Science Self-Efficacy and Innovative Behavior (IB) in Nigerian College Students
Enrolled in Science, Technology, Engineering, and Mathematics (STEM) Programs

DISSEPTION

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Abstract

This study will explore how science self-efficacy among college students in science, technology, engineering, and mathematics (STEM) fields in Nigeria predicts their innovation. Several reports on African development argue that science, technology and innovation underpin targets for dramatically reducing poverty in its many dimensions—income poverty, hunger, disease, exclusion, lack of infrastructure and shelter—while promoting gender equality, education, health, and environmental sustainability (UN Millennium Project, 2005). If African countries in general, including Nigeria, are to move from the exploitation of natural resources to technological innovation as the foundation for development, stakeholders in these countries must encourage development of individual ability to innovate products, services and work processes in crucial organizations (DeJong & DenHartog, 2010).

The common denominator in the scientific and technological development of any country or organization is the individuals that make up these entities. An individual’s engagement is the foundation for group motivation, innovation and improvement. These ideas inform the purpose of this study: to investigate how science self-efficacy among college students in various engineering fields in Nigeria predicts self-reported innovative behavior (IB), also referred to as Innovative Work Behavior (IWB). IB involves initiating new and useful ideas, processes, products or procedures, as well as the process of implementing these ideas (Farr & Ford, 1990; Scott & Bruce, 1994).
The general findings of this study align with the dictates of social cognitive theory. Specifically, research indicates self-efficacy has the most predictive power for performance when it is measured at a level specific to the expected task (Bandura, 1997; Pajares, 1996). The findings from the hierarchical multiple regressions confirm that individuals’ perceived science efficacy plays an important role in their perceived self-reported innovative behavior as it pertains to science and technological advancement.

This dissertation contains five major chapters. The introduction (Chapter 1) makes a case for the significance of the scientific and technological problems facing Nigeria and African in general. The literature review (Chapter 2) examines the conceptualization and research that highlight the cognitive and behavioral processes present in individuals who are innovative and have a sense of self-efficacy in science. The methodology (Chapter 3) describes in detail the methodology that was used for the study, specifically, the participants, procedures, measures used, and analyses. The results (Chapter 4) present the outcome of the analyses with respect to the research questions. Finally, the discussion (Chapter 5) interprets the results from this study, integrating and analyzing the research findings in relation to other literature, as well as reflecting on the implications and limitations of the study.
Dedication

To my late father, Chukwuemeka Okonkwo, who inspired me to pursue and live with empathic curiosity
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Major Field: Education: Policy and Leadership

Specialization: Educational Psychology

Cognate Area: International Development
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Chapter 1

Significance of the Problem

The common denominator in the scientific and technological development of any country or organization is the individuals that make up these entities. An individual’s engagement is the foundation for group motivation, innovation and improvement (Albert, 1983). These ideas inform the purpose of this study: to explore how the perceived sense of science self-efficacy among college students in STEM fields in Nigeria predicts their self-reported innovative behavior, as a precursor to innovation in science and technology.

Many African countries, including Nigeria, gained independence for self-government in the middle and second half of the 20th century (i.e., the fifties to the seventies). However, an ever-present challenge for African socio-political and economic leaders has been how to secure a sustained improvement in the living standard of the African populace. Reports from various international and multinational nonprofit organizations on human development and wellness indicate that by virtually all indices of human development, Africa/Nigeria fared poorly compared with citizens of other nations in other continents (e.g., UNDP, 2009; World Bank, 2007). It has been posited that the developmental process and trajectory by which these African (Nigeria as focal country) countries can improve their living standards should be informed by science and technological innovation, alongside issues of governance, security and trade (DeJong & DenHartog, 2010; Ukaegbu, 1985).
The United Nations Millennium Project for Africa proposes that if abject poverty is going to be dramatically reduced or eradicated in Africa, science and technological innovation must play a prominent role. Aspects of both human development and national governance will lead to national security for a nation and international security for other nations, by reducing the number of global conflicts (UN Millennium Project, 2005). Thus, it is important that African countries, including Nigeria, act with urgency to pursue macro-social, political and economic public policies that will promote investments in science and technological innovations.

Theoretical Framework: Innovative Behavior and Social Cognitive Theory

At this juncture, it becomes expedient to ask the question: Who and where are these African/Nigerian innovators in science technology who will adapt and exploit scientific and technological solutions that align with the unique needs and problems in Africa/Nigeria? The quality of life among any group of people is significantly influenced by the creative and innovative contributions made by a few individuals in the group (Albert, 1983). Thus, it can be speculated that one common denominator in all forms of human (or group) progress is individual innovation. A country’s facility to explain difficulties associated with sustainable development is a function of the innovative activities of certain members of that country. The capabilities and confidence of scientists and technologists, especially their abilities to be innovative, have the potential to initiate and sustain economic growth. It is the science and technological innovations of these individuals that will facilitate robust transportation systems, portable clean water, universal healthcare, and enough safe food or agricultural products for the populace (Juma & Yee-Cheong, 2005).
Innovation occurs when new and useful ideas, processes, and services are developed, sustained, implemented, and in some cases, commercialized. Scientific and technological expertise and knowledge will empower Nigerians to discover resolutions to unique Nigerian problems. The organization for economic cooperation and development (OECD, 1981) stated:

Innovation consists of all these scientific, technical, commercial, and financial steps necessary for the successful development and marketing of new or improved manufactured products, the commercial use of new or improved processes, or the introduction of a new approach to the social service. (p. 15)

Bandura (1997) recognized the likely connection between self-efficacy, innovation, and creativity. He postulated that for an individual to exhibit innovation in a domain-specific task, it necessary for that individual to have a high sense of personal self-efficacy for that task. One’s self-efficacy beliefs allow one to persevere in innovative pursuits, especially when the demand to be successful requires long hours and sustained effort and occurs within a context of mitigating structural and socio-economic problems.

Bandura’s social cognitive theory (SCT) is a useful theoretical framework for explaining these relations. SCT attributes personal learning and individual engagement to the occurrences of transactional relationships among an individual’s behavior, environmental factors and personal factors, labeled as “triadic reciprocal causality” (Bandura, 1986, p. 18). As stated by Bandura:

In the social cognitive view people are neither driven by inner forces nor automatically shaped and controlled by external stimuli. Rather, human functioning is explained in terms of a model of triadic reciprocality in which
behavior, cognitive and other personal factors, and environmental events all operate as interacting determinants of each other. (Bandura, 1986, p. 18)

Specifically, in the present study, I examine an individual’s perceived sense of self-efficacy in science as a predictor of self-reported innovation. Self-efficacy refers to individuals’ “beliefs about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives” (Bandura, 1993, p. 71). In justifying an individual’s sense of self-efficacy as an important foundation for human agency and engagement, Bandura stated:

This belief system is the foundation of human agency. Unless people believe that they can produce desired effects by their actions they have little incentive to act or to persevere in the face of difficulties. Whatever other factors serve as motivators, they are rooted in the core beliefs that one has the power to produce changes by one’s actions. (Bandura, 1999, p. 28)

Furthermore, Linnenbrink and Pintrich (2003) demonstrated, especially in academic settings, that individuals’ perceived efficacy beliefs are associated with the amount of effort they expend in trying to accomplish any particular set of tasks.

The implication of the above observations cannot be overemphasized in the context of African/Nigerian sustainable development and the recognition that science, technology and innovation underpin the trajectory to true independence. As such, results of this study may contribute to scholarly understanding of the relations between self-efficacy and innovation in Nigerian college students enrolled in science, technology, engineering, and mathematics (STEM) programs.
Research Questions

In the present study, I examine science self-efficacy and how it relates to self-reported innovative behavior. More specifically, I examine how science self-efficacy among Nigerian students in STEM fields predicts their self-reported innovative behavior (IB). In addition, I examine how other contextual factors (e.g., age, gender, ethnic heritage) relate to self-reported innovative behavior. In this study, I aim to address the following research questions:

- Does the science efficacy of Nigerian college students in STEM fields predict their perceived innovative behavior?
- Does Nigerian students’ decidedness in a STEM career moderate the relation of their science self-efficacy to their innovative behavior?
- Does academic achievement of Nigerian college students in STEM fields predict their innovative behavior?
- Does the educational level of parents of Nigerian college students in STEM fields predict their innovative behavior?
- Do other demographic variables (e.g., age, gender, students’ socioeconomic status [SES], ethnic region, and their year of study) of Nigerian college students in STEM fields predict their innovative behavior?
Chapter 2

A Review of the Literature

In this study, I will explore how science self-efficacy among college students in STEM fields in Nigeria predicts their innovation. It is imperative that scientific skills and knowledge enable Africans, including Nigerians, to find solutions to their own problems and promote the potential for innovation in science and technology, thereby creating sustainable socio-economic and political development. In this literature review, I will address the role of technological innovation in national development. Subsequently, I will conceptualize innovation in relation to creativity and how individual innovative behavior can be a precursor to institutional or group innovation. Next, I will discuss the past and current condition of scientific and technological innovation in Africa and Nigeria. Then, I will review how the construct of self-efficacy, with particular focus on science efficacy beliefs, is related to the development of innovative behaviors of college students in STEM fields in Nigeria. I will also discuss the integration of innovation with self-efficacy and other contextual variables (e.g., gender, ethnic affiliation). Finally, I will speculate on the role self-efficacy can play in the development of technological innovation in Nigeria.

The Role of Technological Innovation in National Development

Nations inevitably vary in their technological capabilities and innovation. In this age of information and knowledge, however, it is imperative that nation-states invest in science and technological innovation in order to be proactive in their macro-social,
political, and economic development. A nation’s economic change and sustainable development are, to a large measure, accounted for by investments in science, technology and innovation. It is not the simple buildup of physical capital and natural endowment that transforms economies and stimulates human development, but rather the capability of countries to create, apply and intelligently use scientific knowledge and associated technological innovations (Kogut, 1991).

The economic and developmental history of the most advanced and industrialized countries, as well as more recently developed countries, is a testament to the fact that economic improvement and sustainability has resulted from the application of knowledge to productive activities. Indeed, there is an explicit correlation between a country’s scientific and technological capabilities and its economic performance and affluence (NEPAD, 2007).

Leaders of most countries are likely to realize that scientific and technological policy decisions are crucial for the continued sustainability of their socio-cultural and political existence. In particular, the policymakers of any of these nations should plan for rapid changes in technological development, for it is likely that every following generation will live in substantially different scientific and technological realities from the previous generation. As Bandura (1997) espoused with clarity, “societies of today are undergoing extraordinary informational, social and technological transformations…these changes are not new over the course of history, but what is new is their magnitude and accelerated pace” (p. 1). In keeping up with the demand of this information age, people’s sense of efficacy has to play a crucial role in managing the science, technology and
innovational changes taking place in our globalized world. The improvement in human welfare over the past century is a function of technological innovations in public health, nutrition, and agriculture. Juma and colleagues (2001) posited that according to global trends, science, technology, and innovation play crucial roles in economic transformation in particular and sustainable development in general. Kalu (2000) postulated that “the level of advances in information technology and computer software also suggests that individuals and countries that currently lag behind in technology-based knowledge are more likely to be further marginalized” (p. 93). This situation has resulted in continued political and economic underdevelopment.

