commitment mediates the effects of STESS on LOUT</td>
<td>Yes</td>
</tr>
<tr>
<td>$H_{5c}$: Students satisfaction mediates the effects of STESS on Retention</td>
<td>Yes</td>
</tr>
<tr>
<td>$H_{5d}$: Student’s satisfaction mediates the effects of STESS on LOUT</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Learning Outcomes and Retention as mediators</strong></td>
<td></td>
</tr>
<tr>
<td>$H_{6a}$: LOUT (Learning outcomes) positively relate to Retention</td>
<td>No</td>
</tr>
<tr>
<td>$H_{6b}$: LOUT mediates the effects of STESS on Retention</td>
<td>No</td>
</tr>
<tr>
<td>$H_{6c}$: Retention positively relate to LOUT</td>
<td>No</td>
</tr>
<tr>
<td>$H_{6d}$: Retention mediates the effects of STESS on LOUT</td>
<td>No</td>
</tr>
</tbody>
</table>
Other Cluster Analysis:

Table 11a: Path Coefficient of College Type – Total Effects

<table>
<thead>
<tr>
<th>College Type</th>
<th>University</th>
<th>Community College</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Original Sample</td>
<td>T Statistics</td>
</tr>
<tr>
<td>Complete</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ExPressure -&gt; GoalComm</td>
<td>0.095</td>
<td>1.434 ns</td>
</tr>
<tr>
<td>ExPressure -&gt; LOUT</td>
<td>0.013</td>
<td>0.203 ns</td>
</tr>
<tr>
<td>ExPressure -&gt; RETN</td>
<td>0.055</td>
<td>0.842 ns</td>
</tr>
<tr>
<td>ExPressure -&gt; SATF</td>
<td>0.006</td>
<td>0.099 ns</td>
</tr>
<tr>
<td>ExPressure -&gt; STESS</td>
<td></td>
<td>0.955 ns</td>
</tr>
<tr>
<td>ExPressure -&gt; SchlConfit</td>
<td>-0.419</td>
<td>7.182***</td>
</tr>
<tr>
<td>GoalComm -&gt; LOUT</td>
<td>0.361</td>
<td>5.071***</td>
</tr>
<tr>
<td>GoalComm -&gt; RETN</td>
<td>0.424</td>
<td>6.27***</td>
</tr>
<tr>
<td>GoalComm -&gt; STESS</td>
<td>0.242</td>
<td>5.239***</td>
</tr>
<tr>
<td>RETN -&gt; LOUT</td>
<td>0.441</td>
<td>7.304***</td>
</tr>
<tr>
<td>SATF -&gt; LOUT</td>
<td>-0.035</td>
<td>0.496 ns</td>
</tr>
<tr>
<td>SATF -&gt; RETN</td>
<td>0.228</td>
<td>3.032**</td>
</tr>
<tr>
<td>SATF -&gt; STESS</td>
<td>0.114</td>
<td>1.493 ns</td>
</tr>
<tr>
<td>ExPressure -&gt; GoalComm</td>
<td>0.44</td>
<td>7.567***</td>
</tr>
<tr>
<td>ExPressure -&gt; LOUT</td>
<td>0.208</td>
<td>3.379**</td>
</tr>
<tr>
<td>ExPressure -&gt; RETN</td>
<td>0.246</td>
<td>3.714***</td>
</tr>
<tr>
<td>ExPressure -&gt; SATF</td>
<td>0.547</td>
<td>10.837***</td>
</tr>
<tr>
<td>SchlConfit -&gt; SATF</td>
<td>-0.009</td>
<td>0.236 ns</td>
</tr>
<tr>
<td>SchlConfit -&gt; STESS</td>
<td>-0.017</td>
<td>0.235 ns</td>
</tr>
</tbody>
</table>

ns: non-significant; *p < 0.05; **p < 0.01; ***p < 0.001

The outputs seem quite comparable for university and community college students based on Table 11a. The only difference seemed to be the effects of satisfaction on the retention of community college students was significant, but the effect size was not significant.
Comparison of Nontraditional Adult Students and Traditional Students

The result for both groups were comparable. The external environmental pressure had significant effects for both groups, especially on their schedule conflicts. (See Table 11b above). The likely effects of STESS on RETN, GoalCommt and SATF were significant for both groups, but LOUT of NTAS could be positively influenced by STESS. The effects of GoalCommt on LOUT were significant for both groups, but its effects on RETN is positive only for NTAS and not for traditional age students.

The effects of STESS on LOUT as shown in the model appeared as STESS is negatively correlated with the learning outcomes of traditional students. It is not likely that was the case, but it certainly means that STESS does not have any effects on

Table 11b: Comparison of Nontraditional Adult Students and Traditional Students

<table>
<thead>
<tr>
<th>Path Coefficient</th>
<th>Nontraditional Adult Students</th>
<th>Traditional Aged Students</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Original Sample</td>
<td>T Statistics</td>
</tr>
<tr>
<td>ExPressure -&gt; GoalCommt</td>
<td>0.103</td>
<td>2.058</td>
</tr>
<tr>
<td>ExPressure -&gt; LOUT</td>
<td>-0.078</td>
<td>1.016 ns</td>
</tr>
<tr>
<td>ExPressure -&gt; RETN</td>
<td>-0.068</td>
<td>0.839 ns</td>
</tr>
<tr>
<td>ExPressure -&gt; SATF</td>
<td>0.049</td>
<td>1.085 ns</td>
</tr>
<tr>
<td>ExPressure -&gt; STESS</td>
<td>-0.176</td>
<td>2.29*</td>
</tr>
<tr>
<td>ExPressure -&gt; SchlConfl</td>
<td>-0.539</td>
<td>8.223***</td>
</tr>
<tr>
<td>GoalCommt -&gt; LOUT</td>
<td>0.164</td>
<td>2.294*</td>
</tr>
<tr>
<td>GoalCommt -&gt; RETN</td>
<td>0.204</td>
<td>2.673**</td>
</tr>
<tr>
<td>LOUT -&gt; RETN</td>
<td>0.012</td>
<td>0.193 ns</td>
</tr>
<tr>
<td>SATF -&gt; LOUT</td>
<td>0.213</td>
<td>2.803**</td>
</tr>
<tr>
<td>SATF -&gt; RETN</td>
<td>0.157</td>
<td>2.109*</td>
</tr>
<tr>
<td>STESS -&gt; GoalCommt</td>
<td>0.535</td>
<td>11.09***</td>
</tr>
<tr>
<td>STESS -&gt; LOUT</td>
<td>0.18</td>
<td>2.37**</td>
</tr>
<tr>
<td>STESS -&gt; RETN</td>
<td>0.253</td>
<td>3.381**</td>
</tr>
<tr>
<td>STESS -&gt; SATF</td>
<td>0.643</td>
<td>17.958***</td>
</tr>
<tr>
<td>SchlConfl -&gt; LOUT</td>
<td>0.059</td>
<td>0.685 ns</td>
</tr>
<tr>
<td>SchlConfl -&gt; RETN</td>
<td>-0.192</td>
<td>1.977*</td>
</tr>
<tr>
<td>SchlConfl -&gt; STESS</td>
<td>-0.072</td>
<td>0.732 ns</td>
</tr>
</tbody>
</table>

ns: non-significant; *p < 0.05; **p < 0.01; ***p < 0.001
Nontraditional adult students who worked at least 30 hours per week versus Traditional aged students who worked only 0 - 10 hours per week

The Comparison of Female versus Male Students

The results for both groups were quite comparable. Except for the effects of Satisfaction on Retention which was slightly (insignificant effect size) significant for the male students, the rest of the results were the same for both genders.

Table 11c: A Comparison of Female versus Male Students

<table>
<thead>
<tr>
<th>Path Coefficients of Gender</th>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>Path</td>
<td>Original Sample</td>
<td>T Statistics</td>
</tr>
<tr>
<td>ExPressure -&gt; Goal_Commit</td>
<td>0.168</td>
<td>2.542*</td>
</tr>
<tr>
<td>ExPressure -&gt; LOUT</td>
<td>-0.034</td>
<td>0.531ns</td>
</tr>
<tr>
<td>ExPressure -&gt; RETN</td>
<td>-0.041</td>
<td>0.718ns</td>
</tr>
<tr>
<td>ExPressure -&gt; SATF</td>
<td>0.062</td>
<td>1.037ns</td>
</tr>
<tr>
<td>ExPressure -&gt; STESS</td>
<td>-0.082</td>
<td>1.276ns</td>
</tr>
<tr>
<td>ExPressure -&gt; SchlConflt</td>
<td>-0.455</td>
<td>9.231***</td>
</tr>
<tr>
<td>GoalCommit -&gt; LOUT</td>
<td>0.214</td>
<td>2.9**</td>
</tr>
<tr>
<td>RETN -&gt; LOUT</td>
<td>0.281</td>
<td>3.762***</td>
</tr>
<tr>
<td>SATF -&gt; LOUT</td>
<td>0.199</td>
<td>2.593**</td>
</tr>
<tr>
<td>SATF -&gt; RETN</td>
<td>0.099</td>
<td>1.197ns</td>
</tr>
<tr>
<td>STESS -&gt; GoalCommit</td>
<td>0.448</td>
<td>7.794***</td>
</tr>
<tr>
<td>STESS -&gt; LOUT</td>
<td>0.023</td>
<td>0.307ns</td>
</tr>
<tr>
<td>STESS -&gt; RETN</td>
<td>0.236</td>
<td>3.077**</td>
</tr>
<tr>
<td>STESS -&gt; SATF</td>
<td>0.545</td>
<td>10.768***</td>
</tr>
<tr>
<td>SchlConflt -&gt; GoalCommit</td>
<td>-0.03</td>
<td>0.368ns</td>
</tr>
<tr>
<td>SchlConflt -&gt; SATF</td>
<td>-0.026</td>
<td>0.399ns</td>
</tr>
<tr>
<td>SchlConflt -&gt; STESS</td>
<td>0.046</td>
<td>0.592ns</td>
</tr>
</tbody>
</table>

ns: non-significant; *p < 0.05; **p < 0.01; ***p < 0.001

Comparison of Course Delivery Options

There appeared to be a considerable difference between the results for the students who take only online courses as opposed to the students who take both online and in-class courses. See Table 11d below. Goal commitment and satisfaction seemed to be the only two variables that could influence the ability of an institution to retain them. Additionally, SchlConflt had significant negative relationships with the goal commitment, the satisfaction as well as the program as STESS for students who take only online courses, which was not the case for students taking only in-class
or mixed delivery method options. Although the number of students who indicated taking only online courses was less than 10% of the sample, the result in the present study calls for further research to confirm the present result and also determine how the ESSD and STESS concepts could be adapted to online education in general.

**Table 11d: A Comparison of Different Course Delivery Options**

<table>
<thead>
<tr>
<th>Path</th>
<th>Original Sample</th>
<th>T Statistics</th>
<th>Original Sample</th>
<th>T Statistics</th>
<th>Original Sample</th>
<th>T Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>ExPressure -&gt; GoalCommnt</td>
<td>0.169</td>
<td>0.574 ns</td>
<td>0.038</td>
<td>0.558 ns</td>
<td>0.103</td>
<td>1.675 ns</td>
</tr>
<tr>
<td>ExPressure -&gt; LOUT</td>
<td>0.044</td>
<td>0.169 ns</td>
<td>0.014</td>
<td>0.192 ns</td>
<td>-0.039</td>
<td>0.604 ns</td>
</tr>
<tr>
<td>ExPressure -&gt; RETN</td>
<td>-0.081</td>
<td>0.272 ns</td>
<td>0.009</td>
<td>0.136 ns</td>
<td>0.074</td>
<td>1.205 ns</td>
</tr>
<tr>
<td>ExPressure -&gt; SATF</td>
<td>-0.057</td>
<td>0.217 ns</td>
<td>0.016</td>
<td>0.227 ns</td>
<td>0.011</td>
<td>0.161 ns</td>
</tr>
<tr>
<td>ExPressure -&gt; STESS</td>
<td>0.042</td>
<td>0.163 ns</td>
<td>-0.086</td>
<td>1.229 ns</td>
<td>-0.089</td>
<td>1.315 ns</td>
</tr>
<tr>
<td>ExPressure -&gt; SchlConfct</td>
<td>-0.348</td>
<td>1.286 ns</td>
<td>-0.336</td>
<td>5.509 ***</td>
<td>-0.508</td>
<td>11.487 ***</td>
</tr>
<tr>
<td>GoalCommnt -&gt; LOUT</td>
<td>0.65</td>
<td>2.133 *</td>
<td>0.191</td>
<td>3.099 ***</td>
<td>0.277</td>
<td>4.25 ***</td>
</tr>
<tr>
<td>GoalCommnt -&gt; RETN</td>
<td>0.5</td>
<td>1.535 ns</td>
<td>0.386</td>
<td>5.348 ***</td>
<td>0.238</td>
<td>3.383 **</td>
</tr>
<tr>
<td>GoalCommnt -&gt; STESS</td>
<td>0.637</td>
<td>1.626 ns</td>
<td>0.227</td>
<td>3.121 **</td>
<td>0.213</td>
<td>4.536 ***</td>
</tr>
<tr>
<td>RETN -&gt; LOUT</td>
<td>0.522</td>
<td>0.482 ns</td>
<td>0.093</td>
<td>1.391 ns</td>
<td>0</td>
<td>0.001 ns</td>
</tr>
<tr>
<td>SATF -&gt; LOUT</td>
<td>0.327</td>
<td>1.263 ns</td>
<td>0.301</td>
<td>4.528 ***</td>
<td>0.234</td>
<td>3.345 ns</td>
</tr>
<tr>
<td>SATF -&gt; RETN</td>
<td>0.525</td>
<td>2.053 *</td>
<td>0.201</td>
<td>2.494 **</td>
<td>0.27</td>
<td>4.204 ***</td>
</tr>
<tr>
<td>SATF -&gt; STESS</td>
<td>0.426</td>
<td>1.596 ns</td>
<td>0.369</td>
<td>4.95 ***</td>
<td>0.515</td>
<td>11.972 ***</td>
</tr>
<tr>
<td>STESS -&gt; LOUT</td>
<td>0.134</td>
<td>0.336 ns</td>
<td>-0.033</td>
<td>0.466 ns</td>
<td>0.111</td>
<td>1.561 ns</td>
</tr>
<tr>
<td>STESS -&gt; RETN</td>
<td>0.072</td>
<td>0.171 ns</td>
<td>0.266</td>
<td>3.368 **</td>
<td>0.195</td>
<td>2.785 **</td>
</tr>
<tr>
<td>SchlConfct -&gt; GoalCommnt</td>
<td>-0.452</td>
<td>1.246 ns</td>
<td>-0.095</td>
<td>1.192 ns</td>
<td>0.076</td>
<td>0.916 ns</td>
</tr>
<tr>
<td>SchlConfct -&gt; SATF</td>
<td>-0.326</td>
<td>0.959 ns</td>
<td>0.024</td>
<td>0.34 ns</td>
<td>0.046</td>
<td>0.622 ns</td>
</tr>
<tr>
<td>SchlConfct -&gt; STESS</td>
<td>-0.259</td>
<td>0.521 ns</td>
<td>-0.089</td>
<td>1.073 ns</td>
<td>0.107</td>
<td>1.496 ns</td>
</tr>
</tbody>
</table>

The group of students who took only online classes seem to only be affected by their personal goal commitment and satisfaction with their intellectual growth. The program as STESS did not seem to have any significant effects on them (Table 11c).
Comparison of Different Ethnic Groups

Of all the ethnic groups in the study, the American Indians seemed to be the least affected by the direct activities of a program as STESS, and Asians seemed most affected by the different variables (they are the only group whose satisfaction can be positively influenced by external environmental pressures). Although the effects were weak, the external environmental pressure seemed more likely to influence the learning outcomes of Blacks negatively, and the impacts of goal commitment and retention on learning outcomes are more likely with Blacks and Caucasians than other ethnic groups. Moreover, the effects of STESS on retention, learning outcome, goal commitment, and satisfaction seem more likely with the two ethnic groups as well.