Several reports on African development argue that science, technology and innovation underpin targets for dramatically reducing poverty in its many dimensions—income poverty, hunger, disease, exclusion, lack of infrastructure and shelter—while promoting gender equality, education, health, and environmental sustainability (UN Millennium Project, 2005). If African countries in general and Nigeria in particular are to move from the exploitation of natural resources to technological innovation as the foundation for development, stakeholders in these countries must encourage development of individual ability to innovate products, services and work processes in crucial organizations (DeJong & DenHartog, 2010).

**Conceptualization of Innovation**

Generally, innovation is described as transforming an invention or design that will be useful to the public. The usefulness involves improving products, processes or services for the benefit of the public. A nation’s economic change and sustainable development are, to a large measure, accounted for by investments in science, technology and
innovation. The organization for economic cooperation and development (OECD, 1981) stated:

Innovation consists of all these scientific, technical, commercial, and financial steps necessary for the successful development and marketing of new or improved manufactured products, the commercial use of new or improved processes, or the introduction of a new approach to the social service. (p. 15)

This definition of innovation includes several concepts ranging from newness and novelty to commercialization and implementation. An idea is not technically defined as innovation unless it has been developed and transformed into a product, process or service that is implemented or commercialized. A comprehensive conceptualization of innovation was described by Urabe (1988):

Innovation consists of the generation of a new idea and its implementation into a new product, process or service, leading to the dynamic growth of the national economy and the increase of employment as well as to a creation of pure profit for the innovative business enterprise. Innovation is never a onetime phenomenon, but a long and cumulative process of a great number of organizational decision-making processes, ranging from the phase of generation of a new idea to its implementation phase… Through the implementation process the new idea is developed and commercialized into a new marketable product or a new process with attendant cost reduction and increased productivity. (p. 3)

Categories of Innovation

Science and technological innovation are cardinal components in the development of any country. However, the conceptualization of innovation is important. In the
management and economic disciplines, innovations are described in four basic
dimensions: product and process innovations; radical and incremental innovations;
competence-enhancing and/competence-destroying innovations; and architectural and
component-based innovations (Kogut, 1991; Mayers, 1984).

Product and process innovation involves structural change in the product or
output of an organization, whereas process innovation reflects the effective and efficient
process of the entire production in an organization (Schilling & Phelps, 2007). Radical
innovations are those that are said to be new and different from previous innovations.
According to Dahlin and Behrens (2005), radical innovation consists of three features.
First, it has to be novel in comparison with prior innovations; second, it has to influence
future innovations; and third, it can both be new and influence future innovations. In
contrast, incremental innovation just involves making minor changes or additions to
present ideas or products. A radical innovation in an agro-based rural or urban area of
Nigeria/Africa (or for that matter in developed countries) would be the transmutation of
extensive human excrement into valuable manure for crops. In contrast, an incremental
innovation will be making improvement on how this human excrement are despoiled
without any associated productive benefit.

With respect to competence-enhancing and competence-destroying innovations,
an innovation is competence-enhancing when it comes from the existing knowledge base
of an organization, like the series of improvement breakthroughs made in mechanical
watches and improvements made in building materials. Conversely, when an innovation
is labeled competence-destroying, this implies that the generated innovation was not built
from the knowledge base of the organization or its competencies but, rather, was
generated from new competencies outside the organization. An example would be the development of quartz watches, totally overtaking mechanical watches. Finally, when an innovation is considered architectural, it means that the innovation process completely changes the overall design of a system or the way its constituent parts relate with each other. For example, the use of desktop photocopiers over the use of the big stand-alone photocopiers represents an architectural innovation shift. On the contrary, when an innovation is component-based, the constituent parts do not change significantly or upset the general formation of the system within which it is entrenched (Henderson & Cockburn, 1994). For example, the continuous reduction of the size of a transistor (from 180nm to 90nm) resulted in the improved performance of an integrated circuit (Borkar, 2005).

**Innovation as an Extension of Creativity and Inventions**

It has been generally assumed that the concepts of innovation and creativity are synonymous in meaning and process. However, there are some distinctions between the two concepts. Some innovation and creativity researchers (e.g., Kenter, 1988; Van de Ven, 1986) have postulated that creativity in most cases describes the production of new and useful ideas or products. Conversely, innovation not only implies the production of useful new ideas or products but also includes the implementation and commercialization of the useful ideas or products. As pointed out by Urabe (1988), “through the implementation process the new idea is developed and commercialized into a new marketable product or a new process with attendant cost reduction and increased productivity” (p. 3).
In other words, it is the production of useful ideas that is novel. The new and useful idea, product or process must be different from what has been done before. The creative new idea should not be merely different, but different enough and also intended to meet a predetermined objective. The predetermined goal of a creative new idea is the drive for innovation, because innovation is the implementation of the creative new and useful ideas. Thus, creativity is the starting point for innovation; it is an essential requirement but not an adequate condition (Amabile, 1988). In respect to the difference between innovation and invention, innovation is the application of a new concept to an already existing invention. In other words, an invention is the design of a product, process, and service at the original beginning, whereas, innovation is the significant improvement on the cost, reliability, and performance of the product, process, and service (Amabile, 1988; Dahlin & Behrens, 2005).

**Individual Innovative Behavior as a Precursor to Innovation**

The common denominator in the scientific and technological development of any country or organization is the individuals that make up these entities. Individual innovation has been defined operationally in terms of individual characteristics, traits and behaviors. West and Farr (1986) conceptualized innovative behavior as every action that an individual takes that is directed toward the effort to generate, introduce and apply new and useful ideas. An individual’s engagement is the foundation for group/institutional innovation and improvement. When it comes to conceptualizing such behaviors, a relevant construct is Innovative Behavior (IB), also referred to as Innovative Work Behavior (IWB), which involves initiating new and useful ideas, processes, products or
procedures, as well as the process of implementing these ideas (Farr & Ford, 1990; Scott & Bruce, 1994). The idea that innovative individuals play a key role in the development of countries informs the purpose of this study: to investigate how self-efficacy among college students in science, technology, engineering and mathematics (STEM) fields in Nigeria predicts their self-reported Innovative Behavior (IB).

In their study, Kleysen and Street (2001) condensed over 289 creativity and innovation-related activities into 24 group activities; they eventually identified 17 particular behavioral processes underlying the 24 grouped activities. Klensen and Street (2001) constructed five factors that appear to most appropriately categorize these 17 behaviors into more general dimensions. These five general dimensions associated with individual innovation include: opportunity exploration, generativity, formative investigation, championing, and application. According to Kleysen and Street (2001), opportunity exploration refers to paying attention to opportunity sources and recognizing and gathering information about opportunities. Generativity is a term that references Erikson’s (1980) developmental stage of adulthood (generativity vs. stagnation). Kleysen and Street (2001) appropriated the term generativity to refer to the idea of “behaviors directed at generating beneficial change for the purpose of ‘growing’ organizations, their people, products, processes, and services (p. 286). Formative investigation refers to elaborating new ideas, getting opinions on the ideas and trying out the ideas through investigation. Championing new creative ideas involves negotiating, persuading and influencing others about the new idea. Lastly, the term application refers to the process of bringing creative ideas to fruition and integrating these ideas into the operating system of
Ordinarily, innovative behavior or innovative work behavior is articulated to be a more complex construct than creativity. The behavioral processes within innovative behavior are perceived to be made of four interconnected progressive arrangements of behavioral activities, including: problem recognition, idea generation, idea promotion, and idea realization (Scott & Bruce, 1994; Janssen, 2000). The first two behavioral activities (i.e., problem recognition and idea generation) represent the operational process of creativity-oriented behavior. As pointed out by Amabile (1988), creativity involves the production of novel and useful ideas. Thus, whether for an individual or a team, creativity is the preparatory phase for innovation.

The last two behavioral activities (i.e., idea promotion and idea realization) represent the completion of the innovative process. Such activities encompass the implementation-oriented behavior of an individual. These behaviors include sustaining, championing and creating support for new ideas and eventually implementing and bringing the ideas to fruition (Janssen, 2000).

**Status of Technological Innovation in Africa**

Africa is the second largest continent after Asia with a population of over 900 million, speaking 2000 different languages (World Population Perspective, 2010). In the continent, 65% of the population are under 25 years of age. (UN, Department of Economic and Social Affair, Population Division, 2001). Over 60% depend on agriculture for their livelihood, and 50% live below the poverty line of one US dollar daily (ATPS, 2010). Wagner and colleagues (2001) developed four broad categorizations
for countries: scientifically advanced, proficient, developing, or lagging. According to Wagner and colleagues, all African countries are classified within the last two groupings, with most categorized as lagging. The G8 leaders in their 2003 summit declared, “Without embedding science, technology and innovation in development we fear that ambitions for Africa will fail” (p. 1). The leaders endorsed an action plan for science and technology in sustainable development. Similarly, the Commission for Africa and the UN Millennium Project observed that without a major improvement in technological agriculture’s performance, African countries would not meet their pledge to halve the number of people living on less than a dollar a day by 2015 (Commission for Africa, 2005; UN Millennium Project, 2005).

In their seminal study, Pouris and Pouris (2009) reported on the state of science and technology in Africa in the period from 2000 to 2004. They reported data on the number of technological research publications and the number of patents awarded within the continent. Africa produced 68,945 publications over the 2000-2004 period, which represents just 1.8% of the world’s publications. Similarly, in terms of patents awarded to African inventors in the 2000-2004 period, Africa had only 633 (0.1%), while the rest of the world received 817,197 (Pouris & Pouris, 2009). These reported findings indicate an expedient need for Africans to pay attention to the development of an effective and productive research system. Enhancing the ability to produce and document scientific, technological and innovation (STI) indicators will facilitate evidence-based socio-economic and political policy decision making.
Status of Technological Innovation in Nigeria

Nigeria is the most populous country in Africa with over 160 million inhabitants. According to Joy (2000), Nigeria is a key player in the Organization of Petroleum Exporting Countries (OPEC) and ranked as the seventh highest oil exporting country in the world. Oil exports constitute 90% of her foreign earnings; nevertheless, pervasive poverty continues to be a bane in Nigerian economic development. It is estimated that 66-70% of Nigerians are poor and live below the poverty line of one US dollar daily. The unemployment rate in Nigeria increased to 23.90 percent in 2011 from 21.10 percent in 2010 (NBS, 2011). Nigeria is ranked 41st in the world in gross domestic product (GDP) and 161st in terms of GDP per capita (UNDP 2009).

The science and technology assessment by Pouris and Pouris (2009) showed that Africa contributed 1.8% of scientific and technological publications produced internationally. Within Africa, Nigeria ranks fourth with just 5.9% within Africa, behind South Africa with the highest publications (30.1%), followed by Egypt (20.2%) and Morocco (7.9%). Likewise, in patents awarded to Nigerian inventors in the 2000-2004 period, Pouris and Pouris (2009) indicated that Nigeria developed only 17 utility patents, against the background of 633 in Africa and 817,197 in the entire world.