Table 11e: A Comparison of Different Ethnic Groups

<table>
<thead>
<tr>
<th>Path Coefficient</th>
<th>American Indians</th>
<th>Asians</th>
<th>Black</th>
<th>Caucasians</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Path Coefficient</td>
<td>Original Sample</td>
<td>T Statistics</td>
<td>Original Sample</td>
<td>T Statistics</td>
<td>Original Sample</td>
</tr>
<tr>
<td>ExPressure -&gt; GoalCommit</td>
<td>-0.038</td>
<td>0.16ns</td>
<td>-0.133</td>
<td>1.069ns</td>
<td>0.127</td>
</tr>
<tr>
<td>ExPressure -&gt; OUT</td>
<td>0.003</td>
<td>0.013ns</td>
<td>0.04</td>
<td>0.252ns</td>
<td>-0.043</td>
</tr>
<tr>
<td>ExPressure -&gt; SATF</td>
<td>-0.26</td>
<td>1.468ns</td>
<td>-0.001</td>
<td>0.005ns</td>
<td>0.014</td>
</tr>
<tr>
<td>ExPressure -&gt; STESS</td>
<td>-0.015</td>
<td>0.119ns</td>
<td>-0.174</td>
<td>1.949ns</td>
<td>-0.042</td>
</tr>
<tr>
<td>ExPressure -&gt; SchrConflit</td>
<td>-0.046</td>
<td>0.215ns</td>
<td>-0.13</td>
<td>1.008ns</td>
<td>-0.118</td>
</tr>
<tr>
<td>GoalCommit -&gt; OUT</td>
<td>-0.342</td>
<td>1.392ns</td>
<td>-0.476</td>
<td>4.947ns</td>
<td>-0.387</td>
</tr>
<tr>
<td>GoalCommit -&gt; RETN</td>
<td>0.378</td>
<td>1.441ns</td>
<td>0.023</td>
<td>0.175ns</td>
<td>0.278</td>
</tr>
<tr>
<td>LOUT -&gt; RETN</td>
<td>0.057</td>
<td>0.283ns</td>
<td>0.368</td>
<td>1.222**</td>
<td>0.275</td>
</tr>
<tr>
<td>SATF -&gt; LOUT</td>
<td>0.116</td>
<td>0.6ns</td>
<td>0.076</td>
<td>0.175ns</td>
<td>0.016</td>
</tr>
<tr>
<td>SATF -&gt; RETN</td>
<td>0.119</td>
<td>0.302ns</td>
<td>0.38</td>
<td>2.639**</td>
<td>0.188</td>
</tr>
<tr>
<td>STESS -&gt; LOUT</td>
<td>0.678</td>
<td>3.922***</td>
<td>0.215</td>
<td>1.661ns</td>
<td>0.095</td>
</tr>
<tr>
<td>STESS -&gt; RETN</td>
<td>-0.105</td>
<td>0.509ns</td>
<td>0.055</td>
<td>0.427ns</td>
<td>0.122</td>
</tr>
<tr>
<td>STESS -&gt; GoalCommit</td>
<td>-0.035</td>
<td>0.169ns</td>
<td>0.085</td>
<td>0.675ns</td>
<td>0.243</td>
</tr>
<tr>
<td>STESS -&gt; SATF</td>
<td>0.408</td>
<td>2.165ns</td>
<td>0.255</td>
<td>2.022*</td>
<td>0.406</td>
</tr>
<tr>
<td>STESS -&gt; RETN</td>
<td>0.103</td>
<td>0.579ns</td>
<td>0.264</td>
<td>2.304*</td>
<td>0.34</td>
</tr>
<tr>
<td>STESS -&gt; SchrConflit</td>
<td>0.306</td>
<td>1.386ns</td>
<td>0.294</td>
<td>2.334*</td>
<td>0.408</td>
</tr>
<tr>
<td>SchrConflit -&gt; STESS</td>
<td>-0.013</td>
<td>0.234ns</td>
<td>0.116</td>
<td>1.666ns</td>
<td>-0.012</td>
</tr>
</tbody>
</table>

Further research could provide additional insight concerning the different student groups to inform pre-design analysis and designing of effective programs for adult learners in pre-college/college STEM programs.
Model Fit

Measure fit measures of SRMR < 0.08, NFI < 0.9 (Kock, 2015) are based on covariance, which formative constructs are not expected to have. However, after the model has been simplified by the latent factor scores method, a model fit might be appropriate.

The RSMR and NFI measures of model fit were ascertained for the structural mode. The model fit was assessed with RSMR = 0.042 < 0.08 acceptable score and NFI = 946. Therefore, the model fits the data as expected.

Figure 7b: Model of Goal Commitment and SATF Predicting STESS
CHAPTER 4: DISCUSSION

The synergy of the social and the technical construct in their effects on retention not only confirmed a widely held theories concept of STS, but could be more detrimental for education programs than in the technical industries. Further research should retest the interdependence of social and technical on the student’s intent to complete a degree to determine if indeed, the effects of one might not be beneficial in the absence of the other. The conceptual STESS and the establishment of components that constitute and contribute to its performance are essential results both for practice and for further research. The different segments of the people component of the social system gave a better understanding of the dynamics of workgroups in a STESS. The technology associated with service offerings was assigned to the service offerings component in the ESSD. In the present study, its items loaded with those of infrastructure components together and contributed to the effects of the technical system on the performance of STESS on retention. Based on the findings, the technology part of the service offerings worked better with the infrastructure component.

The predictive effects of the social and the technical on the STESS were first tested and it was determined that as a third-order factor, STESS fully mediated the effects of the social and the technical subsystems on students’ retention.

The structural model analysis started with testing the predictive effects of each of the four components on their constructs. Step two of the measurement ascertained that the social and the technical components indeed predict the social technical system. The results confirmed that the social and the technical system significantly predict the STESS. (Table 8a above).

Then, the hypothesis testing followed, and a summary of the result of the testing are in table 10 above. The highlights of the findings are below after the major contributions. The effects of all the variables, first order, and second, order were significant at a p value less than 0.05. The
weight speaks to the relative importance of the effects, the t-score speaks to the range, and the p-value is the probability that the result was a chance statistical anomaly. In all of the cases where the p-value was less than 0.05, it is highly unlikely that the effect happened by chance.

The social construct with (b = 0.59, t = 5.68, p < 0.001) and technical construct with (b = 0.52, t = 4.75, p < 0.001) were significant within the 95% confidence interval. Two indicators, one from external factors and the other from the socioeconomic factors, had very low weights, and although they weights were significant, future work in this area could review and retest the external environmental pressure on a STESS to determine its viability. It is a critical aspect of an STS view of education as it speaks to the environment in which the program and the student are embedded. The items that were not replaceable and that represent an important aspect of the HOC, were retained because eliminating them could lead to a content validity concerns (Hair et al, 2017). Hair and his colleagues recommended modeling HOCs with equal number LOCs, as the number could influence their individual effects on the HOC. All ten first-order variables have significant relative indirect effects on STESS, thus the STESS concept is established.

The measures of the constructs and their indicators were shown to be adequate for the structural education model. Bootstrapping analysis of the model was performed on both the twenty-variable model and the simplified structure with 7 latent variables. (Chin 1998b). The large model revealed that STESS has a significant direct effect on retention and student outcomes. Although only the STESS construct was used on the simplified structural model, all of the direct and indirect effects of the primary indicators, variables, and second order factors were represented in the one item score of STESS, which would make adding other variables to the model redundant.

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7 The latent variables generated for the measurement of the formative constructs.
and could introduce error into the measurement. Both the possible moderating and mediating effects of the antecedents were tested. The moderating effects of student goal commitment and satisfaction on the STESS were tested by the SmartPLS 3 feature for moderating effects.

The significance of the effects (direct, indirect and total) and the significance of the size of the effect represented by f-score were obtained. The weight gives the effect of a predictor relative to the others variables in the model (Cenfetelli & Bassellier, 2009), while the f-score addresses the significance of the size of the effect. For example, the effects of learning outcomes on retention based on its weight was significant, but the size of the effect was not.

As mentioned above, each of the ten first-order variables had a significant effect on their second-order constructs as shown in Table 7. The Table 8 a shows the weight of the third-order construct STESS on retention. The effects of the ninth component of the ESSD, the external environmental demands, was tested and found not to have a significant effect on Retention and Learning outcome. Its effects were significant for STESS, but the effect size was not significant. It was not removed as it formed a major aspect of the phenomenon being tested, so removing it could jeopardize the content validity of the construct (Bollen & Diamantopoulos, 2017; Hair, Ringle, & Sarstedt, 2011).

It is commonly believed, and previous research confirms, that the number of hours worked by NTAS, and their family responsibilities, can significantly affect their intention to finish college. Moreover, STS are open to their external environment and are required to have standing measures to buffer the possible adverse effects of the external environment in which they are embedded (Pasmore, 1988). Future researchers should test the external environmental pressures on a STESS. The positive aspects of the external environment, which were represented by supportive and encouraging family, friends, employers and professional organizations, were included as part of the people component that possibly enhance the effectiveness of a college/pre-college STEM
program for adult learners. These were shown to have a significant positive effect as evidenced by their relative weight.

The effects of external pressure on STESS was negative as expected, and statistically significant, but the effects’ size was not significant. Both the learning outcome and satisfaction were introduced into the model at the same time, and they both mediated the relative effects of STESS on the two independent variables.

Some critical items about adult learner’s success, like the number of hours worked and rate of progress for example, had very low loadings in the present study, and therefore need to be retested. The rate of progress was calculated by multiplying the self-reported average number of credit hours a student earned per semester by the number of semesters they enrolled for classes in a year.

The observations about the learning outcome in the present study suggest a number of possible interpretations. It does not mean that a STESS does not influence adult learners’ learning outcomes in the presence of goal commitment and satisfaction with their intellectual growth. However, it does mean that STESS, as a facilitator of the success, in providing the learning co-creation resources, could focus on strategies that increase students' goal commitment than on any other plan. The adage “you can take a horse to water but you can't make him drink” is true in education as well. Tinto found that goal commitment is both an entry characteristic of students as well as a dependent variable that could be influenced by a continuum of the student’s college experiences.

The terminology, STESS, could be new, but the concept is where education programs and institutions reside and operate. The particular first-order, second-order, and third-order levels have both practical and research implications.
Major Contributions

A major contribution of the present work is that it confirms that the sociotechnical systems philosophies and principles can be extended to the education service sector for a more holistic approach for educational system intervention design. The systematically developed ESSD contributes to the literature and to practice for a robust design approach to education programs, especially for NTAS. The Conceptual ESSD crystallizes seemingly amorphous and inter-related interactive components of an education program for better understanding, designing and management. Each component of the ESSD as a concept can be studied and understood further in the context of education reform and interventions.

The sociotechnical education service systems (STESS) view of a college STEM program can be systematically operationalized by using the ESSD components developed in this study. Although much still needs to be done to translate each component of the social and the technical system to processes and procedures, the light at the end of the tunnel of such design, change, or improvement can be anticipated based on the findings of this research. Although the context of this work was college/pre-college STEM programs for nontraditional learners, it is believed that the ESSD can be adapted to another section of the educational system continuum.

The adaptive nature of programs like a college STEM program may not be apparent, and often rigid hierarchical decisions and authority structures make the possibility of effecting the needed change prohibitive. The present research shows not only the need for an adaptive view of such a program but also of adaptive management by utilizing the principles and philosophies of the sociotechnical systems approach.

The present research is one of the few organizational perspectives on the issue of student success and retention. There are four decades of research work with a large number of theories and
principles produced that, according to Tinto (2006, 2012), are yet to translate into a practitioner's “how-to,” which the present research broached. Educators, higher education practitioners, and policymakers could revisit how education programs are structured and operated and apply the findings of the present study to more effectively forge better programs. The present study provides practical tools, the ESSD and its associated STESS, that could provide a starting point for further work in this area.

**Limitations**

The student’s perspective of the present study provides the “voice of the customer.” However, the STS phenomenon requires the views of all the internal organizational actors for an increased understanding of the concepts developed in the present study. Not yet having entirely piloted the ESSD, we have limited knowledge of the possible weaknesses and potential strengths not revealed in the present study.

The items used in the present study imposed some limitations to the study. Although the items covered every component of the framework, they were limited in their coverage of every aspect of each component.

**Practical Implications**

The findings in the present study that the social system and the technical system need each other to exert significant positive effects on both Retention and Learning Outcome has an enormous practical implication. Some suboptimal results in the college education of NTAS could be traced to the social and the technical not working together in the context of the abstraction, STES. When not sure, an in-depth review of STES components could review the source of variances in the suboptimal performance of college programs for strategic plans for interventions or designs. The concept could also be adapted for other college education programs, as well. Four sections of STES that should suffice include, the technical, the social, enabling, and inhibiting
components. As can be observed from the present study, each of the four components can be adapted to the program of interest.

In terms of strategies for students' success and retention, the present study suggests a greater focus on strengthening goal commitment and student satisfaction, which could yield a better outcome than an over-concentrated focus on student retention and improved learning outcomes. Targeting students' satisfaction granularly throughout the continuum of their experience could improve their learning co-creation behaviors, which seemed to have a higher potential for enhancing their retention. Understanding the nature and active ingredient of goal commitment, it is a catalyst, and how to leverage its tenacity in propelling students to their success could be one of the most useful and practical contributions to teaching and learning.

**Research Implications**

The present study has two research implications. The three sets of concepts developed in the present study can be studied further. In particular, the ESSD, a pre-design framework premised on a socio-technical systems view of a college program, STESS, and the conceptual components of STESS should receive further study. Case studies of the ESSD from multiple perspectives can increase understanding gained in the present study. Although, the qualitative research interviewed four constituents- the student, their family members, the faculty, and the directors of three pre-college and college STEM programs for NTAS, it would add to the understanding gained in the present study if researchers could assess the views of two crucial members of the constituents: the employers and philanthropists (both individual and corporates) of such programs.

It could increase understanding to develop the conceptual STESS further and study its adaptive nature. Because any viable STESS needs to be positively adaptive to the demands of the external environments, different scenarios of the external pressure and inhibitions can be simulated and modeled. The external environmental pressure and schedule conflict as defined in this study
were expected to have significant negative effects on STESS, retention or learning outcome but they did not. Although only a little over 50% of the participants indicated that they worked at least 30 hours per week, the result could be different if close to 100% of participants worked at least 35 hours per week, which tends to be the case for more nontraditional adult students.