In a science and technology summit organized by the federal ministry of science and technology of Nigeria (FMST) in 2010, ministry representatives observed that the integration of a national culture of science, engineering, technology and innovation (STEI) would facilitate an era of economic growth and development driven by technological advancement. Furthermore, a report published by the National Technical Working Group (NTWG) on science technology and innovation (STEI) under the
direction of Nigerian National Planning Commission highlighted some of the core challenges for development and sustainability (NTWG, 2009). These challenges for Nigerian STEI included:

(a) The political will to encourage and support STEI, especially in the area of how much capital is allocated to STEI, by the federal and state governments.

(b) STEI policy is inconsistent from one political administration to another.

(c) The underfunding of research activities in Nigerian Universities and allied institutions.

(d) The unfavorable legal framework undermining research and development (R&D).

(e) Absence of motivation in Nigerian youths to pursue professions in research and STEI, instead of administrative job because individuals in STEI fields earn less.

(f) Lack of linkages and cooperation between research and development in Nigerian universities efforts and manufacturing firms in Nigeria.

(g) Lack of appreciation of and self-efficacy in the application of modern technology by Nigerians in general (although this factor can be attributed to poverty). (NTWG, 2009)

If Nigerian policy decision makers are to create effective, evidence-based policies for the development and progress of science, technology and innovation in Nigeria, then productive national research system indicators are important. Universities are in a better position to play a crucial role in the development of local and national research system indicators than are other entities. Freeman (2002) postulated that the process of technological innovation involves interactions among a varied array of actors in any country that mutually reinforce learning activities. Core stakeholders in innovative
systems are universities, with the dynamic mandate of combining research, teaching and application.

**Theoretical Rationale for the Concept of Self-Efficacy**

An individual sense of efficacy presumably will influence one to recognize and understand problems that are associated with a particular task at work or other situations. Bandura (1997) posits that in order for an individual to be innovative and creatively productive and participate in discovery of new knowledge in any particular domain, the individual has to have a high sense of efficacy in that domain.

Perceived self-efficacy is a fundamental component of Bandura’s (1986) social cognitive theory, which emphasizes the role of observational learning and social experience in the development of personality. Social cognitive learning theory attributes learning to the occurrence of transactional relationships between behaviors, environmental factors and personal factors that consist of cognitive, affective and behavioral processes (Bandura, 1986). A personal sense of efficacy will propel individuals to move forward in the face of difficulty and be assured that they are capable of tackling challenging tasks within a particular domain of knowledge. In fact, Zimmerman (1995) posits that individuals’ self-efficacy beliefs in many cases can predict performance more accurately than can actual ability. Research findings support the important role of self-efficacy, indicating that an individual’s perceived sense of efficacy is an accurate predictor of skill acquisition, rate of performance, expenditure of energy, persistence, goal setting, and self-monitoring of goals (Bandura, 1997; Lent & Hackett, 1987; Pajares, 1996; Schunk, 1991; Zimmerman, 1995).
Bandura (1993) defines self-efficacy as “people’s beliefs about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives” (p. 71). Individuals with a high sense of self-efficacy are likely to be confident of their capabilities to accomplish difficult tasks. Self-efficacy is shown in several studies to positively correlate with academic achievement. In their comprehensive meta-analysis of major studies conducted on self-efficacy and academic performance from 1977 to 1988, Multon, Brown, and Lent (1991) showed that self-efficacy beliefs accounted for approximately 14% of the variance of students’ academic achievement. Additionally, perceived efficacy determines, to a large extent, a student’s behavioral, affective and motivational practices toward academic subjects (Lent & Hackett, 1987; Pintrich & De Groot, 1990).

There are a number of differences between high-efficacy and low-efficacy students. As compared with students who have a lower sense of efficacy, students who have a higher sense of perceived efficacy are more likely to exert effort physically, endure in challenging tasks, and engage in instrumental help-seeking behaviors. Students with high self-efficacy are also more likely to choose academically oriented peer groups than individuals with low self-efficacy, again resulting in higher academic achievement (Bandura, Barbaranelli, Caprara, & Pastorelli 1996; Linnenbrink & Pintrich, 2003). As such, it can be concluded that self-efficacy promotes and facilitates academic achievement.

The positive role of self-efficacy is not just limited to academic achievement. The construct of self-efficacy has been tested in a multitude of studies and diverse fields, including academic motivation and self-regulation (Schunk, 1991), teachers’ self-efficacy

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(Tschannen-Moran & Woolfolk-Hoy, 2001), social skills (Moe & Zeiss, 1982), clinical phobias (Bandura, 1983), depression (Davis & Yates, 1982), and sports (Barling & Abel, 1983). Results of all of these studies indicate that perceived self-efficacy beliefs tend to boost personal effort and drive individuals to engage in challenging tasks or deal with difficult situations in spite of setbacks. Whether it is self-regulating cognitive motivation in academia, teaching difficult students, interacting in unfamiliar social settings, overcoming clinical phobias or depression, or excelling in sports, the self-efficacy beliefs that individuals have about their abilities to accomplish specific tasks can be a strong determinant in the choice of whether or not to actually engage in a task. Thus, it can be speculated an individual personal sense of self-efficacy or, in reference to this study, the science self-efficacy of Nigerian college students in STEM fields, may be related to their self-reported innovative behaviors (IB) in science and technology.

**Sources of Self-Efficacy Beliefs**

To understand how an individual can develop and strengthen perceived efficacy beliefs in any particular domain, it is important to understand the source of self-efficacy beliefs as well as the psychological processes behind self-efficacy beliefs. How people develop their sense of efficacy is usually via four main sources. The four sources of self-efficacy as proposed by Bandura (1986) include: enactive mastery experiences, vicarious experiences, verbal persuasion, and physiological states.

First, mastery experiences refer to direct experiences with particular tasks. These experiences are considered the strongest source of self-efficacy. Bandura (1997) speculated, “Successes build a robust belief in one’s personal efficacy. Failures undermine it, especially if failures occur before a sense of efficacy is firmly established”
(p. 80). There are a variety of elements that tend to determine how effective a mastery experience will be, including: self-knowledge, self-monitoring, and reconstruction of the experience; task difficulty and contextual factors; the amount of effort expended; and the pattern of success/failure (Bandura, 1997).

The implications for innovation in science and technology for Nigerian college students in STEM fields are far reaching. To boost the science efficacy of these students, activities have to build on students’ self-schemata (expressed in their self-knowledge, self-monitoring, and reconstruction of experiences) of any particular scientific task. These self-schemata influence the environmental cues these students attend to during, before and after the performance of any specific scientific task. The perceived difficulty of the task also determines the value and effort that are exerted in mastering the task. Moreover, the pattern of success/failure plays a role in determining the kind of efficacy judgments one makes in the process of engaging in the task.

The second source of efficacy information is vicarious experience, which involves gauging one’s capability in relation to the performance produced by the actions of others. A person’s sense of efficacy can develop as one observes others performing a task well. Occasionally, one can envision oneself performing the task after having viewed others engaging with the same task. Individuals make judgments of their capabilities by making comparisons to the performance of others (Bandura, 1997; Schunk, 1987). Hence, outperforming colleagues in a particular task usually is a boost to one’s sense of efficacy. On the contrary, if one underperforms in a task and colleagues succeed, it will possibly lower one’s sense of self-efficacy.
However, Bandura noted that different task contexts and models (that is, the observed colleague or others) will have varying influences on each observer, because each observer is uniquely predisposed to interpret his or her vicarious experiences differently. As such, how the experience impacts one’s sense of efficacy depends on the interpretation. According to Bandura (1997), the elements that moderate the impact of a vicarious experience on an observer are the cognitive and motivational processes of the observer, the mode or the different forms of the actual modeling experience, and the perceived characteristics of the model that is being observed. Normally, observing accomplishments made by those judged to be most similar to the observer will influence most positively the observers’ sense of self-efficacy (Bandura, 1997).

With respect to the development of science and technological innovation in Nigerian college students in the STEM fields, there is a lack of real-time vicarious learning from accomplished models who have contributed to innovative discoveries in science and technology. As an implication of the lack of vicarious learning from real-time innovators, these students may experience impeded self-efficacy in science and technology.

Third, people can develop self-efficacy beliefs as a result of the verbal persuasion they receive from others. Social persuasion is one way of strengthening another’s personal efficacy beliefs. Persuasion involves being exposed to the verbal judgment that others provide. Although they provide a weaker source of self-efficacy information than mastery or vicarious experience, persuaders or encouragers can play an important part in the development of an individual’s self-beliefs (Zeldin & Pajares, 1997).
Bandura (1997) proposed that the act of persuading another has varying effects on the one that is being persuaded. He identified some features that determine the usefulness of social persuasion as a source of self-efficacy. First, the kind of performance feedback one receives from a persuader determines whether the social persuasion will boost one’s sense personal efficacy. Bandura noted that feedback that is presented in a format that encourages improvement in the direction of one’s goals tends to boost the self-efficacy of the recipient, unlike when feedback is focused on the failures of the recipient. Secondly, a persuader’s credibility is critical in determining how feedback is received and impacts the recipient’s sense of efficacy. Thirdly, if the performance appraisals from the persuaders are only moderately different, as opposed to very different, from the recipient’s performance beliefs, then the persuasion will be more effective in boosting the recipient’s sense of efficacy than when the performance appraisals from persuaders are very different from the recipient’s beliefs.

Finally, Bandura (1994) posits that people sometimes depend on their cognitive interpretations of their somatic and emotional states in judging their capabilities. Bandura (1997) points out that “people often read their physiological activation in a stressful or taxing situation as signs of vulnerability to dysfunction” (p. 106). Accordingly, a positive mood often promotes perceived self-efficacy, whereas a despondent mood impedes it (Kavanagh & Bower, 1985). Bandura (1997) notes specific factors involved in assessing the impact of physiological and affective states on one’s sense of self-efficacy. One such factor is the salience of the somatic information, which is important in determining the impact of a physiological/affective state on one’s sense of personal efficacy for a given task. A second important factor is individual appraisal and interpretation of the somatic
information. The linkages are such that individuals tend to infer that the experiences of tense and stressful outcomes are signs of their vulnerability, which leads to poor performance and achievement.

Furthermore, it is important to note that various sources of efficacy information are in reality integrated, because tasks are typically performed in complex contexts. Thus, Bandura (1997) argues that these sources seldom function in isolation, as “efficacy beliefs are the product of cognitive processing of diverse sources of efficacy information conveyed enactively, vicariously, socially, and physiologically” (p. 115). For example, a Nigerian college student enrolled in a Biochemistry program and attempting an innovative task (e.g., discovery of malaria vaccine) may visualize the possibilities and the usefulness of such a vaccine for Nigerians, while also reflecting on how other successful vaccines were historically developed (e.g., polio vaccine). At the same time, this student may make judgments about her/his capability to accomplish the goal and, in the pursuance of this goal, may be receiving performance feedback from colleagues. It can also be speculated that, because of the possibility of saving lives, the student may have an exciting sense of anticipation, thereby inferring information related to self-efficacy from her/his affective or physiological states.