Future research might study the various components of STESS from personnel and management perspectives. Each of the components of the social and technical systems of education programs can further be examined and developed. The social system’s components conceptually explored in the present study - people, policies, course network (peer study groups), and customer orientated strategies and behaviors - that constitute the social system could be further developed. Similarly, the technical system’s components of goal clarifications, measurement and monitoring, the service offerings, the associated technologies and infrastructure, and the socioeconomic strategies could each be studied and developed further.

Each of the components of the social and technical systems of education programs can further be examined and developed. The social system’s components explored in the present study - people, policies, course network (peer study groups), and customer orientated strategies and behaviors that constitute the social system could be further developed. Similarly, the technical system’s components of goal clarification, measuring and monitoring the service offerings, associated technologies, infrastructure, and the socioeconomic strategies could each be studied and developed further.

Further studies of the differences between traditional aged students and nontraditional adult learners could increase insight about some possible peculiar features for designing effective STEM programs for the two categories of students. (Table 11a – 11e show path coefficients of different categories). Additionally, further studies of the conceptual ESSD and STESS in other areas of the
educational systems like the K-12 could give insight on how to adapt these concepts in pre-design or pre-improvement strategies.

Theoretically, the nature and forms of challenges faced by IHE with regards to student success and retention call for increased conciliation of knowledge and concepts. Further development and establishment of these concepts could continue to bridge any unnecessary divide between theories and concepts that may currently exist in some disciplines and industries. Systems, (Banathy & Jenlink, 2013), services (Bitner et al., 2012), social views (Banathy, 2013; Bozkuş, 2014), educational systems design (Kahn & Reigeluth, 1993) and technical focus (J. Groff, 2013; Martone, 2015; Smith, 2014) of education are not new, but what may be new is the concept of STESS, a melting pot of all the five concepts.

The ESSD components seem quite adequate for gaining more in-depth insight that can the design of an effective college/pre-college programs for adult learners. The STS view of a college education in the context referred to in the present study as STESS, can be employed in the institution's effort to improve students' success and retention.
APPENDIX A: INFORMED CONSENT LETTER TO PARTICIPANTS

Systems Approach for Designing Effective College STEM Program for Adult Students

Behavioral Research Informed Consent

Title of Study: Sociotechnical Systems (STS) Approach for Designing an Effective Pre-College STEM Program for Nontraditional Adult Students (NTAS)

Principal Investigator (PI): Ifeoma Okechukwu
Industrial and Systems Engineering
(248) 470 7252

Please note:
1. When we say “you” in this consent form, we mean you; “we” means the researcher(s) and dissertation committee members/other staff.
2. When we say “nontraditional adult student” or “adult” in this consent form, we mean financially independent college students, who either work at least part-time and attend school and/or have dependent children.
3. When we say “STEM” we mean any form of science, technology, engineering or mathematics based course or program.
4. When we say “system”, we mean components that must work together as a unit to achieve a common goal.

Purpose

This research study is meant to determine critical elements for designing an effective college or pre-college science, technology, engineering and mathematics (STEM) program for adult students. You are asked to take part because you participated in a pre-college or college program with financially independent adult students or are a family member of such a student. This study is being conducted at Wayne State University in Detroit, Michigan. The estimated number of study participants is 60. Please read this form and ask any questions you may have before agreeing to be in the study.

Procedures

If you agree to take part in this research study, you will be asked to identify what you understand to be the most effective factors of your college STEM program based on your experience designing, operating, or attending the program, or supporting adult students who attended the program. This
consent form is necessary to ensure that you understand the procedures for ethical academic research conducted by Wayne State University, that you understand the purpose of your involvement, and that you agree to the conditions of your participation.

Please read the accompanying information sheet and then sign this form to certify that you approve the following:

- The interviewees will be asked to tell the interviewer their roles and their experiences in the STEM program they were part of.
- The interviewees will be asked to explain what they understand to be most important for the effectiveness of their program and the success of adult students, and why they think so.
- Each interview will last between 30 and 60 minutes. Follow-up interviews will be requested if more information or clarification is needed from the interviewee(s). All interviews will be conducted in a face-to-face setting at a public location that is mutually agreed to by the interviewer and the interviewee.
- The interviewees will be asked general questions regarding their perceptions of both the technical (infrastructure, tools, technology, etc.) and social (interpersonal interactions between students, faculty, administration etc.) components of the STEM program. We do not anticipate any risks associated with your participation, but you have the right to stop the interview and withdraw from the research or decline to answer any specific question you are not comfortable with at any time.
- The interviewees and other participants of the study will be asked to complete questionnaires, which will be sent and collected via email.
- The interview will be recorded and a transcript produced. The recoding will be erased after the transcript has been produced without the interviewee’s name being included, and then coded by the principal investigator so that the identity of the interviewees remains anonymous.

Benefits
As a participant in this research study, there might be no direct benefit for you. However, information from this study may benefit other people now or in the future. If you are a director of a pre-college/college STEM program (PCSP) for adults, the benefits of this study could include increasing your understanding of the critical components of program effectiveness and adult student success. The findings will increase the available information about vital preparations for adults returning to college to increase their chances of success. The results of this research will educate educational service management about meeting the multiple objectives of faculty job satisfaction and increasing program sustainability and adult students’ degree completion rate throughout the design-to-operations process. Indirectly, the research is expected to contribute to the body of literature in the area of educational service system design, particularly regarding the faculty’s role in increasing the success rate of adults pursuing STEM degrees.

Risks
There are no known risks of participation in this study.
Costs
Participation in this study will be of no cost to you.

Compensation
You will not be paid for taking part in this study.

Confidentiality
All information collected about you during the course of this study will be kept confidential to the extent permitted by law. You will be identified in the research records by a code name or number. If and when the results of this research are published or discussed in public, no information will be included that would reveal your identity. Information that identifies you personally will not be released without your written permission. However, the study sponsor (the Institutional Review Board of Wayne State University) or federal agencies with appropriate regulatory oversight [e.g., Food and Drug Administration (FDA), Office for Human Research Protections (OHRP), Office of Civil Rights (OCR), etc.] may review your records.

If photographs, videos, or audiotape recordings of you will be used for research or educational purposes, your identity will be protected or disguised. Any audiotape will be destroyed after transcripts have been produced. You have the right to review and/or edit the audiotapes before they are destroyed. Only codes with numbers would be used to identify your input in the study. All access to the coded interview transcripts will be limited to the principal investigator and her research staff. Any summary interview content, or direct quotations from interviews, that are made available through academic publication or other academic outlets will be anonymized so that you cannot be identified, and care will be taken to ensure that other information in the interview that could identify you is not revealed.

Voluntary Participation/Withdrawal
Taking part in this study is voluntary. You have the right to choose not to take part in this study. You are free to only answer questions that you want to answer. You are free to withdraw from participation in this study at any time. Your decisions will not change any present or future relationship with Wayne State University or its affiliates, or other services you are entitled to receive.

The principal investigator may stop your participation in this study without your consent. The PI will make the decision and let you know if it is not possible for you to continue.
Questions

If you have any questions about this study now or in the future, you may contact Ifeoma Okechukwu or one of her research team members at the following phone number: (313)-577-5683. If you have questions or concerns about your rights as a research participant, the Chair of the Institutional Review Board can be contacted at (313)-577-1628. If you are unable to contact the research staff, or if you want to talk to someone other than the research staff, you may also call the Wayne State Research Subject Advocate at (313)-577-1628 to discuss problems, obtain information, or offer input.
Consent to Participate in a Research Study

To voluntarily agree to take part in this study, you must sign on the line below. If you choose to take part in this study you may withdraw at any time. You are not giving up any of your legal rights by signing this form. Your signature below indicates that you have read, or had read to you, this entire consent form, including the risks and benefits, and have had all of your questions answered. You will be given a copy of this consent form.

Signature of participant/Legally authorized* ___________________________ Date ___________________________

Printed name of participant/Legally authorized* ___________________________ Time ___________________________

Signature of witness** ___________________________ Date ___________________________

Printed name of witness** ___________________________ Time ___________________________

Signature of person obtaining Authorization ___________________________ Date ___________________________

Printed name of person obtaining Authorization ___________________________ Time ___________________________

*Remove LAR reference if you do not intend to consent participants that have or may have a LAR
** Use when participant has had this consent form read to them (that is, if they are illiterate, legally blind, translated into a foreign language)

Signature of translator ___________________________ Date ___________________________

Printed name of translator ___________________________ Time ___________________________

APPROVED

FEB 07 2019

WAYNE STATE UNIVERSITY INSTITUTIONAL REVIEW BOARD

Submission/Revision Date: 12/18/2018
Protocol Version #: 01

Page 5 of 5
Participant’s Initials
APPENDIX B: INSTITUTIONAL REVIEW BOARD (IRB) APPROVAL LETTER

CONCURRENCE OF EXEMPTION

To: Ifeoma Okochukwu
    Industrial and Systems Engineering

For: Dr. Deborah Ellis
    Chairperson, Behavioral Institutional Review Board (33)

Date: February 07, 2019

RE: IRB #: 012419B3X
    Protocol Title: Socio-technical Systems Approach for Designing an Effective Pre-college STEM program for Nontraditional Adult Students

Status Check-in Date: February 06, 2021

The above-referenced protocol has been reviewed and found to qualify for Exemption according to paragraph #1 of the Department of Health and Human Services Code of Federal Regulations [45 CFR 46.101(b)].

- Social/Behavioral/Education Exempt Protocol Summary Form (received in IRB Office 01/14/2019)
- Research Protocol (received in the IRB Office 01/14/2019)
- Medical records are not being accessed therefore HIPAA does not apply
- Behavioral Research Informed Consent (revision dated 12/18/2018)
- Verbal Consent Script
- Letter to Study Participants
- Interview Scripts (4): (I) For Directors, (II) For Faculty, (III) For Adult Student, and (IV) For family member/peer.

Please submit a Status Update Report for this project by 02/09/2021. The Minimal Risk Status Update Form should be used to provide a status report to the IRB. The Minimal Risk Status Update Form is available on the IRB’s website (http://research.wayne.edu/irb/forms-requirements-categories.php). Modifications/changes to the research project will need to be submitted via an amendment to the WSU IRB.

This proposal has not been evaluated for scientific merit, except to weigh the risk to the human subjects in relation to the potential benefits.

- Exempt protocols do not require annual review by the IRB. However, the IRB does require a status check-in to maintain accurate records regarding the research. The Status Update Report Form is available on the IRB’s website (irb.wayne.edu).
- All changes or amendments to the above-referenced protocol require review and approval by the IRB BEFORE implementation.
APPENDIX C: INTERVIEW PROTOCOL

Sociotechnical Systems Approach for Designing Effective Pre-College Stem Programs for Nontraditional Adult Students
**Introduction**

My name is Ifeoma Okechukwu and I am a Ph.D. candidate at Wayne State University. I am currently conducting a study to identify critical factors for an effective pre-college/college STEM program for financially independent adult students. Additionally, a framework for designing an effective STEM program for this demography will be proposed. You have been selected for this interview because you participated as a director, a faculty member, a student, or a family member of an adult learner in a pre-college/college STEM program. Thank you for making the time available for me to interview you.

The goal of this interview is to learn from your perspective the most effective components of a pre-college/college STEM program for busy adults, also, how they relate to the faculty members of the program. I encourage you to be as open and objective as possible. This research is not about judging your opinion or perceptions. Rather, I hope to gain more understanding into factors that could positively influence adult students’ rate of progress towards program or degree completion in a STEM field.

With your permission, I would like to record this interview in addition to the notes that I will take. The recordings of your interview will not be shared with anyone. Please feel free to ask me to pause the recording if you want to say something that you do not want recorded, and you can decline any question that you are not comfortable answering.

Do you have any questions for me before we get started?

**RQ1** (Koper & Olivier, 2004; W. A. Pasmore, 1988)

**For directors**

1. How did you go about designing an educational program to benefit nontraditional adult student (NTAS) learners?
   a. Please give me details of how you went about designing the program. If not specifically designed for adult students, what, if anything does the program has that accommodates the learning needs of adult students in the program?
   b. Why was the program started?
   c. Who was involved in the decision to design the program?
   d. Who participated in the design and implementation of the program?*
   e. What were the primary factors you considered in designing the program?
   f. How was success described?
   g. What, if anything would you do differently, if you were to redesign the program today?

2. There are three main schools of thought about a student - as a process, a product or a customer. Which one of the schools of thought influenced your approach to the design and
why? How was the preferred school of thought reflected in the design and implementation of the program? (Eagle & Brennan, 2007; Guilbault, 2016)

3. As frontline employees, what in your understanding do the faculty need to be able to teach and work more effectively with adult learners in a pre-college/college STEM program? (Keashly & Neuman, 2010; W. A. Pasmore, 1988; Rockwell, Schauer, Fritz, & Marx, 1999)

For faculty (Day et al., 2011; W. A. Pasmore, 1988)

1. What is your understanding of a successful NTAS learner/graduate from your program?
   a. What is/was your role in the STEM pre-college/college program? Please describe how you contribute to the goal of increasing the rate of adult student’s success. (W. A. Pasmore, 1988)

2. What is your understanding of an effective STEM pre-college/college program for adult learners?
   a. How do you contribute to the effectiveness and continuous improvement of your STEM program to benefit adult learners? (Gazzoli et al., 2013)

3. What do you understand about the design of the program, and what was your level of involvement?

4. From your understanding, what unique characteristics, do the adult learners possess that influence their learning? (in other words how would you describe the adult students in your program?)
   a. How much room do you have in the work design/curriculum design to innovate and adjust for individual learning style of your students?
   b. How much freedom do you have to adjust or adapt your lessons, the delivery processes, and the technologies in order to better serve your adult learners? (in other words, How much autonomy and discretion do you exercise in executing your assignment?)

5. There are three main schools of thought about a student - as a process, a product or a customer. Which one of the schools of thought influenced your approach to teaching the adult learners and why? How does the preferred school of thought reflect in the design and implementation of your lessons, the delivery approach and your general attitude towards the adult learners?

4. What is your opinion about faculty members participating in major decisions about the following: a). design of your work – that is your daily tasks, and the choice of the technologies for course delivery; b). who is admitted and retained in the pre-college/college STEM program; c). everything that affects the quality of your work life.

6. If you have the opportunity to change anything in the program, what would you change and why?

For adult student (La France, 2008)

1. You attended or attending pre-college/college STEM program as a financially independent adult learner and working at least part time. Please describe your experience working and attending school. (Berker et al., 2003; Hammer et al., 1998)
2. What is your perception about the physical components of the program? How about the social components? (Mullen, 2016; W. A. Pasmore, 1988)

3. Were there any particular characteristics that you associate with faculty who were interested in innovative teaching/learning styles that may have influenced you either positively or negatively? Please explain. (Day et al., 2011)

4. How would you describe your perception of your STEM program environment's: a. climate, b. norms and c. values and d. the culture?
   a. Please, describe the process and experience of obtaining assistance.