The Psychological Processes of Self-Efficacy Beliefs

To understand how efficacy beliefs influence how people think, motivate themselves, feel, and act, it is essential to recognize the psychological processes of self-efficacy beliefs. Self-efficacy influences human functioning through four processes: cognitive processes, motivational processes, affective processes, and selection processes
The interaction of the processes and their outcomes can influence an individual’s innovative behavior, as will be discussed below.

**Cognitive processes.** The cognitive processes of an individual can be influenced by perceived efficacy beliefs. How people think about any particular task can promote or undercut success in accomplishment of the task (Bandura, 1997). Because thoughts can occur before, after and even during a task or behavior in progress, thoughts impact how people feel and what they seek to do—thus, the goals individuals choose to pursue. For example, a Nigerian college student seeking a degree in robotics engineering will not seek to pursue the vocational goal of becoming a “Creative Robotic Designer” if the student is not efficacious in simple mechanics and tool handling. As Bandura (1997) pointed out, “personal goal setting is influenced by self-appraisal of capabilities” (p. 116). Carroll and Bandura (1990) posit that cognitive processes play a role in guiding the actions that people undertake.

Furthermore, an individual’s cognitive processes give direction to productive action through a structured thought process. Accordingly, individuals who have a high sense of efficacy for a goal or task they seek to pursue are likely to engage in success-promoting thoughts (what Bandura calls cognitive constructions) and visualization that positively drive performance. On the other hand, those with low perceived efficacy beliefs may engage in failure-promoting thoughts and visualizations that retard performance (Bandura, 1997). Additionally, in relation to cognitive processes, students who display a high sense of efficacy tend to engage in deeper cognitive processing in their learning strategies, unlike students who have low perceived efficacy beliefs (Linnenbrink & Pintrich, 2003). Highly efficacious students are better able to regulate
their learning process, because they are in tune with and aware of their thoughts (Bandura, 1997).

**Motivational processes.** Motivational processes involve the deliberate actions people engage in to accomplish a goal. According to Bandura (1997), “the capability for self-motivation and purposive action is rooted in cognitive activity” (p. 122). An individual’s sense of efficacy influences his/her motivational processes in different patterns. Because human motivation is cognitively generated (Bandura, 1995), a Nigerian college student in a Microbiology program can motivate herself through the exercise of forethought by driving herself to discover a malaria vaccine and anticipating the possibility of her discovery.

According to Bandura (1997), there are three forms of motivational processes by which self-efficacy influences one’s actions or goals. These forms include the causal attributions one makes, the outcome expectancies one holds, and the cognized goals one develops. For example, a student with a high sense of efficacy for mathematical manipulation probably will attribute poor performance on a math task to controllable factors (like lack of preparation, low effort or faulty strategies) instead of making a causal attribution to his/her ability with respect to the math task. Furthermore, sense of efficacy determines to what degree and under which conditions individuals will persevere if the task is not going as planned, the kind of effort they will expand on the task, and how failure will impact their future endeavors (Bandura, 1997; Zimmerman, 1995). As Linnenbrink and Pintrich (2003) pointed out, individuals’ motivation tends to increase if the task is interesting to them. When a task is interesting, individuals regard it as valuable and have positive emotions about it. For example, a Nigerian college student in the
STEM fields who has intrinsic interest in studying quantum physics, and who values and has positive emotions about the course content, will most likely exhibit a high sense of efficacy in learning quantum physics.

**Affective Processes.** The affective processes involve the self-regulatory control of a one’s emotional states. Perceived efficacy beliefs seem to influence the fluctuation of emotional states. There is evidence that individuals with high self-efficacy can exercise control over stressors and subsequently manage stress and depression. This connection likely occurs because a person’s sense of efficacy influences the interpretational mechanism of present and future threats (Bandura 1991). The interpretation of present and future threats also underlies why students with a high sense of self-efficacy remain unflustered in the face of a threatening difficult exam, whereas those with a low sense of self-efficacy often are overwhelmed with anxiety (Bandura, 1997).

It is likely that this mechanism can be extrapolated to the Nigerian context. Nigerian college students with high self-efficacy in the STEM fields may view and interpret some of the structural issues in Nigeria (e.g., lack consistent electrical energy, unreliable internet and communication network, high unemployment, poor road network) as technological and scientific challenges to address innovatively. Those with low self-efficacy, on the other hand, may emotionally give up on the possibility of tackling these problems and may instead settle for an administrative vocation upon graduation.

Additionally, a person’s sense of efficacy can moderate affective processes in the self-regulation of distressing and ruminative thoughts (Bandura, 1997). Individuals with a high sense of efficacy tend to manage distressing situations effectively and not be overwhelmed, whereas those with low self-efficacy tend to become depressed and
anxious. Meece, Wigfield and Eccles (1990) pointed out that one reason students with low sense of self-efficacy have test anxiety is that past academic failures trigger anxiety.

Selection Processes. The selective processes involve the deliberative action of making individual choices, that is, to engage or not to engage in a task. Bandura (1997) posits, “by selecting their environment, people can have a hand in what they become. Choices are influenced by beliefs of personal capabilities” (p. 160). As such, Bandura hypothesized that individuals with a high sense of perceived efficacy have a tendency to contemplate multiple possibilities as they make choices to engage in a task, unlike individuals with a low sense of self-efficacy, who tend to contemplate fewer possibilities. The tendency to contemplate several possibilities when engaging a task is representative of innovative individuals who engage in problem recognition, generation of novel ideas and ways to promote those ideas. As Lent and Hackett (1987) have reported, individuals with high self-efficacy beliefs are likely to have many options in the kind of careers they pursue. As compared with low-efficacy individuals, highly efficacious individuals show better interest in the career they choose to pursue and better prepare themselves educationally for their chosen vocation. The choices people make will cultivate the kind of competence, interest, and social networks they develop, which will accordingly determine their life course (Bandura, 1995).

Self-Efficacy in Science, Technology, Engineering and Mathematics (STEM)

There has been an increased focus in Nigeria on the problem of dwindling enrollment and achievement in STEM fields (FMST, 2010). This low enrollment in the STEM fields is becoming a source of concern, even here in the United States. This concern owes to the potential developmental implications and detrimental effects that
reduced enrollment and achievement will have politically and economically in any particular nation (National Science Foundation [NSF], 2007).

Since the construct of self-efficacy was introduced by Bandura (1986), there have been a variety of studies conducted with different age groups, different ethnicities, and across diverse educational environments. A common finding of these self-efficacy studies is that the strongest relations or predictability of outcomes occurs when specific forms of self-efficacy correspond with expected specific outcomes (Chio, 2005; Lent & Brown, 2006; Pajares & Miller, 1995). By extension, several studies have focused on students’ and learners’ perceived sense of self-efficacy in STEM fields (e.g., Anderman & Young, 1994; Andrew, 1998; Kupermintz, 2002).

Science self-efficacy is one’s judgment of one’s capabilities to organize and execute courses of action required to conduct science tasks, whether at the high school, college level or workplace. Science self-efficacy also predicts academic performance in science subjects among high and middle school students (Britner & Pajares, 2001; Kupermintz, 2002). High levels of scientific self-efficacy generally are related to effort, performance, and persistence in STEM courses (Lent et al., 2007; 2008).

Several researchers have identified mathematics self-efficacy and science self-efficacy as predictors of science achievement in STEM courses and in making career decisions (e.g., Lent, Lopez, Brown & Gore, 1996; Uzuntiryaki & Aydin, 2008). Few researchers, however, have examined how science self-efficacy predicts innovative behavior in science and technology. In the present study, I address this gap by examining how a number of variables identified in the literature as important to STEM achievement and
how self-efficacy predict innovative behavior (IB) in science and technological innovations in Nigeria.

**Integration of Self-efficacy and Innovation**

Amabile (1988) has conceptualized creativity as the production of novel and useful ideas. On the other hand, Scott and Bruce (1994) differentiated innovation from creativity, proposing that innovation includes not only idea generation but also the sustainability, implementation or commercialization of these useful ideas. Bandura (1997) recognized and articulated a likely connection between self-efficacy, innovation and creativity by postulating:

innovativeness requires an unshakable sense of efficacy to persist in creative endeavors when they demand prolonged investment of time and effort, progress is discouragingly slow, the outcome is highly uncertain, and creations are socially devalued when they are too incongruent with pre-existing ways.” (p. 239)

Thus, creative and innovative effort is usually a demanding activity requiring time and effort. Since there is a high risk of failing in difficult and challenging tasks, it is important to maintain persistence in order to allow continuous creative action (i.e., innovativeness) in the face of various obstacles. Given these demands, one’s perceived efficacy beliefs, or one’s efficacy for innovation, may be necessary as antecedents of creative performance or innovativeness (Bandura, 1997; Choi, 2004; Tierney & Farmar, 2002).
Other Contextual Variables Related to Innovation

Researchers have shown that the cognitive and behavioral processes articulated, discussed and proposed about innovation in science and technology are done in context. Innovative behavior can be explained and analyzed contextually in terms of relations to various demographic variables (e.g., age, gender, ethnic heritage, SES).

Age and STEM innovation

To understand the conceptual issues associated with innovative and creative behavior, it is important to look at underlying individual differences with respect to age. An individual’s age can result in differentiations in declarative, procedural and self-regulatory knowledge, as well as in skills and abilities (Schraw, 2006). In his comprehensive developmental study, Lehman (1966) attempted to discover at what age innovative individuals made their major contributions. He found that major innovative contributions occurred more during young adulthood, whereas minor innovative contributions tend to occur during middle age.

It is generally assumed in working environments that older adults are less innovative than younger adults (e.g., Rosen & Jerdee, 1976). Research does not support this assumption. Choi (2004) reported a positive relation between age and innovative behaviors, whereas Zhou, Zhang, and Montoro-Sanchez (2009) reported no relation between age and innovation-related behavior. Thus, it can be hypothesized that in this study the self-reported innovative behavior of younger adults and older adults will not differ significantly.
Gender and STEM innovation

Bray (2007) suggested that even in western nations where industrialized and innovative technology appear open and progressive, “technology is firmly coded male” (p. 2). He explained that “men are viewed as having a natural affinity with (innovative) technology, whereas women supposedly fear or dislike it” (p. 2). It has been posited that women are not adequately represented in science and technological innovations. This under-representation of women in science and technological innovation may be a result of environmental factors influencing whether women pursue a career in science and technology (Cole, 1987). Bray (2007) asserts that in many societies today, gender differentiations and expression can be found in science and technology. In fact “technical skills and domains of expertise are divided between and within the sexes, shaping masculinities and femininities” (p. 38). Charyton et al. (2011) declared that “women and their creativity are underrepresented in science” (p. 203). In the Nigerian context, Izuagba, Nwigwe, and Nwamuo (2013) suggested that patriarchal structures marginalize women in various socio-political and economic aspects of civil society. They further suggested that these structures sustain beliefs that males are more innovative and contribute more to societal development than females. Vogt et al. (2001) reported that female students in engineering programs expressed concerns about bias and discrimination. Female students also found that their male counterparts did not respect them as equals. Thus, it can be hypothesized that in this study the self-reported innovative behavior of male and females participants will likely differ significantly.
Ethnic/cultural Origin and STEM Innovation

In developmental studies, scholars have proposed that predispositions for innovative behavior may be determined and modified as a result of social and cultural environments (Erikson, 1980). In the course of development, an innovative individual may be exposed to a variety of circumstances and nuanced social interactions that constitute the broader ethnic heritage and culture. Simonton (1992) further speculated that the opportunities an individual accrues by virtue of belonging to a particular ethnic group may lead to experiences that influence the development of innovative potential.

It would be impossible to adequately describe the ethnic and cultural characteristic of the 250 people groups in Nigeria. There are, however, three recognizable composite cultural groups. These composite cultural groups located in different regions of Nigeria are the largest ethnic groups in Nigeria. These include: the Hausa-Fulani people group, located in the northern region; the Yoruba people group, located in the southwestern region; and the Igbo people group, located in the southeastern region. It is generally acknowledged that the Igbos as a group are more innovative and enterprising than other groups in Nigeria (Ukeagbu, 2007). This distinction is what motivated Forsyth to state, “Biafra (Igbos) are variously described as the Japan, the Israel, the Manchester, and the Kuwait of the African continent (Forsyth, 1969, as cited in Ukeagbu, 2005, p. 1400).
Socioeconomic Status (SES) and Innovation

Socioeconomic status is usually measured by one or more of the following factors: household income, parents’ education, and parents’ occupation. It is generally agreed that the combination of income, education, and occupation represents a more accurate measure of SES than any single factor (White, 1986). It has been reported that high SES families provide for themselves and their children services, goods, and social and psychological connections that promote positive developmental outcomes. In contrast, low SES adults and their children lack a high degree of resources and experiences, which presents a risk of negative developmental outcomes (Brooks-Gunn & Duncan, 1997).

Findings from several researchers indicate that SES is associated with health, cognitive abilities, and socio-emotional disorders (Bradley & Corwyn, 2002). There are no specific studies that look directly at the relation between SES and innovative behavior; however, there are several scholars who provide evidence of the association between SES and cognitive performance (Bloom, 1964; Duncan et al., 1994; McCall, 1981). In his meta-analysis, White (1982) reported that 5% of the variance in cognitive and academic achievement was accounted for by SES. Bradley and Corwyn (2002) stated that “the relation between SES and cognitive attainment may be quite complex” (p. 376). Therefore, it can be speculated that that cognitive and psychological processes of innovative behavior can be influenced by SES.
The Role of Self-Efficacy in the Development of Technological Innovation in Nigeria

In this section, I briefly describe the student population enrolled in the STEM program in Nigeria. I then explore the rapid socio-economic transformation in Nigeria and the opportunity it presents. Finally, I speculate that science efficacy can play a crucial role in the development of technological innovation in Nigeria.

According to Nigerian Federal Ministry of Education, the most important predictor of success in the STEM programs in Nigerian universities is students’ performance in the specialized subjects (e.g. Mathematics, Physics, Chemistry, and Biology) of the university’s matriculation examinations. These examinations include: the West African Examination Council (WAEC); the Nigerian Examination Council (NECO); and the Joint Admission Matriculation Board (JAMB). JAMB is the equivalent of SAT here in the US, and it is the most important predictor of success for students enrolled in STEM programs.

Elder (1995) speculated that in the course of human lives, dislocation and strain are particularly likely to occur in times of rapid socio-economic development. This developmental process is typically problematic during eras of social and economic transformation, particularly when human dislocation and deprivation also present an opportunity for growth. Applying this reflection to Nigeria, it can be argued that Nigeria is at the crossroads of socio-economic and technological transformation. There is an opportunity for Nigeria to pursue national development and make policy decisions that bolster technological advancement.

Furthermore, Elder (1995) posited that any nation or group of people that experience an era of rapid social change (with its attendant problems of human
dislocation and deprivation) has an opportunity to make progressive contributions to the
development of such a society. He emphasized that this opportunity only exists if the
members of such a society have a sense of personal capability and control. This point
highlights the importance of self-efficacy.

At all the different national levels of Nigerian government, it is being
acknowledged that scientific and technological innovation will be greatly beneficial for
Nigeria’s national development. These objectives have been addressed in a basic sense in
policy paper presentations by various government departments (e.g., the report of Nigeria
Vision 2020 of the National Technical Working Group [NTWG] on science technology
and innovation). Creating an actionable and implantable policy that will facilitate and
support Nigeria in general and Nigerian students in particular remains an important goal.
Helping Nigerian STEM students develop a personal sense of efficacy in critical sections
of the Nigerian political economy—especially in science and technological innovation—
should be an urgent goal. Ukaegbu (1985) posited that the development of students’
science self-efficacy is important in creating effective utilization of scientific and
technological manpower. Developing science self-efficacy can create opportunities for
Nigerian STEM professionals to exercise autonomy and promote their innovative
abilities.

With particular reference to science and technological innovation in Nigeria, self-
efficacy and innovative behavior have to be encouraged and promoted at all educational
levels, if Nigeria is to become technologically independent. Most Nigerian educators and
policy thinkers have advocated that the education section will contribute greatly to
Nigerian national development in general and technological innovation in particular (see
Fafunwa, 2007; Ukaegbu, 1985). Fafunwa (2007) pointed out that the underdevelopment in Nigeria is not only a deplorable physical state but also a lamentable and distressing state of one’s mind and capabilities; conversely, a well-funded and structured university system will facilitate Nigeria’s development.

Furthermore, an individual sense of self-efficacy in educational achievement can lead to productive performance outside school, thus boosting personal development and innovativeness in science and technology outside of the school environment. Bandura (1997) theorized that “a fundamental goal of education is to equip students with self-regulatory capabilities that enable them to educate themselves. Self-directedness not only contributes to success in formal instruction but also promotes lifelong learning” (p. 174). Perceived self-efficacy beliefs determine and sustain one’s self-directedness in an innovative pursuit or endeavor. A high sense of self-efficacy in any domain-specific STEM related program is instrumental to mastery of academic content. Self-efficacy facilitates cognitive processes that reinforce one’s sense of self-efficacy in that particular academic program. Attaining mastery in an academic program can underscore the motivational drive to pursue vocations or careers in that particular academic program (Zimmerman, Bandura & Martinez-Pons, 1992). Furthermore, a student with a high sense of self-efficacy in a particular academic program will likely demonstrate – both within and outside the formal educational environment – an active engagement in that academic program (Bandura, 1997).
Conclusion and Reflections

When considering the national development of Nigeria, one cannot overemphasize the importance of education and learning and, by extension, capacity and capability-building in technological innovation. The challenge will be present as early as Pre-K (nursery) school and throughout every subsequent stage of education, including postgraduate education and training. It is important that any reform in the Nigerian educational system respond innovatively to the needs of all students at all levels, including both conventional educational settings (e.g., classrooms) and non-conventional educational settings (e.g., vocational and professional apprenticeships).

The potential implications of the issues that will be underscored in this study are summarized by Juma and Yee-Cheong (2005), who reasoned:

A nation’s ability to solve problems and initiate and sustain economic growth depends partly on its capabilities in science, technology, and innovation. Science and technology are linked to economic growth; scientific and technical capabilities determine the ability to provide clean water, good health care, adequate infrastructure, and safe food. Development trends around the world need to be reviewed to evaluate the role that science, technology, and innovation play in economic transformation in particular and sustainable development in general.

(p. 20)

Bandura (1997) recognized the likely connection between self-efficacy, innovation, and creativity. He postulated that for an individual to exhibit innovativeness in a domain-specific task, it is necessary for that individual to have a high sense of personal self-efficacy. One’s self-efficacy beliefs allow one to persevere in innovative
pursuits, especially when the demand to be successful requires long hours and sustained effort and occurs within a context of mitigating structural and socio-economic problems.

Furthermore, in his articulation of innovative systems, Freeman (2002) postulated that the process of technological innovation involves interactions among a varied array of actors in any country that mutually reinforce learning activities. Core stakeholders in this process of innovative systems are universities, with the dynamic mandate of combining research, teaching and application. Perhaps this role is no more pressing than it is in Nigeria, where technological and scientific innovations are low in relation to her natural and human capital. Future research that examines relations not only in survey research designs but also through students’ own reflections in qualitative designs will further what is known about innovation and its relations to various underlying and motivational factors. It is vital that scientific skills and knowledge enable Nigerians to find solutions to their own problems by developing socially relevant technological innovations. Promoting science self-efficacy in Nigerian college students (future scientists) will boost the potential for innovation in science and technology, thereby creating sustainable socio-economic and political development.

In this proposed study, I intend to further the research on science self-efficacy as it relates to scientific and technological innovation. Specifically, I will explore how science self-efficacy among college students in science, technology, engineering and mathematics (STEM) fields in Nigeria predicts self-reported Innovative Behavior (IB). Results of the study ultimately may assist me and other researchers in subsequently developing interventions to enhance self-efficacy and scientific innovation in Nigeria. Conceivably, results of this study may contribute to the educational pipeline of training
and supporting upcoming scientists and inventors in the Nigerian socio-educational context.
Chapter 3: Methods

The present study addressed three broad goals: (a) to examine the role that science self-efficacy plays in self-reported innovative behavior, (b) to examine the moderating role of choosing to go into a STEM field on the relation between science self-efficacy and innovative behavior, and (c) to better understand other contextual variables (e.g. SES, academic achievement, parental education level, and other demographic factors) that may promote individual engagement in innovative behavior. With a focus on Nigerian college students in STEM fields, I aimed to address the following questions:

- Does science efficacy predict innovative behavior?
- Does level of decidedness in a STEM career moderate the relation of science self-efficacy to innovative behavior?
- Does academic achievement predict innovative behavior?
- Does the educational level of parents predict innovative behavior?
- Do other demographic variables (e.g., age, gender, SES, students’ ethnic region, and their year of study) predict innovative behavior?

Participants

Participants were 797 undergraduate students enrolled in several programs in Science, Technology, Engineering, and Mathematics (STEM) at two public and one private university in Nigeria. These universities were the University of Nigeria, Nsukka; the University of Lagos; and Covenant University. I travelled to Nigeria during the summer of 2013. Most of the participants were in their second, third or fourth year in several STEM programs
(6.3% were in their first year, 21.3% were in their second year, 28.8% were in their third year, and 43.6% were in their fourth year). Among the participants, 58% were male and 42% were female. In terms of participants’ ethnic regional grouping, 51.6% were from the southeast (comprised mainly of the Igbo speaking people), 44.8% were from the southwest (comprised mainly of the Yoruba speaking people), and 3.6% were mainly from the northern part of Nigeria and from other African countries. This third group was not entered in the regression model, because this third was made up of mainly students from other African countries, who did not indicate their ethnic/regional group. In addition, these other African students could not be qualitatively compared with the people group description within Nigeria. The SES (combined monthly income) of participants is as follows: 17% earned under 50,000 naira ($300.00 a month), 12% earned between 51,000 to 100,100 naira, 55% earned between 101,000 to 1,000,000. 5% of participant’s parents earned over 10,000,000 naira ($67,000.00 a month).