5. How would you describe the support services of the program and how they may have assisted you in earning more college credits. (Bauman et al., 2004)

6. If you have opportunity to redesign or improve the STEM program, what would you do differently?

For family member/peer
1. Please describe your perceptions of the program’s features that enabled/enables quality family’s support or quality peer support of the adult learners.
   a. What kinds of support do/did you provide to your adult learner?
   b. How does/did each of the support enable them to earn more college credits?

QR2 (Bjordal, 2011; W. A. Pasmore, 1988)

For director
1. How did you go about the recruitment of the adult learners in your STEM program?
   a. What are the learning needs of adult learners pursuing pre-college/college STEM degrees?
   b. How and when were the adult learners’ needs (academic, social and financial needs) obtained?
   c. From your understanding, what unique characteristics, do the NTAS learners possess that influence their learning? (in other words how would you describe the adult students in your program?)

2. How do/did you recruit faculty members who work with the adult learners in your program?
   a. How are/were their buy-in and commitment to the vision and philosophy behind the adult STEM program obtained?
   b. What do the faculty members know about the characteristics of the adult students prior to working with them (teaching, advising, etc.)?
   c. What kinds of preparation or training did the faculty members assigned to teach adult learners receive before they started working with them?

For the faculty
1. How and why did you become adult learners’ educator?
   a. What are their unique learning needs and how do their learning needs affect your teaching style?
   b. How much preparation, if any, did you have to be able to teach/work with the adult students in your program?

2. How does working with the adult learners impact the quality of your work life? (W. A. Pasmore, 1988)
3. In your opinion, how important is your work of educating the adult learners in STEM fields?

For adult student
(Sogunro, 2014)
1. How did you come up with the idea of returning to college?
2. What was your main motivations for making the decision to return to college, and why are you pursuing or why did you pursue a STEM degree?
3. How much did you know about how your daily life could change when you made the decision to return to college?
4. What do you know now about pursuing college degree in a STEM fields that could have helped you to be better prepared to return to college?
5. How would you describe the support you receive/received from your family/peers and how does/did the support you receive/received enabled you to be more successful (earn more college credits) in the program?

For family member/peers
1. Please describe the role you played in encouraging your students to return to college, and how might you have influenced their choice of pursuing a STEM degree?

RQ3 (Forsman et al., 2014; W. A. Pasmore, 1988)
For director
1. What in your understanding were the most effective assistance you provide/provided that encourages/encouraged the adult learners to stay motivated and committed to earn as many college credits as possible or complete the program/degree requirements?
2. How did you enable/enabled the faculty to stay committed in keeping the adult learners motivated to persist to earn more credits/complete program/degree requirements?

For faculty (Day et al., 2011; Plageman, 2011)
1. What are/were the major challenges and how do they threaten/threatened the effectiveness of the program?
2. What are/were the major challenges and how do they threaten/threatened the success of the adult learners?
3. Describe the sources of your motivation and commitment to continue to keep the students motivated to persist to program/degree completion.
4. How would describe your overall job satisfaction teaching and working with the adult learners in your program?

For adult student
1. How would you describe your rate of progress towards earning your dream STEM degree or earning college credits in the program?
2. How do/did you stay motivated and committed to persist to complete the degree requirement? (T. H. Bailey & Phillips, 2016)
3. What were your expectations and how well did the program staff and management meet your expectations for administration, mentorship and/or guidance?
4. What were your expectations from the program curriculum (in terms of courses, assignments, and tests) and from program staff (faculty and administrators)?

5. As an adult student what are your perceptions of the characteristics that are associated with faculty members who are innovative in their teaching/learning styles that may have influenced your success rate either positively or negatively? Please explain.

6. How well does/did the program technical (the physical non-human features like technology, etc.) components meet your academic needs and enabled you to be successful in the program?

7. Describe the sources of your motivation and commitment to continue to stay motivated and committed to persist to program/degree completion. (T. H. Bailey & Phillips, 2016; Kasworm, 2014)

**For Family member/ Peers**

1. Please describe specific support you provided to your student that you believe that may have enabled them to be successful in the college program?

2. Based on your understanding of how your student grapples through school, work and family, if you have opportunity to change anything to increase the success rate of your student, what would you change?

Note:

- Probing questions would be asked as needed. Why, what, when, and questions about examples could be posed for clarity and further understanding.
- For family members only:
  - The survey questions for the family members (form D) will be posed during the interview sessions.

Appendix C The Study Sample
Student Service & Support Network (S3N) – Academic support + financial support + support services:
From right to the left of the S3N displayed above in an Atlas.ti network shows a causal relationship from the management commitment to three distinct support services, which are associated with one another and working holistically for optimum support for NTAS learners.
Figure 8b Student Success – Summary of Participants’ Perceptions

Students’ perception of the policies and procedures of their program positively influence their decisions to follow instructions designed to move them towards graduation.
Figure 8d: The Value the Students Place on Time to Graduation

The value the students place on time to graduation directly relates to their perception of the policies and procedures of the STEM program and positively influences their decisions to follow instructions designed to move them towards graduation.
Students’ perceptions of the policies and procedures of the STEM program are influenced by the technical, social, and “course interaction” networks (Forsman, Linder, et al., 2014) networks.

**Figure 8f: Students’ Interactions with Staff**

Interactions with staff both within and outside the classroom influence student’s overall perceptions and attitude.
Figure 8g: Family Influence on Decision to Persist to Graduation

Family bond was much more likely to influence family support, than just level of education alone.

Figure 8h: Educated Friends Influence on Degree Completion

Figure 8h showed that friends who had college degrees were mentioned as very helpful, and those were may have influenced the interviewees.
Figure 8i: Student’s Success from Faculty’s Perspective

See summary of the Figure 8i in Appendix D
Figure 9a: Faculty’s Job Satisfaction from Faculty’s Perspective

Faculty’s Job satisfaction <= (Positive students’ Outcome) See summary in Appendix D
Faculty motivation and commitment <= choosing to teach NTAS + mission to transform lives + students’ success + faculty’s job satisfaction + valued faculty’s opinion + adequate compensation + equity reward system + mutual respect (of management and of NTAS) + supportive management + management commitment to transform NTAS life
Figure 10: Lessons Learned from Program Designers
APPENDIX E: PROPOSITIONS FROM THE QUALITATIVE STUDY

Table 13: Qualitative Study Findings Summarized as Propositions:

1. Findings Related to Students' Perceptions and Attitude

<table>
<thead>
<tr>
<th>Students' Perceptions and Attitude Propositions:</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Although, some more so than others directly lead to action, the overall performance of the NTAS learners directly relates to their actions (participation behavior) rather than perceptions, values, beliefs, desires, and intentions, or/and motivation).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Proposition #1.1</th>
<th>Students’ positive perceptions of policies increase their engagement in learning activities of a program:</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Students’ positive perceptions of the policies and procedures of a pre-college program have a positive influence on students’ decisions to follow instructions designed to move them towards graduation;</td>
<td></td>
</tr>
<tr>
<td>i. Perceiving policies as beneficial for various reasons influenced over 80% of the students interviewed to engage more and follow instructions that led to their academic success.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Proposition #1.2</th>
<th>The perceived value of STEM careers increases motivation of adult learners to seek STEM degrees:</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. The perception that STEM-related employment would earn them more income positively influences the initial value the NTAS learners place on STEM degrees completion.</td>
<td></td>
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<tr>
<td>b. To the extent the interactions, policies, or procedures of a STEM program are perceived not to be adult friendly, degree/program completion is unlikely to occur.</td>
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<tr>
<td>c. The value NTAS learners place on subsidized or tuition-free STEM degrees causes positive attitudes even in the face of negative perceptions about the program.</td>
<td></td>
</tr>
<tr>
<td>i. Student support and services increase the value NTAS learners place on completing courses every semester, evidenced by a statement like: “I didn’t want to have to pay for the courses out of pocket if I failed…” (Student Respondent 01)</td>
<td></td>
</tr>
<tr>
<td>d. NTAS learners are likely to take actions that lead to program completion if they have positive perceptions of the people, policies, or/and procedures in the program.</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Proposition #1.3</th>
<th>Positive course-related interactions positively influence NTAS learners' academic success:</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Positive perceptions of course-related interactions with the technical components of a STEM program increase students’ cooperative engagement in a STEM program.</td>
<td></td>
</tr>
<tr>
<td>b. Positive perceptions of course-related interactions with faculty, peers, and learning center attendance of a STEM program increase students’ cooperative engagement in a STEM program.</td>
<td></td>
</tr>
<tr>
<td>i. A course-interaction network is a formal or informal team formed in a course for group projects or collaboration between course mates. Course interaction networks where adult learners choose their teammates instead of assigned teammates by the faculty result in better learning outcomes.</td>
<td></td>
</tr>
<tr>
<td>ii. Data revealed that students cooperated and engaged more with teammates they chose than the ones assigned by their instructors.</td>
<td></td>
</tr>
<tr>
<td>c. Thus, self-organized course-related interactions positively influence NTAS learners' persistence toward degree completion.</td>
<td></td>
</tr>
<tr>
<td>i. The study revealed that adults prefer to pick their groups and that most of the students who engaged in these group course interaction networks were encouraged to persist in the course, in spite of negatively viewed policies, and procedures.</td>
<td></td>
</tr>
<tr>
<td>d. Adult learners' perceptions of the technical, social, and course-related interactions directly influence their perceptions of the program's policies.</td>
<td></td>
</tr>
</tbody>
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2. The roman numerals are the explanations
e. Continuous positive academic outcomes motivate NTAS learners to persist and positively influence retention.
   i. Adult learners expect assessments to be formative rather than dismissive and leading to dismissal from a program.

f. Overall, the motivation of the NTAS learners fluctuates, with its zenith at the beginning, ebbing out more towards degree completion.

<table>
<thead>
<tr>
<th>Proposition #1.4: Positive interactions with faculty and staff influence NTAS learners' attitudes.</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. The higher the positive interactions between NTAS learners with their instructors, the more likely they are to engage in learning activities that lead to better performance.</td>
</tr>
<tr>
<td>i. The study showed that if adult learners do not think that their faculty members care about their overall wellbeing, they probably do not care about their knowledge acquisition either.</td>
</tr>
<tr>
<td>b. The more respectful and empathetic NTAS learners perceive the faculty members to be, the higher their cooperation with learning activities that lead to better performance.</td>
</tr>
<tr>
<td>c. When perceived as useful, adult learners embrace structure in a program that enhances performance.</td>
</tr>
<tr>
<td>d. Most students desire more faculty flexibility with teaching needs and style, assignment deadlines, amount of homework, and mutual respect.</td>
</tr>
<tr>
<td>i. Knowledgeable and interested faculty need additional adult-learning style preparation and training for optimal performance working with NTAS learners. The students and some directors in the study recommended adequately prepared and trained faculty who understand the complicated life of the NTAS, because as expressed by one of the students, &quot;many of them don't have a clue what I go through every single day.&quot; (Students respondent 08)</td>
</tr>
<tr>
<td>e. Inclusion in decisions that concern NTAS learners positively influences them to cooperate with related policies more positively.</td>
</tr>
<tr>
<td>i. NTAS learners predominantly view themselves as adults and wish to be treated as such in decisions that affect them.</td>
</tr>
<tr>
<td>f. The faculty's motivation and commitment towards the NTAS positively influence students' decision to persist.</td>
</tr>
<tr>
<td>i. A significant number of students in the study viewed adjunct faculty members in their program as less committed.</td>
</tr>
</tbody>
</table>
Findings related to Student Perceptions and Attitudes continued:

<table>
<thead>
<tr>
<th>Proposition #1.5: Quality customized curriculum positively influences intention to complete program/degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Relevant and useful professionally or personally relatable concepts and topics motivate the NTAS learners.</td>
</tr>
<tr>
<td>b. Relevant and immediately applicable and useful lessons with experience-based and hands-on strategies engage NTAS learners much more than abstract topics and concepts.</td>
</tr>
<tr>
<td>c. Lively classrooms engendered by humorous faculty members create a more learning-friendly atmosphere for adult learners.</td>
</tr>
<tr>
<td>i. Most of the students in the study associated a lively classroom with faculty members who had a sense of humor and preferred to engage in lessons by such faculty.</td>
</tr>
<tr>
<td>d. Adequate intellectually challenging course work or projects intrinsically motivate NTAS learners.</td>
</tr>
<tr>
<td>i. All case #1 students loved the two-week pre-program where they reviewed math concepts and logic in the context of Euclidean geometry proof writing. Even the students who indicated not doing very well in the course said that they enjoyed the mentally stimulating nature of the course. This point is significant because NTAS learners could be mistakenly assumed not to have the intellectual capacity to handle complex analytical concepts.</td>
</tr>
<tr>
<td>e. The NTAS learners need support services to persist in a pre-college or college program.</td>
</tr>
<tr>
<td>i. Almost all the students in the present study needed support services without which most said that they would have dropped out of their program.</td>
</tr>
<tr>
<td>ii. Ample supply of and readily available support and services (academic, financial, and general support services) and encouraging words were equated to “caring” and influence NTAS learners’ attitude and persistence towards the program and degree completion.</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>2. Faculty and staff-related Findings:</th>
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<tbody>
<tr>
<td>Faculty and Staff Job Satisfaction and Commitment</td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>a. Faculty’s job satisfaction and their students’ success are mutually reinforcing, which leads to the commitment of the faculty member even with less than optimum job satisfaction.</td>
</tr>
<tr>
<td>i. Data revealed. “My job is to see them get what they came here for, and to know that I am part of their success gives me satisfaction.” (Faculty Respondent 02).</td>
</tr>
<tr>
<td>ii. A significant number of faculty members did not feel satisfied working with NTAS learners, mostly because of the workload and social challenges they encounter. “… Sometimes, they want to tell me how to teach my class,” Faculty Respondent 01 said.</td>
</tr>
<tr>
<td>b. Faculty members whose psychological needs align with an organization’s vision for adult learners of changing their lives by providing them with the opportunity to earn college degrees have more job satisfaction working with NTAS learners.</td>
</tr>
<tr>
<td>i. The present study revealed that suboptimal job satisfaction did not affect the dedication of faculty members whose psychological needs aligned with the organization’s vision for more NTAS learners to earn STEM college degrees.</td>
</tr>
<tr>
<td>c. Knowledgeable and interested faculty members are more likely to stay motivated in working with NTAS learners in college STEM or pre-college programs if they understand better how best to meet the students’ learning needs and institution’s business goals in the courses they teach.</td>
</tr>
</tbody>
</table>
### Proposition #2.2: The support of management positively influences the faculty's job satisfaction and commitment.