**Procedure**

I travelled to Nigeria and subsequently visited three of the universities in Nigeria during April and May of 2013, when the three universities were in the second semester of a two-semester session for the 2012-2013 academic year. At the universities, there were different procedures of negotiating with the administration of the universities to carry out the study. Apart from meeting my main contacts in each of the universities, I also met with several administrators that my main contacts suggested I meet. At each of the universities, I explained the purpose, potential benefits, and potential risks of the study to several key administrators (Deans, head of departments, section heads and student union officials). Subsequently, with the assistance of several professors/lecturers,
as well as key administrators, I facilitated different sub-group informational meetings with STEM students enrolled in different programs at each of the universities.

At the group meetings, which took place in various classrooms, I provided students with the survey measures and consent forms. Initially, I had intended that most of the students would complete the research survey online. After none of the surveys was completed online by students at the first university, it was apparent that I would have to adjust my strategy. A key administrative officer (faculty officer) informed me that although most students have access to the internet, most of them are used to filling out paper and pencil research surveys; as such, if I want to get large response, the paper and pencil survey should be the main mode of response.

At each of the universities, I collected data during a two-week period. The students who elected to complete the survey came to one of several group meetings, where I described the study. They then stayed and completed the consent form and the survey measure voluntarily. As an incentive and encouragement for participation, students could enter a drawing to win one of eight cash prizes. Eight participants at each of the universities received three thousand naira (the equivalent of $20 USD).

**Measures**

The core measures selected for this study were informed by the research questions and previous research. In addition, these measures all demonstrated acceptable reliability and validity. All the items on the various measures were aligned on nine-point or seven-point behavioral frequency response categories (Likert-type scales), with anchored end points and neutral middle alternatives.
Innovative Behavior (IB) was measured by administering two scales. The first scale in its original format was a six-item Innovative Behavior Scale developed by Scott and Bruce (1994), and the second one was a 14-item Innovative Behavior Scale constructed by Kleysen and Street (2001). The six-item scale developed by Scott and Bruce was a one-dimensional scale, and they reported Cronbach’s alpha of .89. The scale in its original format was anchored with a 5-point Likert-type scale, where 1=not at all and 5=to an exceptional degree. An example item in the scale was, “In the course of my studies I will always champion and promote ideas to my professors and colleagues”. In their study on creativity and innovative behavior in a service setting, Hsu, Hou and Fan (2011) used Scott and Bruce’s 6-item innovative behavior scale and reported a Cronbach’s alpha of .91.

The 14-item scale developed by Kleysen and Street (2001) was an individual innovative behavior measure, based on items representing five dimensions (opportunity exploration, generativity, formative investigation, championing and application). They set out in their conceptualization to assess the multi-dimensional nature of individual innovation, operationalizing the five previously stated dimensions. However, using exploratory factor analysis, they found that their data did not produce a multi-dimensional measure of individual innovative behavior. According to Kleysen and Street (2001) the 14 items remaining after their analysis were combined into a single measure of innovative behavior with good construct validity. They calculated an alpha of .95 for their scale. The scale in its original format was anchored with a 6-point behavioral frequency response, with one as “never” and six as “always.” An example item in the scale was, “Define problems more broadly in order to gain greater insights into them”. In
this particular study, both scales (the six-item Innovative Behavior Scale developed by Scott and Bruce (1994) and the 14-item scale developed by Kleysen and Street (2001) were combined into a 20-item scale that was anchored with a 9-point behavioral frequency response, with one as “never” and nine as “always”. In addition, I adapted the twenty items by adding, “In your current academic program, how often do you…?”. The intent of this adaptation was to prompt participants to respond domain specifically, with respect to their individual academic programs. However, it is important to note that the innovative behavior scale is a self-report measure that has not really been shown to have predictive validity. Thus, the self-reported innovative behavior scales may not indeed be predictive of innovative behavior in actual science and technological professions.

**Science self-efficacy** was measured by using a modified version of the 21-Item College of Chemistry Self-Efficacy Scale (CCSS), developed by Uzuntiryaki and Çapa Aydın (2009). The modified version integrated vocabulary and content from other STEM programs in order to reflect statements that included all the programs in STEM fields. Drawing upon extant literature of science education and their experience and discussions with chemistry educators, Uzuntiryaki and Çapa Aydın (2009) proposed four dimensions of chemistry self-efficacy: self-efficacy for knowledge/comprehension-level skill, self-efficacy for higher-order skills, self-efficacy for psychomotor skills and self-efficacy for everyday applications. They administered the initial 22-item scale to a sample of 363 college students taking general chemistry classes and subsequently conducted exploratory factor analysis. What emerged was a three factor structure, based on eigenvalues that were greater than 1. The three factors related to self-efficacy for cognition (combing self-efficacy for knowledge/comprehension-level skill and self-efficacy for higher-order
skills), self-efficacy for psychomotor skills, and self-efficacy for everyday applications. Uzuntiryaki and Çapa Aydın (2009) also dropped one item from the original 22-item scale. The reliability coefficient of each of the dimensions ranged from 0.82 to 0.92. The results from a confirmatory factor analysis indicated the three-factor structure fit the data well. Each dimension of the CCSS demonstrated moderate and significant correlations with student chemistry achievement and differentiated between major and non-major students. The scale was administered on a 9-point rating scale, where 1 = very poorly and 9 = very well. An example item was, “How well can you establish the relationship between chemistry and other sciences?” However, in the administration of this particular scale in this study, the word “chemistry” was replaced with “your course or major area of study.” As such, the above stated item read, “How well can you establish the relationship between your course or major area of study and other sciences?”

Career decision, which was used as a moderator variable, was measured by the Decidedness Scale of the Career Decision Profile (CPP), developed by Jones (2 items; 1 = strongly disagree and 8 = strongly agree; 1989). The scale was used to assess students’ level of decidedness with regard to a future career in science. The scale presented acceptable test-retest reliability and internal reliability. Jones (1989) also found that the scale was associated with criterion measures such as Career Salience and Identity Achievement Status. In their study to understand the trajectories of science self-efficacy beliefs during the college transition and academic and vocational adjustment in science and technology programs, Larose and colleagues (2006) reported alphas at Time 1 (.87), Time 2 (.88), and Time 3 (.83). The items were, “I have a science occupational field in mind that I want to work in” and “I am fully satisfied with the progress I am making
toward my career decision.” However, because the reliability coefficient between the two items was relatively low in my data (alpha = .34), I decided to use only the first item, as it captured the intent of the construct I wanted to measure. Specifically, the first item directly assessed whether the students had made up their minds about the STEM career they wanted to pursue.

**Demographic and control measures.** The following control measures and demographic data were also assessed:

The variable “Male” referred to the categorical variable of gender. The numerical code “0” represented female and “1” represented male.

The variable “Age” was numerically ranked into five categories: students who were under 30 years old were coded “1”; students who were between 30 to 39 years old were coded “2”; students who were 40 to 49 years old were coded “3”; students who were 50 to 59 years old were coded “4”; and students who were over 60 years old were coded “5”.

The variable “Year of program” refers to the year students were in their programs. It was numerically coded with “1” equaling students in their first year, “2” equaling students in their second year, “3” equaling students in their third year, and “4” representing students in the fourth or greater year of their programs.

The variable “JAMB” was used to measure prior academic achievement of the students who participated in the study. The acronym “JAMB” stands for Joint Admissions and Matriculation Board. It is Nigerian’s central body in the federal ministry of education that officially administers examinations that are available for the majority of Nigerian secondary school students that aspire to apply to Nigerian public and private
polytechnic schools, colleges, and universities. JAMB is the equivalent of the SAT in the United States. The highest score a student could earn on the JAMB was 400 points. In this study, JAMB score was coded categorically: “1” represented a score under 100 points, “2” represented a score between 101 to 200 points, “3” represented a score between 201 to 300 points, and “4” represented a score above 300 points.

The variable “Combined parent income” referred to the combined household monthly income of both parents (or of the single parent if there was only one parent in the student’s household). Using the basic exchange rate of one dollar to 150 Nigerian naira, the combined parent income was coded as follows:

- 1 = under 50, 000 naira,
- 2 = 51,000 to 100, 000 naira,
- 3 = 101,000 to 200,000 naira,
- 4 = 201,000 to 500,000 naira,
- 5 = 501,000 to 1,000,000 naira,
- 6 = 1,010,000 to 10,000,000 naira, and
- 7 = Over 10,000,000 naira.

The variable “Mean parent education” referred to the mean educational ranking of both the father and mother. The numeric ranking was coded as follows:

- 1 = No secondary school education,
- 2 = Secondary school education,
- 3 = Ordinary national diploma (two-year degree),
- 4 = Bachelor (four-year degree),
- 5 = Master’s degree,
6 = Doctoral degree (e.g., Ph.D.)

The variable “Ethnic grouping” referred to two major regional categories that were contextual to Nigeria. In this study, the numerical code “0” equaled the southwest region of Nigeria and “1” equaled the southeast region of Nigeria.

**Cognitive Interviews**

To address issues of validity, I conducted cognitive interviews with six Nigerian students enrolled in STEM fields in three different departments at a large Midwestern University. The cognitive interviews served to assure that respondents’ interpretation of the various items was consistent with the constructs from which the items were developed, prior to finalizing the survey and travelling to Nigeria. The cognitive interviews were informative, allowing me to enhance comprehensibility for a Nigerian audience and promote internal validity of the modified versions of the measures (Karabenick, et al., 2007). The general presentation of the surveys was modified in response to the cognitive interviews. Modifications were done basically in two areas. First, reliable and specific instructions were provided to respondents. Secondly, more detailed explanations were added in respect to terms that could be unclear.
Chapter 4: Results

In this chapter, I will present the results guided by the research questions. Data analyses include the use of descriptive statistics, exploratory factor analysis, correlations, and hierarchical regression analyses (including conditional interaction analyses between the two major predictor variables: science self-efficacy and STEM career decidedness). I will examine, in my sample of Nigerian college students, how (a) sense of science self-efficacy, (b) career interest in a STEM field (looking at direct effects and interactive effects), and (c) other contextual variables (e.g. SES, Academic Achievement and Demographic factors) predict individual engagement in self-reported innovative behavior.

Exploratory Factor Analysis

To determine how many latent variables underlay the twenty items assessing innovative behavior, exploratory factor analysis (EFA) was conducted on the items. I used EFA because I combined two pre-existing scales into one, and I did not have any a priori notions of the type of factor structure that would emerge. The two innovation scales were: The 6-item Innovative Behavior Scale developed by Scott and Bruce (1994) and the 14-item scale (Innovative Behavior Scale) developed by Kleysen and Street (2001). Since both scales’ psychometric properties originally were developed from Western samples, and because these items measured the outcome variable of this study (innovation), it was important to explore the underlying factor structure. It was possible that using the scales in a non-Western culture would yield factor structure that differed
from that found in Western samples. I also wanted to make sure that the underlying structure of the data represented the actual variation within the data. In so doing, I sought to determine if the combined innovation scale items were unidimensional, tapping only a single construct of innovative behavior.

The two most common criteria for determining that enough factors have been extracted in exploratory factor analysis are the Eigenvalue rule (Kaiser, 1960) and the scree plot test (Cattell, 1966). When conducting the exploratory factor analysis, the visual examination of the scree plot indicated the existence of one clearly noticeable factor, and another second barely noticeable factor (see table 1.2 and figure 1.1). In addition, two Eigenvalues were above 1.0. The second Eigenvalue for the second factor loading was barely above one (1.17), and accounted for just 3% of the variance in the items. In contrast, the first factor was clearly above one (11.31), and accounted for more than half (56%) of the variance. To examine the items’ loadings in each of the two factors, and to simplify and clarify the data structure, I used the maximum likelihood extraction method of factor analysis, as data were normally distributed, and oblique rotation - direct oblimin method (Costello & Osborne, 2005).

In exploratory factor analysis it is conventional to retain factors with Eigenvalue of is 1.0 or above (Kaiser, 1960). However, some scholars are asking whether it is reasonable to retain factors with Eigenvalue that are just barely above 1.0 (e.g., Hayton, Allen & Scarpello, 2004). Hayton et al. (2004) found that the traditional K1 criterion (i.e., retaining components with an Eigenvalue larger than 1.0) was vastly inaccurate (correct 22% of the time) and tended to over-factor. Thus, following Conway and Huffcutt’s (2003) recommendations, I conducted a one factor analysis. On examination of the
structure, the 20-item EFA scale converged on the expected single-factor solution, with all the items loading strongly on the factor (> .57).

As such, I decided to retain one factor for this study. The reasons are that, first, the scree plot showed that beyond the first factor (with an Eigenvalue of 56%), and each additional factor added little to account for additional variation in the data. Second, the one factor model yielded satisfactory results. All the items loaded highly onto one factor and all loadings were large and positive, which were indications of a one-dimensional scale measuring innovative behavior. Finally, Cronbach’s alpha (.93) indicated high internal consistency of the 20-item scale measuring innovative behavior.
Table 1.1
Exploratory Factor Analysis of the 20-Item Innovative Behavior Scale

<table>
<thead>
<tr>
<th>Factor and Items</th>
<th>M</th>
<th>SD</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>In your current academic program, how often do you search out new technologies, processes, techniques, and/or product ideas?</td>
<td>4.67</td>
<td>1.75</td>
<td>.565</td>
</tr>
<tr>
<td>In your current academic program, how often do you generate creative ideas?</td>
<td>4.90</td>
<td>1.71</td>
<td>.625</td>
</tr>
<tr>
<td>In your current academic program, how often do you champion and promote ideas to your professors and colleagues?</td>
<td>3.91</td>
<td>1.85</td>
<td>.631</td>
</tr>
<tr>
<td>In your current academic program, how often do you investigate and secure funds needed to implement new research ideas.</td>
<td>3.25</td>
<td>2.02</td>
<td>.669</td>
</tr>
<tr>
<td>In your current academic program, how often do you develop adequate plans and schedules for the implementation of new research ideas?</td>
<td>3.70</td>
<td>2.01</td>
<td>.765</td>
</tr>
<tr>
<td>In your current academic program, how often do you innovate?</td>
<td>4.31</td>
<td>1.97</td>
<td>.776</td>
</tr>
<tr>
<td>In your current academic program, how often do you look for opportunities to improve an existing process, technology, products, services or work relationship?</td>
<td>4.64</td>
<td>2.08</td>
<td>.732</td>
</tr>
<tr>
<td>In your current academic program, how often do you recognize opportunities to make a difference in your work towards research application?</td>
<td>4.88</td>
<td>2.02</td>
<td>.721</td>
</tr>
<tr>
<td>In your current academic program, how often do you define problems more broadly in order to gain greater insight into them?</td>
<td>5.18</td>
<td>1.94</td>
<td>.632</td>
</tr>
<tr>
<td>In your current academic program, how often do you experiment with new ideas and solutions?</td>
<td>5.18</td>
<td>1.94</td>
<td>.765</td>
</tr>
<tr>
<td>In your current academic program, how often do you test out ideas of solutions to address unmet needs?</td>
<td>4.46</td>
<td>1.94</td>
<td>.798</td>
</tr>
<tr>
<td>In your current academic program, how often do you evaluate the strengths and weaknesses of new ideas?</td>
<td>4.61</td>
<td>2.05</td>
<td>.754</td>
</tr>
<tr>
<td>In your current academic program, how often do you try to persuade others of the importance of a new idea or solution?</td>
<td>4.91</td>
<td>2.02</td>
<td>.765</td>
</tr>
<tr>
<td>In your current academic program, how often do you push ideas forward so that they have a chance to become implemented?</td>
<td>4.35</td>
<td>2.11</td>
<td>.814</td>
</tr>
<tr>
<td>In your current academic program, how often do you take the risk to support new ideas?</td>
<td>4.39</td>
<td>2.12</td>
<td>.801</td>
</tr>
<tr>
<td>In your current academic program, how often do you implement changes that seem to be beneficial?</td>
<td>4.71</td>
<td>2.13</td>
<td>.824</td>
</tr>
<tr>
<td>In your current academic program, how often do you work the bugs out of new approaches when applying them to existing process, technology, product or service?</td>
<td>4.57</td>
<td>2.07</td>
<td>.804</td>
</tr>
<tr>
<td>In your current academic program, how often do you incorporate new ideas for improving an existing process, technology, product or service into daily routines?</td>
<td>4.61</td>
<td>2.12</td>
<td>.822</td>
</tr>
<tr>
<td>In your current academic program, how often do you pay attention to non-routine issues in your work, studies and research?</td>
<td>4.85</td>
<td>2.06</td>
<td>.624</td>
</tr>
<tr>
<td>In your current academic program, how often do you generate ideas or solutions to address problems?</td>
<td>4.91</td>
<td>2.10</td>
<td>.763</td>
</tr>
</tbody>
</table>

| Eigenvalue | 11.31 |
| Percentage of variance explained | 56.52 |
| Cronbach’s a | .93 |

Note: Though the bolded text indicates the factor loading. However, because of the low Eigenvalue of the second factor, as well as the indication on the scree plot and the high reliability coefficient of the 20-item, I decided to use on factor loading for this study.
Descriptive Statistics and Bivariate Correlations

Descriptive statistics, correlations, and Cronbach’s alphas are presented in Table 1.3. For all inferential analyses the alpha level was set at .05. The measurement perspective for this study aligned more with the liberal theorist perspective. Thus, I used the same parametric procedures for ordinal scales that can be used for interval scales (Baggaley & Hull, 1983; Vickers, 1999). As Allen and Seaman (1997) pointed out, it is appropriate to treat Likert-type scales as interval because the intervals in Likert scales are associated with the data, not the label. Allen and Seaman suggested that it also prudent to make sure that the scale items have seven categories, or at least five. The scale anchors in this study have seven and nine points. The most important predictor scale (Science Self-Efficacy) and the outcome scale (Innovative Behavior) had reliability coefficients of .93 and .96, respectively.
The bivariate correlation matrix revealed several significant associations between the variables measured in this study. There were also several dissimilarities among the variables measured. Students’ program level was significantly and positively correlated with parents’ combined monthly income ($r = .16$) and mean parental educational level ($r = .11$).

The combined monthly income of the students’ parents was significantly correlated with all the other variables (male, program level, mean educational level of parents, ethnic group and innovation), except for age, academic achievement, and science self-efficacy.

The mean parental educational level was correlated highly with combined monthly income of the students’ parents ($r = .64$). The ethnic group that students belonged to (represented by whether the students were originally from the southwest region or southeast region of Nigeria) was significantly and negatively correlated with their self-reported innovative behavior ($r = -.16$). This relation demonstrated that Nigerian STEM students from the southwest region indicated less self-reported innovative behavior than the Nigerian STEM students from the southeast region. Students that had made up their mind to pursue a STEM field (career interest decidedness) reported high science self-efficacy ($r = .23$) and innovative behavior ($r = .21$). Finally, students’ sense of science self-efficacy was significantly and positively correlated with their innovation behavior ($r = .49$).
<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Gender (male measure)</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Age</td>
<td>.06</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Year of program</td>
<td>.07</td>
<td>.02</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Academic achievement (JAMB)</td>
<td>.03</td>
<td>.01</td>
<td>-.11**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>5. Combined parent income (SES1)</td>
<td>-.11**</td>
<td>-.05</td>
<td>.16**</td>
<td>-.01</td>
<td>1</td>
<td></td>
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<tr>
<td>6. Mean parent education (SES2)</td>
<td>-.11**</td>
<td>-.09*</td>
<td>.11**</td>
<td>-.05</td>
<td>.64**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Ethnic grouping</td>
<td>.10**</td>
<td>-.007</td>
<td>.11**</td>
<td>-.07</td>
<td>.19**</td>
<td>.21**</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Career interest decidedness</td>
<td>-.02</td>
<td>.007</td>
<td>-.13**</td>
<td>.11**</td>
<td>-.10**</td>
<td>-.06</td>
<td>-.19**</td>
<td>1</td>
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<td>9. Science self-efficacy</td>
<td>-.03</td>
<td>.04</td>
<td>-.05</td>
<td>.06</td>
<td>-.03</td>
<td>-.04</td>
<td>-.07</td>
<td>.23**</td>
<td>1</td>
</tr>
<tr>
<td>10. Innovative behavior</td>
<td>.06</td>
<td>.09**</td>
<td>.004</td>
<td>.09*</td>
<td>-.11**</td>
<td>-.05</td>
<td>-.16**</td>
<td>.21**</td>
<td>.48**</td>
</tr>
</tbody>
</table>

Note: All measures were coded in the same direction, higher scores indicate higher levels of that construct. Male and ethnic grouping were coded (1 = male or Southwest and 0 = female or Southeast). Age was coded: Under 30=1; 30-39=2; 40-49=3; 50-59=4 and over 60=5. *p < .05; **p < .01.
Hierarchical Multiple Regression Analyses

Hierarchical Multiple Regression analyses were used to examine the amount of variance in Nigerian students’ self-reported innovative behavior explained by their sense of science self-efficacy after controlling for their interest in pursuing a career in a STEM field and demographic variables.

I conducted a four step hierarchical multiple regression (Keith, 2006). At the first step of the regression process, the dependent variable (DV—innovative behavior) was regressed onto all the demographic and control variables. That is, age, gender, student’s year in program, student’s academic achievement (Jamb), student’s parent combined income, student’s parent mean educational level, and student’s ethnic heritage.

At the second step of the hierarchical regression process, student’s career decidedness was entered; that is the dependent variable (DV—innovative behavior) was regressed onto one of the main independent variables (career interest decidedness). In the third step of the hierarchical regression process, the student’s self-reported science efficacy was entered; that is the dependent variable (DV—innovative behavior) was regressed onto science self-efficacy.

Finally, in the last step of the hierarchical regression process, the interaction between the self-reported science self-efficacy and career decidedness was entered; that is the dependent variable (DV—innovative behavior) was regressed onto the interaction between the two independent variables (IVs- the students’ science self-efficacy and their career interest decidedness). This final step in the regression process was included to determine if Nigerian students’ decidedness in a STEM career moderated the relation of their science self-efficacy to their self-reported innovative behavior.
To minimize the issue of multicollinearity among the major variables of interest, I centered the science self-efficacy scale, career interest decidedness measure, and the conditional interaction between these two predictor variables (Keith, 2006). Listwise deletion was used in the regression analysis resulting in a sample size of 668.