- a. Management support and adequate reward systems drive the faculty's continued motivation and commitments.
- b. The inclusion of faculty in decisions that affect them increases the faculty's sense of belonging.
  - i. The faculty's sense of belonging increases their job satisfaction. The faculty's job satisfaction improves their performance in working with NTAS learners.
- c. The more the involvement of the faculty in the program's design, the greater their flexibility in adjusting to the program's success, which implies the student's success.
  - i. All the faculty members who participated in the design and decisions in two of the cases went beyond the call of duty to ensure program success. The following statement by one of the faculty respondents captures the commitment of these faculty members: "I was overstretched during the two weeks of Math Booth Camp. I didn't complain because I felt like doing whatever it would take for our program to succeed". The word "our" shows the faculty (Faculty Respondent 02) expressed ownership of the program's success.
- d. The more the involvement of the faculty in the selection of their students, the more they feel professionally responsible for the student's success.
  - i. Some faculty members of one of the cases in the present study were involved in the decision of who made the final class list. Data showed that the faculty members who were involved felt somehow obligated to the success of the students more than the faculty who had no say in the selection decisions of their students. Some faculty members of a different two year college, felt like they would not have recommended some of their students for admission, if they were involved with the selection process, because "some of the students do not possess needed pre-requisite knowledge to be successful in some of their current course" (Faculty Respondent 10).
- e. The more the faculty feels empowered to enforce course-related rules and decisions, the more flexible their work with NTAS learners.
- f. Faculty members holding multiple roles with the students (which may be efficient for the program), likely negatively affects the quality of the faculty's interactions with NTAS learners.
  - i. This is a socio-technical gap in a program. Cross-training faculty members for multiple roles can be efficient for a program but negatively affects the quality of the interactions between them and their students. Some of the faculty members in the study teach as well as work with the students in other capacities. While that was beneficial for the organizations, it was a double-edged sword for faculty members. For example, as an academic advisor, one of the faculty members thought he understood his students better for more and realistic quality advising based on his first-hand experience as their mathematics instructor. However, the amicable social process that should naturally underlay the student advising sessions was sometimes negatively impacted when advising students who failed mathematics classes.
4. Faculty and staff-related Findings Continued

<table>
<thead>
<tr>
<th>Proposition #2.3: Faculty’s perceptions of NTAS learners influence their attitude towards assisting the NTAS learners to persist:</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Faculty’s positive perception of NTAS learners’ intellectual ability influenced their commitment to keeping students motivated and persistent in a STEM program.</td>
</tr>
<tr>
<td>i. This is an STS gap – some faculty do not think that some of the students have the necessary background to be successful in some courses, and therefore are not prompt in providing needed assistance.</td>
</tr>
<tr>
<td>b. The conflicting course objectives and students’ new knowledge absorption rate constrained the faculty’s ability to control variance at the source and adjust to the students learning needs.</td>
</tr>
<tr>
<td>i. This is an STS gap – a learning need of a student that could be met socially, but technically constrained by conflicting objectives. The faculty indicated that the NTAS learners are different and have unique characteristics, but they were not always able to adapt to their learning needs.</td>
</tr>
<tr>
<td>c. The varying degree of academic status (prior knowledge/skills) of NTAS learners in the same cohort negatively impacts the faculty’s performance and students’ outcomes.</td>
</tr>
<tr>
<td>i. Both the faculty and some directors suggest the need for pre-program remediation to increase homogeneity in the entry-level academic skills of the students.</td>
</tr>
<tr>
<td>d. Faculty’s motivation to assist NTAS learners is more likely affected negatively by NTAS learners’ unavailability to get help outside the classroom.</td>
</tr>
<tr>
<td>i. Most faculty members expressed concern about the rate of absenteeism about NTAS learners, and they vary in their attitudes towards them. Many faculty members found at NTAS learners’ not often taking advantage of flexible office and tutoring hours and their often-transient motivation for learning.</td>
</tr>
<tr>
<td>e. The higher the absenteeism of NTAS learners, the less the faculty’s motivation to assist them.</td>
</tr>
<tr>
<td>f. When the faculty members view adult learners as customers, the more likely the quality of their interactions increases.</td>
</tr>
<tr>
<td>i. Some director participants believed that viewing adult learners as customers would increase faculty’s positive attitude towards their students.</td>
</tr>
<tr>
<td>ii. For example, one of the faculty members said, “My students are not my customers… in my opinion; they are stakeholders who must step up their game if they want to be successful in college. Many of them are capable, but they miss too many classes to be successful.” (faculty respondent 01).</td>
</tr>
</tbody>
</table>

5. Program Related Findings:

<table>
<thead>
<tr>
<th>Program Features and Staff Collective Engagement</th>
<th>Proposition #3.1: Organization’s commitment to the success of the NTAS learners relates directly to the effectiveness of a pre-college or college STEM program design.</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. The organization’s commitment relates directly to the individual and collective motivation and commitment of the staff that interacts with adult learners in a STEM program.</td>
<td></td>
</tr>
<tr>
<td>i. Indispensable to the effectiveness of any pre-college or college STEM program is an organizational commitment to NTAS learners’ success. Most gaps in the effectiveness of the PCSP (both technically and socially) in this study were traced to suboptimal organizational commitment.</td>
<td></td>
</tr>
<tr>
<td>ii. Supportive management for faculty and staff linked directly to enhanced satisfaction, motivation and commitment to the NTAS learners’ success in this study.</td>
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### 6. Program Related Findings Continued:

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</thead>
<tbody>
<tr>
<td>a.</td>
<td><strong>Proposition #3.2:</strong> A high-quality customized curriculum relates positively to students’ intention to persist to degree completion.</td>
</tr>
<tr>
<td>b.</td>
<td>A customized curriculum that consists of relevant and relatable topics and concepts with experience and/or case study scenario project-based assignments and assessments is more likely to motivate NTAS learners to complete STEM degrees faster.</td>
</tr>
<tr>
<td>c.</td>
<td>Appropriately paced course-work is more likely to lead to a higher success rate for NTAS learners.</td>
</tr>
<tr>
<td>d.</td>
<td>Adequately coordinated schedules for a class assignment are more likely to lead to a higher course completion rate.</td>
</tr>
<tr>
<td></td>
<td>i. The students indicated that positive learning outcomes increase their motivation to persist. Hence, accumulating successes from completed assignments is more likely to culminate in greater success in a course, and hence the student’s success in the semester.</td>
</tr>
<tr>
<td>e.</td>
<td>An appropriate amount of workload (in terms of assignments and conflicting due dates from different faculty members) is likely to produce a higher performance rate.</td>
</tr>
<tr>
<td></td>
<td>i. The amount of assignments for adult students in most STEM programs is usually based on the course objectives, with little to no consideration for NTAS students’ complex life-world.</td>
</tr>
<tr>
<td>f.</td>
<td>The variety and flexibility of assessment methods are more likely to enhance adult learners’ performance in a STEM program.</td>
</tr>
<tr>
<td></td>
<td>i. “I don’t test well...some faculty only give tests, and tests make me nervous. I wish more instructors could learn to test me with projects and presentations. I hate sitting in the class for hours to answer some questions”, was the frustration expressed by the student respondent 05. Structuring assignments in ways that allow adult learners to springboard from their experiences is more likely to reduce test anxiety and increase performance.</td>
</tr>
<tr>
<td>g.</td>
<td>Modularized stackable certifications structured in a customized curriculum leading to a desired STEM degree could be more desirable and more likely to lead to a higher rate of degree completion.</td>
</tr>
<tr>
<td></td>
<td>i. Most of the directors and students expressed a desire to have a modularized curriculum that leads to industry-recognized certifications for students and eventually culminates in a baccalaureate degree in a STEM field.</td>
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<tr>
<td></td>
<td>ii. On the other hand, if life happens, and the students do not complete the degree, they may have completed a valuable credential for higher-paying employment. Their status would be completed and not drop out because they completed the requirement for a credential.</td>
</tr>
<tr>
<td>h.</td>
<td>The more conflict-free work-school schedules adult learners have, the less likely absenteeism will occur, and the more likely student’s academic success increases.</td>
</tr>
<tr>
<td></td>
<td>i. Most students desired that their STEM program schedule align more with their dynamic employment schedule to offer classes when the students are available. Polling students for their schedules at the beginning of a new semester could reduce the rate of work-school schedule conflicts.</td>
</tr>
</tbody>
</table>
Program Related Findings Continued:

<table>
<thead>
<tr>
<th>Proposition #3.3: Quality dedicated space/environment and physical structure for learning enhance adult learners’ experience and increase students’ satisfaction significantly.</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Improved student satisfaction leads to improvement in the students’ integration/engagement behavior.</td>
</tr>
<tr>
<td>b. Easy access to program resources is likely to improve students’ chances of review lessons and hence improve performance.</td>
</tr>
<tr>
<td>c. Free and smooth flow of academic information and resources relates directly to improved participation behavior in learning activities, which is likely to lead to improvement of academic performance.</td>
</tr>
<tr>
<td>d. The free flow of useful information from both the program and peers enhances students learning experience.</td>
</tr>
<tr>
<td>e. Welcoming and comfortable classroom and a dedicated student lounge relate directly to the conduciveness of the learning environment that improves students’ college experience and satisfaction.</td>
</tr>
<tr>
<td>f. Flexible course delivery methods (mostly in terms of teaching style than delivery channels) positively influence the academic performance of adult learners.</td>
</tr>
</tbody>
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<tr>
<th>Proposition #3.4: Strategic mutually benefiting partnerships increase the chances of meeting NTAS learners’ needs</th>
</tr>
</thead>
<tbody>
<tr>
<td>i. The present study revealed that adult learners’ needs are many and often mostly interdependent. No one institution can adequately meet the many-faceted learning needs and needs while in the school of the NTAS learners. The directors in this study highlighted partnership as key to a more holistic support network for this demographic. However, for the partnership to be sustainable, it must be mutually benefiting for all the parties involved, the study revealed.</td>
</tr>
<tr>
<td>ii. Partners can include industry, colleges/university (where applicable), learning management systems’ vendors, State Social Service department, students’ families, and so forth.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Proposition #3.4.1: Partnership-based employment for the students is likely to reduce work-school schedule conflicts, improve working conditions, and moderate the number of hours students’ work per week.</th>
</tr>
</thead>
<tbody>
<tr>
<td>i. Some students from two of the three cases in this study worked only 20 hours with much higher pay with partnership support of the students’ education. Stable employment (working an adequate number of hours per week) provides a higher degree of support. Faculty view strong partnership of university and employers favorably for providing stability for NTAS in the classroom through financial stability, conflict-free school-work schedules, possible work-related educational projects, and scholarships and grants.</td>
</tr>
</tbody>
</table>
Program Related Findings Continued:

<table>
<thead>
<tr>
<th>Proposition #3.5: The effectiveness of a PCSP in enabling optimum number of NTAS learners to complete the program or college degree is a program-wide phenomenon that more likely manifests, if everyone, management, academic and non-academic staff, engage collectively in a unified commitment to students’ success.</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Effectiveness of a PCSP is a program-wide phenomenon that requires the coordinated engagement of all actors and is driven by organizational commitment.</td>
</tr>
<tr>
<td>i. The actors include the internal staff (management and frontline academic and non-academic staff), and the leadership and frontline staff of pertinent strategic partners, and the students. The tool that hones the cooperation and engagement of all parties is shared vision and value creation.</td>
</tr>
<tr>
<td>b. Deliberately targeted student satisfaction through customer-oriented interactions and services is more likely to improve student college experience.</td>
</tr>
<tr>
<td>i. The customer-oriented atmosphere that was observed to improve student satisfaction, which links to students' positive attitude towards observing policies that lead to better learning outcomes, was observed to occur through &quot;it seemed like everyone wants you to succeed in the program&quot; (student respondent 04 said. Student's success was a shared vision, and the strategy was a collective effort of all staff members - frontline staff (academic and non-academic).</td>
</tr>
<tr>
<td>c. Technically knowledgeable and socially &quot;nice&quot; faculty members are more likely to be effective in working with NTAS learners.</td>
</tr>
<tr>
<td>i. The students in the present study highly valued knowledgeable and &quot;nice&quot; faculty members. They explained &quot;knowledgeable&quot; in terms of course content, delivery methods, and competence in working with adult learners. For the students, a &quot;nice&quot; faculty member is humorous, flexible with assignment due dates, and is empathetic.</td>
</tr>
<tr>
<td>ii. Fewer than 20% of the faculty interviewed view their adult students as customers. About 88% of directors of the same programs think of their students as customers. This gap resides in the lack of a shared vision strategy and can resolve at the pre-design, design, implementation, and operational phases of the program through a participatory design and decision process.</td>
</tr>
</tbody>
</table>
### 4. Design Related Findings

<table>
<thead>
<tr>
<th>Adequate Pre-design and Participatory Design and Decisions Driven by Organizational Commitment</th>
<th>Proposition #4.1: Student success is a program design outcome. The more the detail of pre-design analyses of a PCSP or college STEM program for adult learners, the more participatory the design will be, and the more inclusive and participatory the design, the more likely program design fits program’s core and supplementary goals.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>a. The organization’s commitment relates directly to the design of effective pre-college STEM programs for NTAS.</td>
</tr>
<tr>
<td></td>
<td>b. A PCSP is more likely to be effective in engendering more program/degree completion if designed to fit the student’s needs (learning needs and needs while enrolled) as well as the needs of the staff (academic and non-academic).</td>
</tr>
<tr>
<td></td>
<td>i. Designing an effective STEM program for NTAS learners requires an in-depth understanding of the magnitude of their needs in terms of the quantity, nature, interdependence, and the levels at which each may need to be solved for any support service to be impactful.</td>
</tr>
<tr>
<td></td>
<td>c. To the extent the physical, social, and psychological needs of the faculty and staff are met in the design process of a PCSP for NTAS, the resulting program effectively enables more students’ success.</td>
</tr>
<tr>
<td></td>
<td>i. Adequate pre-design analyses lead to a better understanding of the spectrum of NTAS learners’ learning needs and needs while in school, as well as the needs of the faculty and staff of the program.</td>
</tr>
<tr>
<td></td>
<td>ii. Multiple dimensional views of the multi-faceted needs of the NTAS require the inclusion of all relevant actors, including faculty/staff and the students’ representatives. There is a need to account for the various aspects of the worlds-life of the NTAS learners to be able to plan for their success.</td>
</tr>
<tr>
<td></td>
<td>iii. Expert and experience-based advice for the definition of goals, content, success, and success benchmarks, in terms of attainability, the feasibility of timeline, relevance, and useful curriculum content (customized); and shortened quality program were considered highly valuable in designing an effective program.</td>
</tr>
<tr>
<td></td>
<td>d. Participatory design, shared vision, and collective decision processes are more likely to lead to an increased understanding of faculty’s perspectives about how best to design their daily tasks for optimum task performance.</td>
</tr>
<tr>
<td></td>
<td>i. Most of the director respondents indicated the need to involve key faculty members, key student service professionals, representatives, and students’ supervisors of partner industries, if applicable, university representatives, and students’ representatives in the design processes from the beginning.</td>
</tr>
<tr>
<td></td>
<td>e. Staff participation in the pre-design and design analyses is more likely to increase their understanding of the students’ needs and to increase the likelihood they will develop some problem-solving strategies to enhance the effectiveness of the program.</td>
</tr>
</tbody>
</table>
### Design Related Findings Continued

| Proposition #4.2: Systematized and jointly optimized technical (academic and associated technology) and social (internal and partners') services are more likely to lead to optimum program performance for NTAS learners.  
| a. Data revealed that systemized academic (technical) and non-academic (mostly social) services would lead to better outcomes. "Even in providing support, financial support without adequate academic support like tutoring and effective academic advising could erase the positive effect of financial support." (Director Respondent 04).  
| b. The support for the students and the program's support systems are likely to be more effective if understood and designed to fit the program's goal from the beginning.  
| i. The determination of the nature, type and strategies for coupling and systematizing support and services of a PCSP for optimum impact for the NTAS learners, if done during a pre-design analysis, is more likely to fit the program better than as an afterthought.  

| Proposition #4.3: The higher the quality of the recruiting mechanism of a STEM program for NTAS learners, the less the incidents of engaging mis-fitting actors.  
| i. Based on the findings in the present study, we conclude that a quality recruiting strategy is a pre-design and design outcome. For example, a combination of a "knowledgeable and "nice" faculty member is less likely to happen always by chance. The determination of the mechanism for recruiting the faculty and other staff members, partners, and students occurs at the beginning, and it is usually based on the overall goal of the program. The directors in this study thought that it was highly needed for selecting students, faculty, partners – University, Industry, Vendors (Educational service support materials, tools, and technology), Pipeline High Schools and government and donors), may be necessary for creating and maintaining higher academic and service standard.  
| a. The higher the quality of the recruitment of all actors in a PCSP for NTAS learners, the more likely the program enables increased number of program completion.  
| i. Quality recruitment of all actors, including students, is likely to increase the effectiveness of a PCSP by ensuring:  
| ii. For the students: that adequate minimum level mathematics skills, financial, Family stability, and employment skill set for the students, so that the students are not set up for failure ab initio. Those who are not qualified can be recommended to other programs, if necessary.  
| iii. Faculty and staff: that adequate preparation for faculty and staff, ensuring interest as well as knowledgability.  
| iv. Partners: that adequate shared value creation for all participating partners  
| v. Family: that the engagement of significant/relevant students' family members from the start of enrollment by intimating them with enough information about the students' need for morals and any other support they can provide.  

5. Student Support and Services Network (S3N)

<table>
<thead>
<tr>
<th>Holistic and Systematized Support and Services</th>
<th>Proposition #5.1: NTAS learners need holistic support and services and are more likely to persist in a pre-college/college STEM program if learning needs and needs while in school are met.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>a. The more holistic and systematized the support and services for NTAS learners, the higher their impact.</td>
</tr>
<tr>
<td></td>
<td>i. The support services that the NTAS learners need include academic support, financial support, and social and emotional. Most NTAS in the study needed these support and services to be focused and persist towards degree completion. Academic support services include – tutoring, mentoring &amp; limited remediation (especially on study techniques); Moral (social and emotional) support include words of encouragement, and family and peer physical and emotional support. Financial support includes scholarships grants, paid internships and co-ops, and employer tuition support were some of the options mentioned by students and directors. Partnership-based employment supports provide stability for the students while in school. Only one of the 15 students interviewed could have managed without financial aid and support, especially for tuition and fees.</td>
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<td></td>
<td>b. When the faculty is committed to their NTAS learner’s academic support, the students’ confidence to improve performance increases.</td>
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<tr>
<td></td>
<td>i. Faculty’s support is most critical for excelling in academics, followed by peers’ support.</td>
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<td></td>
<td>c. Institutionalized financial support in the form of connection to an employer where the employment is contingent upon continued enrolment is more relate directly to retention in a STEM program.</td>
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<tr>
<td></td>
<td>i. Strong partnerships: For clear/more accessible accumulation of credits pathway, clear/more straightforward credit transfer pathway, work/school schedule balance, for employment, scholarships, possible future employment, and family support.</td>
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<td></td>
<td>d. Family: The more the emotional and social support NTAS learners receive from their family, they more likely they persist in college.</td>
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<tr>
<td></td>
<td>i. It is essential to connect with the family early (for example, during orientation).</td>
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<td></td>
<td>e. Family bonds are a stronger motivator for family support for NTAS than the level of education of family members. Most of the students interviewed saw family support as a critical component of their academic success.</td>
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<tr>
<td></td>
<td>i. &quot;Family bond&quot; was more critical for this demography than the level of education of family member(s). The family's physical assistance included words of encouragement, finance, and childcare.</td>
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<td></td>
<td>f. Supportive friends: The support of the educated friends of adult learners is more likely to encourage them to persist in a STEM program.</td>
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</table>
Student Support and Services Network (S3N) Continued

<p>| | |</p>
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</table>
| g. | Supportive Peers: Course-based interaction network and social peer mentoring (formal and informal) positively influence adult learners' persistence in STEM program.  
   | 1. Data highlighted peer mentoring, tutoring, and study groups as essential factors of students' persistent and academic success. |
| h. | Supportive employment supervisors: The more supportive a supervisor of an adult learner in a STEM program is, the less likely there will be work-school schedule conflicts and uncompleted homework, and the more likely the students would complete their homework, which can lead to increased positive academic performance.  
   | 1. Currently, based on data from the present study, students did not feel supported by their supervisors. Most student respondents wished for supportive employment supervisors who would offer words of encouragement and allow limited time to complete homework at work. |
| i. | Quality of work-life (QWL): Poor QWL negatively affects adult learner's ability to complete college degree.  
   | 1. QWL was defined in the interview as "motivated and committed to their employment and looked forward to returning to work not only because they needed to, but also because they wanted to." A significant number of the students did not think that they had good QWL, and poor QWL may negatively impact NTAs learner's success in college. |
### APPENDIX F: ITEMS USED IN THE QUANTITATIVE STUDY

Table 14: Variables used in the Study

<table>
<thead>
<tr>
<th>Variable</th>
<th>Element</th>
<th>Description</th>
<th>Instrument &amp; Author</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dependent:</strong></td>
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<td></td>
<td>Adult Learner Persistence Survey (Bergman, 2012)</td>
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<tr>
<td><strong>Persistence</strong></td>
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<tr>
<td>Entry Characteristics</td>
<td>Age</td>
<td>Questions ec1: Multiple choice: (18-24, 25-29, 30-34, 35-39, 40-44, 45-49, 50 and older)</td>
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<tr>
<td></td>
<td>Gender</td>
<td>Questions ec2: Gender most identified with: Female or Male.</td>
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<td></td>
<td>Ethnicity</td>
<td>Question ec3: 8 multiple choice options, including an option to write in a response</td>
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<td></td>
<td>Marital status</td>
<td>Question ec4: 5 options ranging from not married to widowed</td>
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<tr>
<td></td>
<td>Children</td>
<td>Question ec5: Number of dependent children while enrolled. 4 options: 0-2, 3-5, 6-8, 9 or more</td>
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<td></td>
<td>High School</td>
<td>Question ec6: Multiple choice. Six options (0.5-1.0, 1.1-2.4, 2.5-2.9, 3.0-3.4, 3.5-3.9, 4.0 and greater)</td>
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<td></td>
<td>GPA</td>
<td>Question ec7: Are parents’ education above high school or not? Five options (No, Yes, both, Yes, mother only, Yes, father only, I don’t know)</td>
<td></td>
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<td></td>
<td>Parental education</td>
<td>Question ec8: Eight options (Change of career, Higher income, A family member thought it would be good for me, A colleague at work thought it would be good for me, My friend(s) thought it would be good for me, Unemployment, Underemployment, Be an example for my children, Other:________)</td>
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<td></td>
<td>Reason for returning to college</td>
<td>Question ec9: 8 options (engineering, business and health sciences with an option to write fields not provided)</td>
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<td></td>
<td>Field of study</td>
<td>Question ec10: Write in current institution</td>
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<td></td>
<td>Institution attended or enrolled in currently.</td>
<td></td>
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</tr>
<tr>
<td>Learner's Commitments</td>
<td>Goal</td>
<td>Questions gc1-gc2. (2 items)</td>
<td>Adult Persistence Survey (Bergman, 2012)</td>
</tr>
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<tr>
<td>Institutional Commitment</td>
<td></td>
<td>Question gc1: Five options about the importance of earning a STEM degree (not important to extremely important)</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Question gc2: 3 options (very certain to earn a college degree, very certain to earn a STEM degree no matter what).</td>
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<td></td>
<td><strong>Question ic1-ic2</strong>: Question ic1: four options about how much they like the institution (from enthusiastic to definitely not)</td>
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<td>Question ic2: (Same options as in ic1 about likelihood to choose institution again if starting all over)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>External Environmental variables</th>
<th>Hours of Employment</th>
<th>Questions: (9 items)</th>
<th>Park &amp; Choi, 2009 Casandra, et al., 1993</th>
</tr>
</thead>
<tbody>
<tr>
<td>Family responsibilities</td>
<td></td>
<td>Question h1: (1 item): Number of hours worked in a week (on campus and off campus). 5 response options: 0–20, 21–30, 31–40, 41–50, 51 or more.</td>
<td></td>
</tr>
<tr>
<td>Finance &amp; Financial resources to complete your program/degree?</td>
<td></td>
<td><strong>Questions r2-r3</strong>: (2 items).</td>
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<td></td>
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<td>Question r2: the extent to which childcare interfered with school attendance</td>
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<td>Question r3: the extent to which health problems of family members interfered with school attendance. 5 options of “not at all” – “very great extent” for questions r2-r3.</td>
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<td></td>
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<td><strong>Question fl-f2 (2 items):</strong></td>
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<td></td>
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<td>Question f1: approximate amount of financial contributions from self, family, employers, or other sources (please specify). 6 response options</td>
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<td></td>
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<td>Question 3</td>
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</tbody>
</table>
| Financial resources to complete your program/degree? | **Question f1 - f2 (2 items):**
Question f1: approximate amount of financial contributions from self, family, employers, or other sources (please specify). 6 response options: “none, very little, less than half, about half, more than half, all or nearly all” from each source.
Question f2: The extent of availability of financial resources to complete degree/program. | Question 3 (from Bergman, 2012) |
| Outside encouragement | **Question e1 – e4: (4 items).**
Question e1: The importance of family support for persistence in the pursuit of a STEM degree.
Question e2: the influence of relationships with family members on continued enrollment.
Question e3: the influence of relationships with friends on continued enrollment
Question e4: the influence of relationships with classmates on continued enrollment | CSEQ(Pace and Kuh, 1998) |
| Family influence |  | |
| Friends |  | |
| Classmates/peers |  | |
| Internal environment variables – Technical (22 items) | **Goals**
Clarification, measurement, and monitoring | **Questions g1 – g4: (4 items)**
Question g1: plan to complete degree
Question g2: timely feedback about progress
Question g3: major requirements were clear and reasonable
Question g4: institution valued feedback from learners to improve service performance (5 options of “strongly disagree” to “strongly agree” responses for all 4)
**Questions t1-t13: (13 items)** |
| Service Offerings and Technology | Question 1 - 3: (3 items) the extent to which courses were relevant to career interest. Question 2: the extent of emphasis on personal relevance and practical value. 5 response options “not at all” – “very great extent” for both questions.  

| Dedicated/Customized Program | Question 3: courses are intellectually stimulating.  

| Flexible Delivery and Assessment | Question 4: (2 items) content of courses relate to prior learning (to things seen, done, or thought about in one’s life). 5 response options of “strongly disagree” to “strongly agree” for questions 3 - 4.  

| Question 5: Availability of course delivery options. 3 response options: online only, in-class only, both online and in-class options.  

| Question 6: (2 items) The timesaving from prior learning assessments more likely lead to finish a degree faster. 5 options of “not at all” – “very great extent” |  

| Prior Learning Assessment (PLA) | Question 7: Availability of multiple assessment options other than exams (homework, class/group projects, take-home projects, case study, and formulating plays and skits to demonstrate acquired knowledge). 5 response options of “strongly disagree” to “strongly agree”.  

| Knowledgeable Staff | Questions 8 - 9: (2 items) Question 8: Administrative staff have good knowledge of the program and procedures (Findlay, 2006a, for both questions).  

| Question 9: Academic staff have the knowledge to answer questions relating to the course content. 5 response options of “strongly disagree” – “strongly agree” for both questions. | SERVEPER F created by Cronin and Taylor, (1992); alpha: 0.9
<table>
<thead>
<tr>
<th>Quality learning equipment</th>
<th>Question t10 – t11 (2 items)</th>
<th>Question t10: Access to up-to-date learning technology at the institution.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Question t11: Availability of campus learning lab or center to improve study or academic skills (math, science, reading, writing, etc.) 5 response options of “strongly disagree” to “strongly agree” for both questions</td>
</tr>
<tr>
<td>Support Services (non-financial):</td>
<td>Questions t12 – t13 (2 items)</td>
<td>Question t12: Institution provides sufficient support and services for adult learners’ intellectual growth and academic success.</td>
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<td></td>
<td>Question t13: Institution provides opportunities social integration for adult learners. 5 response options of “strongly disagree” to “strongly agree” for both questions</td>
</tr>
<tr>
<td>Infrastructure (i)</td>
<td>Questions i1-i4: (4 items)</td>
<td>Question i1: Access to campus lounge for unwinding and for study</td>
</tr>
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<td></td>
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<td>Question i2: Conducive location of campus to meet others for discussion, etc.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Question i3: Safe and secure classroom locations for all students.</td>
</tr>
<tr>
<td>Internal environment variables – Social (20 items)</td>
<td>Questions s1-s2: (2 items)</td>
<td>Question s1: Adequate sources for financial aid for adult learners (grants, scholarships from partners and employers, etc.). 5 response options of “strongly disagree” to “strongly agree” for question s1.</td>
</tr>
<tr>
<td>Socioeconomic factors</td>
<td></td>
<td>Question s2: Adequate parking</td>
</tr>
<tr>
<td>5 response options of “strongly disagree” to “strongly agree” for the 4 questions.</td>
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</tr>
</tbody>
</table>

alpha: 0.88


(Rabouni et al., 2015)
<table>
<thead>
<tr>
<th>consideration</th>
<th>Question s2: Importance of institution-based/connected co-ops, internships/employment while enrolled. 5 response options of “not important” to “extremely important” for question s2.</th>
</tr>
</thead>
<tbody>
<tr>
<td>adult students</td>
<td>Questions c1-c2 (2 items)</td>
</tr>
<tr>
<td>(Proxy – Financial assistance)</td>
<td>Question c1: Extent of department/institution-wide commitment to adult learners’ academic success. 5 response options “not at all” to “very great extent” for both questions.</td>
</tr>
<tr>
<td>Customer Orientation</td>
<td>Questions p1 – p10: (10 items)</td>
</tr>
<tr>
<td>(c)</td>
<td>Questions p1-p5 (5 items)</td>
</tr>
</tbody>
</table>
| People (p): faculty, advisors, financial aid officers, student support service professionals | Question p1: Faculty members respect and treat adult learners fairly.  
Question p2: Faculty are interested in helping adult learners grow in more than just academic areas  
Question p3: Non-classroom interactions with faculty have positive influence on intellectual growth and interest in ideas  
Question p4: Possible effect of disrespectful attitude of faculty members – considered dropping out of the program  
Question p5: Non-classroom interactions with faculty have positive influence on career goals and aspirations. 5 response options of “strongly disagree” to “strongly agree” for questions p1-p5.  
Question p6: Financial aid counselors are helpful to adult students |
<table>
<thead>
<tr>
<th>Question p7: Academic advisor is concerned about learners’ success as individuals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question p8: Employees have adequate support from the institution to do their jobs well.</td>
</tr>
<tr>
<td>5 response options of “strongly disagree” to “strongly agree” for questions p6-p8</td>
</tr>
<tr>
<td>Questions p9 –p10 (2 items)</td>
</tr>
<tr>
<td>Question p9: relationships with other students have had a positive influence on personal growth, attitudes, and values</td>
</tr>
<tr>
<td>Questions w1–w5 (5 items)</td>
</tr>
<tr>
<td>Question w1: Work-class conflict</td>
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<tr>
<td>Question w2: Inadequate time for course lectures</td>
</tr>
<tr>
<td>Question w3: Academic staff available at times that are convenient for adult learners</td>
</tr>
<tr>
<td>Question w4: Institution communicates important information to students such as academic rules, degree requirements, individual course requirements, campus news and events, extracurricular activities, tuition</td>
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</tbody>
</table>
| Classmates/o 
other students/ Course interactions with peers 9.0.76; 10.0.72 |
<p>| How often the following occurred |
| Question w1: Work-class conflict |
| Question w2: Inadequate time for course lectures |
| Question w3: Academic staff available at times that are convenient for adult learners |
| Question w4: Institution communicates important information to students such as academic rules, degree requirements, individual course requirements, campus news and events, extracurricular activities, tuition |</p>
<table>
<thead>
<tr>
<th>Policies and procedures (z): IHE</th>
<th>Question 2: Adult learners are treated fairly in this institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commitment to NTAS -- centered policies and procedures</td>
<td>Question 3: Institution meets the unique needs of adult learners.</td>
</tr>
<tr>
<td></td>
<td>Question 4: Adult learners give input on matters that concern them (such as course offerings, rules and regulations).</td>
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<td></td>
<td>Question 5: Adult learners are not given the “run-around” when seeking information at this institution. 5 response options of “strongly disagree” to “strongly agree” for questions w1 – w5.</td>
</tr>
<tr>
<td>Learning Outcomes</td>
<td>Pace of progress</td>
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<td>Perception of growth</td>
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<td>Cumulative GPA</td>
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<tr>
<td></td>
<td>Question X1: intellectual growth and interest in ideas (Davidson, et al., 2009)</td>
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<td></td>
<td>Question X2: quality of instruction (Davidson, et al., 2009)</td>
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<tr>
<td></td>
<td>Question X3: academic advice I receive here (Davidson, et al., 2009)</td>
<td></td>
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<tr>
<td></td>
<td>Question X4: courses curriculum relevance to career interest (Park et al., 2009; Bergman, 2011; Bean &amp; Metzger, 1989)</td>
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<td></td>
<td>Question X5: course delivery options (e.g. online and in-class options) (Bergman, 2012)</td>
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<td></td>
<td>Question X6: frequency of progress tracking, feedback and opportunity for improvement. (Cronin and Taylor, 1992)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Question X7: financial assistance policies for adults (Davidson et al., 2009; Bergman, 2012)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Question X8: the level of care and helpfulness of staff members (faculty and administrative) (Billups, 2008; Bergman, 2012)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Question X9: how welcomed adult learners feel throughout the institution (Douglas et al., 2015)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Question X10: safe and secure classroom locations/campus environment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Question X11: abundance of learning technology provided for academic success (computer based tutorials, labs, etc.) (Davidson et al., 2009)</td>
<td></td>
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<tr>
<td></td>
<td>Question X12: amount of support and services for adult learners, including financial assistance (Bergman, 2012)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Question X13: assessment options (prior learning, case study, competency-based, etc.) at this institution. (Bergman, 2012, 2014)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Questions X14: assess to academic services (Assesse to services students utilize to achieve their academic goals, including library, computer laboratories, tutoring, and study areas. Etc.) (Bergman, 2012). Question X15: Responsiveness at the service centers including academic services (along with students' perceptions of the effectiveness and availability of financial aid programs) (Nashipulu et al., 2018)</td>
<td></td>
</tr>
<tr>
<td>Retention (Y)</td>
<td>Indications</td>
<td>Question (Y1 – Y5) (5 items):</td>
</tr>
<tr>
<td>---------------</td>
<td>-------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Question Y1: As long as the courses I take are useful for my career and interests, I will finish.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Question Y2: I consider a STEM degree so important that I enrolled determined to finish, no matter what.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Question Y3: I will never quit as long as I am progressing at a decent rate in my program.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Question Y4: As long as I have enough finances to pay for my school expenses, I will continue to enroll for classes until I complete my degree.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Question Y5: I plan to enroll for classes until I finish, no matter what.</td>
</tr>
</tbody>
</table>

(Bean & Metzner, 1985; Brown & Kayser, 1985; Johnson, 1991; Shank, 1993; (CSEQ, Pace and Kuh, 1998)
NOTICE OF EXPEDITED AMENDMENT APPROVAL

To: Neoma Okechukwu
Industrial and Systems Engineering

From: Dr. Scott Mills or designee
Chairperson, Behavioral Institutional Review Board (B3)

Date: June 26, 2019
RE: IRB #: 012419B3X
Protocol Title: Sociotechnical Systems Approach for Designing an Effective Pre-college STEM program for Nontraditional Adult Students

Funding Source:
Protocol #: 1901001978
Expiration Date:

The above-referenced protocol amendment, as itemized below, was reviewed by the Chairperson/designee of the Wayne State University Institutional Review Board (B3) and is APPROVED effective immediately.

- Protocol – Data collection tool changes including added survey instrument for the quantitative portion of the proposal mixed methods for this study.
- Data Collection Tool: Receipt of new (1) Student Questionnaire

Notify the IRB of any changes to the funding status of the above-referenced protocol.
STUDENT QUESTIONNAIRE

Instrument items were adopted from four main surveys list below:
1. The College Student Experience Questionnaire (Pace and Kuh, 1998).
2. The Adult Learning Survey (ALS) (Bergman, 2012)
4. Survey of Adult Learners' Retention in Postsecondary Vocational Programs" (SALR-PVP)(Ikegulu, Barham, Farmer, & Roberson, 1999)

"Thank you for completing this survey. Your responses will contribute to the understanding and improvement of adult education. Your individual responses will not be disclosed and will be used only for aggregated statistical purposes."

Section 1 – External Environmental Influence

General Instruction: As you answer the following sets of questions, keep in mind that this questionnaire contains a number of similar items about every topic covered. Each item reduces the chances of error. Please do not try to recall your previous responses. Answer each question as spontaneously and naturally as you can remember.

Work influences (Park & Choi, 2009) (Casandra, et al., 1993)

Hours of Employment

1. During the time school is in session, about how many hours a week do/did spend working on a job for pay? Fill in one oval in each column.

<table>
<thead>
<tr>
<th>On-Campus</th>
<th>Hours Worked</th>
<th>Off-Campus</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 – 10 hours</td>
<td></td>
</tr>
<tr>
<td></td>
<td>11 – 20 hours</td>
<td></td>
</tr>
<tr>
<td></td>
<td>21 – 30 hours</td>
<td></td>
</tr>
<tr>
<td></td>
<td>31 – 40 hours</td>
<td></td>
</tr>
<tr>
<td></td>
<td>More than 40 hours</td>
<td></td>
</tr>
</tbody>
</table>

APPROVED
JUN 28 2019
WAYNE STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD
Appendix H: The Study Instrument

STUDENT QUESTIONNAIRE

Thank you for completing this survey. Your responses will contribute to the understanding and improvement of adult education. Your individual responses will not be disclosed and will be used only for aggregated statistical purposes.

Section 1

General Instruction: As you answer the following sets of questions, keep in mind that this questionnaire contains a number of similar items about every topic covered. Each item reduces the chances of error. Please do not try to recall your previous responses. Answer each question as spontaneously and naturally as you can remember.

Hours of Employment

1. During the time school is in session, about how many hours a week do/did you spend working on a job for pay on-campus and off-campus? Fill in one oval in each column.

<table>
<thead>
<tr>
<th>On-Campus</th>
<th>Hours Worked</th>
<th>Off-Campus</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 – 10 hours</td>
<td></td>
</tr>
<tr>
<td></td>
<td>11 – 20 hours</td>
<td></td>
</tr>
<tr>
<td></td>
<td>21 – 30 hours</td>
<td></td>
</tr>
<tr>
<td></td>
<td>31 – 40 hours</td>
<td></td>
</tr>
<tr>
<td></td>
<td>More than 40 hours</td>
<td></td>
</tr>
</tbody>
</table>

Family responsibilities

Question 2 – 4: Please rate each statement below according to the extent it apply/applied to you while you were enrolled

<table>
<thead>
<tr>
<th>Question</th>
<th>Rating</th>
<th>1 Not at All</th>
<th>2 A Small Extent</th>
<th>3 Some Extent</th>
<th>4 Great Extent</th>
<th>5 Very Great Extent</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Childcare responsibility was the only thing that interfered with my school attendance</td>
<td></td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>3. Health problems of my family greatly interfered with my school attendance</td>
<td></td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>4. To what extent do you believe that you will have/you had the funds to complete your program/degree?</td>
<td></td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

5. How do you meet your college expenses? Fill in the response that best approximates the amount of financial support from each of the various sources:
<table>
<thead>
<tr>
<th>Source of Funds</th>
<th>None</th>
<th>Less Than Half</th>
<th>About Half</th>
<th>More Than Half</th>
<th>All or Nearly All</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self (job, savings, etc.)</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Family member(s)</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Employer support</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Other sources (specify):</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Encouragements

**Questions 6 - 9**: On a scale of 1-5 as shown in the box below, where 1 is “strongly disagree” and 5 is “strongly agree”, please rate the statements below according to how they apply/applied to you.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>6. My family members’ support of my pursuit of a college STEM degree is/was absolutely important.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>7. My relationships with my family members greatly contributed to my continued enrollment.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>8. My relationships with my friends greatly contributed to my continued enrolment</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>9. My relationship with my classmates greatly contributed to my continued enrolment</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

Section 2

Progress Monitoring

**Questions 1 – 4**: On a scale of 1 – 5 as shown in the box below, where 1 is “strongly disagree” and 5 is “strongly agree”, please rate how the following statements apply to you:

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. When I enroll/enrolled for classes, my adviser helps/helped me to develop a plan to complete my degree</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>2. Faculty provide timely feedback about my progress</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>3. Major requirements are very clear</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>4. I receive/received requests often from my college for suggestions to improve service performance</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>
213

Course

**Questions 1 - 13:** On a scale of 1-5, where 1 is “strongly disagree” and 5 is “strongly agree”, please rate each of the statements according to how they apply to you

<table>
<thead>
<tr>
<th>Statement</th>
<th>1 Strongly Disagree</th>
<th>2 Disagree</th>
<th>3 Not Sure</th>
<th>4 Agree</th>
<th>5 Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. My courses make me think in different ways that I enjoy/enjoyed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. I love my courses because I could relate them to things I have seen,</td>
<td></td>
<td></td>
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<tr>
<td>done, or thought about in my own life</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>3. My program/college offers multiple assessment options other than</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>“test” (any combination of at least three of the following assessment</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>methods: homework, class projects, take-home projects, case study,</td>
<td></td>
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<tr>
<td>portfolio, experiment in a lab, senior project, etc.) to demonstrate</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>acquired knowledge</td>
<td></td>
<td></td>
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<tr>
<td>4. My instructors have the knowledge to answer my questions relating to</td>
<td></td>
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<tr>
<td>the course content</td>
<td></td>
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<tr>
<td>5. Administrative staff have good knowledge of the program procedures</td>
<td></td>
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<tr>
<td>6. I have access to quality learning technology at my institution</td>
<td></td>
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<tr>
<td>7. I have used a campus learning lab or center to improve study or</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>academic skills (math, science, reading, writing, etc.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. My institution provides support to help me succeed academically</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. My institution provides opportunities for me to be involved socially</td>
<td></td>
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</tr>
<tr>
<td>10. I enjoy using the campus lounge to study and stay by myself</td>
<td></td>
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<tr>
<td>11. My institution has conducive facilities to meet with other students</td>
<td></td>
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<tr>
<td>at some campus location (campus center, etc.) for a discussion</td>
<td></td>
<td></td>
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<tr>
<td>12. Classroom locations are safe and secure for all students.</td>
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<tr>
<td>13. The amount of student parking is adequate</td>
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</tbody>
</table>

**Questions 14 - 19:** Please rate each statement below according to the extent it apply/applied to you while you were enrolled

<table>
<thead>
<tr>
<th>Statement</th>
<th>3 Not at All</th>
<th>2 Very Small Extent</th>
<th>3 Some Extent</th>
<th>4 Great Extent</th>
<th>5 Very Great Extent</th>
</tr>
</thead>
<tbody>
<tr>
<td>14. To what extent do you believe that your courses are relevant to your</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>career interest?</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>15. To what extent do/did your courses relate to things that are/were of</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>personal value to you?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16. To what extent do you view getting credits (Prior Learning</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assessment) for what you already know as a way to save time in</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>completing your degree?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17. To what extent are/were you more likely to complete your degree</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>because of credits awarded from what you already know (Prior Learning)?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18. To what extent does/did it seem/seemed like every employee in your</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>institution wants/wanted you to be successful?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19. To what extent are/were there office hours that are/were suitable for</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>busy adult students at your institution?</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**20. Which one of the course delivery options below were offered to you?**

- Online only
- In-class only
- Both online and in-class options
Interactions

**Questions 1 – 5:** On a scale of 1 – 5 as shown in the box below, where 1 is “strongly disagree” and 5 is “strongly agree”, please rate how the following statements apply to the faculty, staff and your classmates:

<table>
<thead>
<tr>
<th>Statement</th>
<th>1</th>
<th>2</th>
<th>3 Not Sure</th>
<th>4</th>
<th>5 Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Most of the faculty members in my institution respect/respected me as a person</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>2. Most of the faculty I have had contact with are/were interested in helping me grow in more than just academic areas</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>3. My non-classroom interactions with faculty have had a positive influence on my intellectual growth</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>4. I have considered dropping out of the program because of disrespectful attitude of some of the faculty members</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>5. My non-classroom interactions with faculty have had a positive influence on my career goals</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>6. Financial aid counselors are/were helpful to me</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>7. My academic advisor is concerned about my success as an individual</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>8. It seems/seemed like most of the staff get adequate support from the institution to do their jobs well.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>9. My interpersonal relationships with other students have had a positive influence on my personal growth.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>10. My interpersonal relationships with other students have had a positive influence on my intellectual growth</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

Socioeconomics (SES)

1. I have received / I received adequate financial aid

<table>
<thead>
<tr>
<th>1 Strongly Disagree</th>
<th>2 Disagree</th>
<th>3 Not Sure</th>
<th>4 Agree</th>
<th>5 Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

2. How important is some form of employment through your institution – including a co-op or internship for your continued enrollment?
Workflow and Communication (w):

| Questions 1 - 5. On a scale of 1 – 5 as shown in the box below, where 1 is “never” and 5 is “very often”, please rate how often you experienced the following while enrolled: |
|-------------------------------------------------|---|---|---|---|---|
| 1. Work – School schedule conflict | 1 Never | 2 Seldom | 3 Sometimes | 4 Fairly Often | 5 Always |
| 2. Inadequate time for course lectures | |
| 3. The academic staff available at times that are convenient for you | |
| 4. The institution communicate important information to students such as academic rules, degree requirements, individual course requirements, campus news and events, extracurricular activities, tuition costs, and financial aid and scholarship opportunities | |
| 5. Inadequate time completing class assignments from different courses because of conflicting due dates | |

Policies and procedures (z):

| Questions 1 - 4. On a scale of 1 – 5 as shown in the box below, where 1 is “strongly disagree” and 5 is “strongly agree”, please rate how each of the following statements apply to you: |
|-------------------------------------------------|---|---|---|---|---|
| 1. Registration processes are/were convenient for me | 1 Strongly Disagree | 2 Disagree | 3 Slightly Agree | 4 Agree | 5 Strongly Agree | 6 N/A |
| 2. I am/was treated fairly in this institution | |
| 3. This institution meets my unique needs as an adult student. | |
| 4. I seldom get the “run-around” when seeking information at this institution | |

*If not applicable, choose option 6: N/A

Learning Outcomes:

1. How many credits do/did you usually take per semester?

   1–3        4–6   7–9     10–12   13 or more

2. How many credits do/did you usually complete in a semester?

   1–3        4–6   7–9     10–12   13 or more

3. How many semesters do/did you usually take classes in a year?

   1        2        3

4. I have performed academically as well as I anticipated
5. *What is your current/last cumulative GPA now at this institution?*

0.5 - 1.0  
1.1 – 2.4  
2.5 - 2.9  
3.0 - 3.4  
3.5 – 4.0

---

### Degree completion

**Questions 1 - 5:** On a scale of 1-5, where 1 is “strongly disagree” and 5 is “strongly agree”, please rate each of these statements according to how they apply to you:

<table>
<thead>
<tr>
<th>Statement</th>
<th>1 Strongly Disagree</th>
<th>2 Disagree</th>
<th>3 Slighty Agree</th>
<th>4 Agree</th>
<th>5 Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. As long as the courses I take are useful for my career and interests, I will finish.</td>
<td>○</td>
<td></td>
<td>○</td>
<td>○</td>
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<tr>
<td>2. I consider a STEM degree so important that I enrolled determined to finish, no matter what.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
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<tr>
<td>3. As long as I am doing well in my classes, I complete my program.</td>
<td>○</td>
<td>○</td>
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<tr>
<td>4. As long as I have enough finances to pay for my school expenses, I will continue to enroll for classes until I complete my degree.</td>
<td>○</td>
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<tr>
<td>5. I plan to enroll for classes until I finish, no matter what.</td>
<td>○</td>
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</tbody>
</table>
## Satisfactions

**Questions 1 - 13:** On a scale of 1-5, where 1 is “strongly disagree” and 5 is “strongly agree”, please rate each of the statements according to how they apply to you.

<table>
<thead>
<tr>
<th>Statement</th>
<th>1: Strongly Disagree</th>
<th>2: Disagree</th>
<th>3: Slightly Agree</th>
<th>4: Agree</th>
<th>5: Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am/was very satisfied with the extent of my intellectual growth since coming here</td>
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<tr>
<td>2. In general, I am/was very satisfied with the quality of instruction I am receiving/I received in my institution</td>
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<tr>
<td>3. I am/was satisfied with the academic advisement I receive here.</td>
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<td>4. I am/was very happy that my courses are/were relevant to my career interest</td>
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<td>5. I am/was satisfied with the course delivery options (e.g. online and in-class options) at this institution</td>
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<td>6. I am/was satisfied with the frequent tracking of my progress at my institution</td>
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<tr>
<td>7. I am/was satisfied with the financial aid/financial support policy for adult learners at this institution.</td>
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<td>8. Most of the staff members at this institution are/were caring</td>
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<td>9. I am/was satisfied with how welcomed I made to feel as an adult learner everywhere at this institution</td>
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<td>10. I enjoy/enjoyed the safe and secure campus environment.</td>
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<tr>
<td>11. I am/was satisfied with the abundance of learning technology provided at this institution for academic success (computer based tutorials, labs, etc.)</td>
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<tr>
<td>12. I am/was satisfied with the amount of support and services this institution provides adult learners.</td>
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<td>13. I am/was satisfied with the assessment options (prior learning, case study, competency-based, etc.) at this institution.</td>
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<td>14. I am/was satisfied with the regular feedback that I receive/received at my institution</td>
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</tbody>
</table>

### Section 3

1. **On a scale of 1-5 as shown in the box below, where 1 is “not at all important” and 5 is “absolutely important”, please rate how important it is/was for you to complete your STEM degree:**

<table>
<thead>
<tr>
<th>Rating</th>
<th>Description</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Not Important</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Slightly Important</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Not Sure</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Very Important</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Extremely Important</td>
<td></td>
</tr>
</tbody>
</table>
2. Which of the statement best represents your commitment to earn a STEM degree?
- I am/was not very certain that I would earn a college degree.
- I am/was very certain that I would earn a college degree.
- I am/was not very certain that I would earn a college STEM degree.
- I am/was certain that I would earn a college STEM degree
- I am certain that I will not graduate

3. On average across all your courses, how interested are you in the things that are being said during class discussions?
- Not at All
- A little Bit
- Somewhat
- Quite a Bit
- Tremendous Amount

4. How well do/did you like college?
- I am enthusiastic about it
- I like it
- I am more or less neutral about it
- I am/was in college only because I need/needed to
- I definitely do not like college

5. If you could start over again, would you go to the same institution you are now attending/you attended?
- Yes, definitely
- Probably, yes
- Not sure
- Probably, no
- No, definitely

6. What is your current age range or what was your age range when you attended college?
- 18-24
- 25-34
- 35-44
- 45-55
- 56 and older

7. What is the gender with which you most closely identify?
- Female
- Male

8. What is the ethnic background with which you mostly closely identify?
- American Indian or other Native American
- Asian or Pacific Islander
- Black or African American
- Caucasian (other than Hispanics)
- Mexican-American
- Puerto Rican
- Other Hispanic
- Others (Please specify):

9. What is your marital status?
- Not Married
- Married
- Divorced
- Separated
- Widowed
10. **During your college studies, how many dependent (children and adults) do/did you have?**

- 0-2
- 3-4
- 5-6
- 7-8
- 9 or more

11. **In what range was your high school GPA?**

- 0.5 -1.0
- 1.1 – 2.4
- 2.5 -2.9
- 3.0 -3.4
- 3.5 – 4.0

12. **What made you decide to return to college?**

- Change of career
- Higher income
- A family member thought it would be good for me
- A colleague at work thought it would be good for me
- My friend(s) thought it would be good for me
- Unemployment/Underemployment
- Be an example for my children
- Other (Please specify): [ ]

13. **Which of these fields’ best describes your major?**

- Engineering and engineering Technology
- Physical sciences (Biology, physics, chemistry)
- Computer and information sciences
- Industrial/Manufacturing Technology
- Engineering technology
- Business (Accounting, business administration, management, etc.)
- Health sciences (Nursing, etc.)
- Other (Please specify): [ ]

14. **Which University/College are you currently attending or did you attend?**

15. **Did either of your parents graduate from college?**

- No
- Yes, both
- Yes, mother only
- Yes, father only
- I don’t know

Thank you for your participation.

If you would like a summary of the results, please check yes below and provide your name and email address or US mailing address for that purpose. Your identity will be confidential.

- Yes, I would like a summary of this study sent to me.
- No, I do not wish to receive a summary of the study

Name ___________________________________ Email address ___________________________________
Or US Mailing address __________________________________________________________

_____
APPENDIX I: TWO ADDITIONAL STUDY OUTPUTS

1. STESS Mediating Goal Commitment

Figure 11: Research Model of Goal Commitment (GoalCommt) only Predicting STESS
2. Specific Indirect Effects of the First Order Variables

Table 12: Indirect Effects of First Order Variables

<table>
<thead>
<tr>
<th>Indirect Effects of First Order Constructs on Retention and STESS</th>
<th>STESS</th>
<th>RETN</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-Statistics</td>
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<tr>
<td>CourseNet -&gt; Social -&gt; STESS -&gt; RETN</td>
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<tr>
<td>CustomerO -&gt; Social -&gt; STESS -&gt; RETN</td>
<td>3.664***</td>
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<tr>
<td>Faculty -&gt; Social -&gt; STESS -&gt; RETN</td>
<td>3.715***</td>
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<td>3.025**</td>
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<td>OPeople -&gt; Social -&gt; STESS -&gt; RETN</td>
<td>3.73***</td>
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<td>Policies -&gt; Social -&gt; STESS -&gt; RETN</td>
<td>3.488***</td>
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<td>Social -&gt; STESS -&gt; RETN</td>
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<td>3.638***</td>
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<td>10.713***</td>
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<td>18.184***</td>
<td></td>
</tr>
</tbody>
</table>

APPENDIX K: OUTER LOADINGS

Table 15: Factor Loadings.

<table>
<thead>
<tr>
<th>The Outer Loadings of the Items</th>
<th>Service</th>
<th>Offrg</th>
<th>TECH</th>
<th>INFR</th>
<th>Customer</th>
<th>O</th>
<th>RETN</th>
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<th>People</th>
<th>Goal</th>
<th>Comm</th>
<th>INFM</th>
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<th>Comm</th>
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<th>Course</th>
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The removal of the very low items threatened the content validity of the instrument of the study.
REFERENCES


Bergman, M. J. (2012). An examination of factors that impact persistence among adult students in a degree completion program at a four-year university.


Carmody, L. E. (2009). Clayton M. Christensen, Michael B. Horn, and Curtis W. Johnson: Disrupting class: how disruptive innovation will change the way the world learns: Springer.


Collis, R., & Reed, M. (2016). Non-traditional Students, Non-traditional Teaching: Pathways to Academic Success Include Resourcefulness and Adaptation Skills.


Gross, K., & Godwin, P. (2005). Education's many stakeholders-educational administrators are increasingly recognizing what businesses have long understood: Customer satisfaction matters. *University Business, 8*(9).


HAIR JR, H. (2014). GTM; RINGLE, CM; SARSTEDT, M. *A primer on partial least squares structural equation modeling (PLS-SEM), Los Angeles, SAGE.*


La France, P. (2008). *Nontraditional students' perceptions of factors shaping their learning environment: An exploration of their life-worlds in the community college setting.* Walden University.


Pace, C. R., & Kuh, G. D. (1998). *College student experiences questionnaire: CSEQ*: Indiana University Center for Postsecondary Research and Planning, School of ....


Smith, E. G. (2014). Faculty integration of technology in undergraduate courses at private colleges and universities.


Unertl, K. M., Novak, L. L., Johnson, K. B., & Lorenzi, N. M. (2010). Traversing the many paths of workflow research: developing a conceptual framework of workflow


ABSTRACT

SOCIOTECHNICAL SYSTEMS APPROACH FOR DESIGNING EFFECTIVE PRE-COLLEGE STEM PROGRAMS FOR ADULT STUDENTS

by

IFEOMA E. OKECHUKWU

May 2020

Advisors: Dr. Ratna Babu Chinnam and Dr. Monplaisir

Major: Industrial and Systems Engineering

Degree: Doctor of Philosophy

In the context of its external environment, sociotechnical systems (STS) are tools for restructuring an organization’s components into inter-related and interdependent social and technical subsystems for improving the organization’s performance and the well-being of its actors. The theory of STS states that the optimal performance and effectiveness of an organization lies in the joint optimization of the social (all human-based elements) and the technical (the tools and technology for doing work) subsystems. Many technical industries know the benefits of STS, however the concept has a minimal presence in education, in spite of education’s many challenges such as improving the graduation rates of college students, especially adult learners.

Many educational theories and practices have been propounded, and though there have been some improvements, the graduation rate of adult learners remains low. Literature reveals the highly complex, multi-dimensional nature of the every-day life of financially independent adults learners pursuing a college science, technology, engineering, and mathematics (STEM) degrees, but the approach to providing solutions may not have commensurate.

An STS view of the problem in this mixed-methods research pointed to several concepts that promise a better solution than the traditional educational approach. In crystallizing the internal
structure of a college STEM program for adults into social and technical subsystems, nine components emerged as key to understanding, designing, and achieving effectiveness for this demography. These nine components include 1) People, 2) Policies, 3) Customer Service, 4) Work Flow, 5) Goal Clarification, Measurement and Monitoring, 6) Service Offerings, 7) Infrastructure, 8) Socioeconomic Factors, and the 9) External Environmental Factors.

Of the nine components, 1-4 belong to the social subsystem and 5-8 belong to the technical subsystem. In this study, the social and technical subsystems act as facilitators while the pressures and demands from external environmental factors act as inhibitors. All nine components must be managed to improve student success. The multiple perspectives study highlighted the complex systemic nature of the problem and some key elements that relate to educating nontraditional adult learners for college STEM degrees.

The qualitative study of 43 program directors, faculty members, students and student family members, produced a conceptual educational service systems design (ESSD) with the nine components as a framework that ensures a holistic and comprehensive detailed pre-design analyses for a STEM program for adults. Among other things, the study found that systematized holistic strategies promise higher impact than isolated piece-meal solutions. The study conceptualized the sociotechnical education service system (STESS) as a viable holistic STS approach to the problem, as opposed to the social and technical subsystems working separately towards the same goal. The quantitative study of 512 adult college students empirically confirmed the adequacy of the conceptualized nine components of the ESSD that together with the social and the technical subsystems form STESS.

The findings suggest that an STS view of a program’s operational level processes promises improved retention of adult learners, leading to improved graduation rates. The STESS approach
showed a more significant positive relationship with retention and learning outcome than the combined individual effects of social and technical on retention and learning outcome. Students’ goal commitment showed more significant effects on retention and learning outcome than students’ satisfaction. However, STESS can do relatively more to strengthen retention and learning outcomes through the students’ goal commitment and satisfaction than directly improving them. In other words, adult learners are more likely to positively influence their own learning outcomes, but without STESS this is less likely to happen. The cluster analysis shows that the findings are also comparable to community college and university adult learners.

In conclusion, the sociotechnical systems-based approach seems viable for the analysis and operation of a college program, and the ESSD and STESS are tools likely to lead to better insights and outcomes.
Ifeoma Okechukwu is an educator who for over 20 years served first as manager of the pre-engineering program at Focus: HOPE, and then as manager of the engineering program at the Center for Advanced Technologies in Detroit, Michigan. There she developed processes and procedures aimed at increasing the number of minority students participating in engineering degree programs, particularly those students representing minority groups that are underrepresented in the STEM fields.

Ifeoma holds a Bachelor of Science Education degree in Mathematics from the University of Nigeria, Nsukka and a master’s degree in mathematics from Wayne University in Detroit, Michigan. She was a Michigan Certified High School Math and Biology teacher for 11 years, and for over 5 years an adjunct faculty member at Wayne State University, Lawrence Technological University in Southfield, Michigan, and the University of Detroit Mercy.

Ifeoma’s desire to make an impact in the classroom and in society led her to join the Global Executive Track (GET) in the Department of Industrial and Systems Engineering at Wayne State University in 2015. Her long-term goal is to utilize her doctorate research in Service Systems Design to effect policy changes that will assist the technical education sector.

Ifeoma's extensive experience in education programs and working with both high school-aged and nontraditional adult students has given her a deep understanding of effective program design and management. Her recent findings of the third-order nature of sociotechnical systems philosophies and practices have further added to her insight into the design and management of complex services such as education systems.