The rationale behind using the hierarchical multiple regression analysis was first to determine the total amount of variance explained by the predictor variables. A second purpose was to determine the amount of unique variance explained by certain sets of predictors over and above other predictors (Keith, 2006).

The results of the analysis are shown in Table 2.2. The entry of the first block of seven background variables (i.e., male, age, year of program, JAMB, combined income of parents, mean educational level of parents, and ethnic grouping) resulted in a statistically significant increase in explained variance ($\Delta R^2=.052$, $F(7, 660)=5.156$, $p<.001$). That is, approximately 5% of the variance in the students’ self-reported innovative behavior was explained by the seven background variables.

In the second step, I entered the career interest decidedness measure into the regression model. It also resulted in a statistically significant increase in explained variance ($\Delta R^2=.031$, $F(1, 659) =22.308$, $p<.001$). Approximately 3% additional variance in the students’ self-reported innovative behavior was explained by the students’ career interest decidedness. In the third step, the science self-efficacy of the students, the key independent variable, was entered in the regression model. As shown in the Table 2.3, students’ science self-efficacy explained a statistically significant increase of 19% in the variance in their self-reported innovative behavior ($\Delta R^2=.193$, $F (1, 658) =174.905$, $p<.001$). In total, approximately 26.5% of the variance in the students’ self-reported
innovative behavior was explained after the third step in the regression model.

At the final step of the regression model, the interaction term did not explain any additional variance. As shown in Table 2.3, the science self-efficacy score of the students was the most important predictor of students’ self-reported innovative behavior, with the highest standardized regression coefficient ($\beta = .453$, $p < .001$). Holding all the other variables constant, for an additional unit in a student’s science self-efficacy score, their self-reported innovative behavior increased by .45 units. As compared with students who had a low sense of science self-efficacy, students with a high sense of science self-efficacy reported more innovative behavior characteristics.

In addition, being male was a significant individual predictor ($\beta = .080$, $p < .05$) of self-reported innovative behavior. Hence, males in this study reported slightly more innovative behavior than did females, after controlling for other variables. Also, combined monthly income of the students’ parents was a significant predictor of self-reported innovative behavior, albeit negatively ($\beta = -.113$, $p < .01$). Surprisingly, students whose parents earned more income were slightly less innovative than students whose parents earned less.

The ethnic group that a student belonged to was a significant negative individual predictor of the students’ self-reported innovative behavior ($\beta = -.119$, $p < .001$). Students from the southwest region of Nigeria reported less innovative behavior than those from the southeast region of Nigeria.

The last significant individual predictor of self-reported innovative behavior was the career interest decidedness variable ($\beta = .087$, $p < .05$). Students who had made up their minds to pursue STEM careers reported more innovative behavior than those who had
not categorically made up their minds on pursuing STEM careers. Other individual predictors (age, year of program, academic achievement/JAMB, mean parental educational level, and the conditional interaction between career interest decidedness and science self-efficacy) were not significant.

The major findings from the hierarchical multiple regression analyses indicated that an individual’s perceived sense of science self-efficacy was predictive of their self-reported innovative behavior. In addition, other contextual variables, such as parental income, gender, students’ decidedness on a career, and students’ ethnic heritage, were also predictive of Nigerian STEM students’ self-reported innovative behavior.
Table 1.3
Hierarchical Multiple Analyses Predicting Innovative Behavior

<table>
<thead>
<tr>
<th>Predictor variables</th>
<th>β Step</th>
<th>β B Step</th>
<th>β B Step</th>
<th>β B Step</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

**Step 1**
- Male: .066, .067, .080**, .080*  
- Age: .080*, .079*, .064, .061  
- Year of Program: .034, .050, .058, .057  
- Acad. Achievement (JAMB): .077*, .062, .048, .047  
- Combined Parent income (SES1): -.118**, -.104*, -.114**, -.113**  
- Mean parent education (SES2): .076, .069, .084*, .084  
- Ethnic grouping: -.157***, -.128***, -.119***, -.119***

**Step 2**
- Career interest decidedness: .181***, .084* , .087**

**Step 3**
- Science self-efficacy: .452***, .453***

**Step 4**
- Career interest X Science self-efficacy: .021
  
$R^2$: .052***, .083***, .275***, .276  
$\Delta R^2$: .052***, .031***, .193***, .000

Note: 1=male, 0=female; 0=southwest ethnic group, 1=southeast ethnic group. β indicates the standardized regression coefficient. The career interest X science self-efficacy interaction, tested in in step 4 did not explain significant amount of additional variance in innovative behavior. *p < .05; **p < .01; ***p < .001
Chapter 5: Discussion

The major objective of this study was to examine the relation of science self-efficacy to the self-reported innovative behavior of Nigerian college students enrolled in STEM fields. The general findings of this study align with the dictates of social cognitive theory. Specifically, research indicates self-efficacy has the most predictive power for performance when it is measured at a level specific to the expected task (Bandura, 1997; Pajares, 1996). Relatedly, in this study, science self-efficacy was the strongest predictor of self-reported innovative behavior.

The major findings from both the correlational analyses and the hierarchical multiple regressions in this study support the core theoretical rationale of social cognitive theory, especially with respect to the construct of self-efficacy. The pattern observed in the bivariate correlations among the contextual variables suggests that age, gender, combined parent income of students and the ethnic origin of the students significantly correlate with the indicated students’ self-reported innovative behavior. Specifically, older students reported being more innovative than did their younger counterparts; females reported being less innovative than did males; students from lower SES backgrounds reported being more innovative than did students from higher SES backgrounds; and students from the southwest region of Nigeria reported being less innovative than did students from southeast. In addition, the two major predictive variables (students’ decidedness on a science career and science self-efficacy) displayed
even more significant associations with self-reported innovative behavior. Students who had made up their minds about the career paths they want to pursue reported being more innovative than did students who had not made up their minds about their career paths. In addition, students with high science self-efficacy reported being more innovative than students did with low self-efficacy for science.

The findings from the hierarchical multiple regressions confirm that individuals’ perceived science self-efficacy plays an important role in their perceived innovative behavior as it pertains to science and technological advancement. As West and Farr (1986) pointed out, an individual’s innovation is the foundation of every action that is directed toward the effort to generate, sustain and implement any new and useful ideas. In addition, the foundation of every action to generate innovative ideas and processes to accomplish those ideas must be “rooted in the core beliefs that one has the power to produce changes by one’s actions” (Bandura, 1999, p. 28). The results of this study indicate that perceived science self-efficacy beliefs among Nigerian college students enrolled in STEM programs is predictive of their self-reported innovative behavior. In other words, Nigerian students enrolled in STEM programs who have high self-efficacy for science and technology report being more innovative. If self-reported innovation translates into future innovative behaviors, then these students ultimately may be better able to recognize problems in their fields, proactively generate new and useful ideas to solve the identified problems, personally promote these new and useful ideas to colleagues, and endeavor via personal effort and persistence to bring the new and useful ideas into fruition (Jenssen, 2000; Scott & Bruce, 1994).
As such, it can be said that the findings of the present study align with the findings of several other studies that indicate the positive relation of self-efficacy to multitudes of cognitive and behavioral outcomes. For example, the positive role of self-efficacy has been tested in diverse fields, including academic motivation and self-regulation (e.g., Schunk, 1991), teachers’ self-efficacy (e.g., Tschannen-Moran & Woolfolk-Hoy, 2001), and social skills (e.g., Moe & Zeiss, 1982).

This study also makes scholarly contributions to examining how age, gender, ethnic heritage, and SES are related to self-reported innovative behavior. For example, with respect to the contextual relation between age and innovation, age was related positively to innovative behavior: younger Nigerian students enrolled in STEM programs indicated less self-reported innovative behavior than did their older counterparts. This finding is supported by Chio (2004), who reported a positive relation between an individual’s age and their innovative behavior. Also, with respect to gender, results of the present study indicated that the male Nigerian students enrolled in STEM fields reported being more innovative than did their female colleagues. It is probably that this finding reflects the broad, persistent marginalization of women in science and engineering in both developed and developing countries (Vogt et al., 2007).

An interesting finding of this study – one that will be possibly controversial in Nigeria – is the indication that southeast Nigerian students enrolled in the STEM fields self-reported more innovative behavior than did their colleagues who are ethnically from the southwest region of Nigeria. This finding is consistent with the observations of both foreign scholars (see Forsyth, 1969; Ottenberg, 1971) and Nigerian scholars (see Achiebe, 2012; Ukeagbu, 2005). For example, Ottenberg (1971) observed that the Igbos
(southeast Nigerians) are regarded as very enterprising, have high achievement skills and, because of their egalitarian societal structure, practice open status system (high socio-economic mobility) and are more accepting of changing possibilities. Achebe (2013) observed that the Igbo (southeast Nigerian) culture is receptive to change and promotes individual achievement for the betterment of their town union that is in competition with other Igbo town unions. He elaborated that “the rise of the Igbos in Nigerian affair was due to the self-confidence engendered by their belief that one man is as good as another, that no condition is permanent” (p. 75).

Another thought-provoking finding in this study was that higher SES Nigerian students enrolled in the STEM program indicated less self-reported innovative behavior than did their counterparts who were from middle or lower SES backgrounds. This finding goes against the general positive pattern of the observed role of SES in various cognitive and behavioral outcomes in Western countries. For example, findings from a number of studies indicate that SES is positively correlated with graded outcomes in health, cognitive abilities, and socio-emotional disorders (Bradley & Corwyn, 2002).

In contrast with typical findings related to SES, low SES Nigerian students enrolled in STEM fields self-reported high amounts of innovative behavior. A review of the literature suggested that no previous published studies have examined the relation between SES and innovative behavior in Nigeria. As such, I had a brainstorming session with Kelechi Kalu, a Nigerian born political and economic scholar, presently the Associate Provost for global strategies and international affairs at The Ohio State University. Dr. Kalu offered a possible explanation to clarify why students from higher SES (especially the very high income bracket) homes in Nigeria indicated less innovative
behavior. These students’ parents often are business contractors (who are “less enthusiastic” about higher education) or professional politicians who became very wealthy from no-bid government contracts in oil and general infrastructure awarded by the Nigerian government. In contrast, students in the middle and low SES homes often are children of primary and secondary school teachers, university lecturers and government (local, state and federal) public employees. It can be speculated that these lower-middle and middle-class parents emphasize the need for higher education and innovation to their children because it provides the means to better socio-economic opportunities (Kalu, personal communication, 2014).

Limitations

The findings from this study indicate that an individual’s perceived self-efficacy beliefs for science and technology are related to self-reported innovation. However, there are limitations to this study. First, the study’s dependence on self-report measures from Nigerian university students may have resulted in participant bias. In other words, there may have been some questions in the survey that participants felt uncomfortable answering; participants may have felt the need to embellish their responses to gain approval from self or others, including the researcher. In addition, participants in this study completed the survey in classrooms or classroom-like settings; the presence of other students while filling out the surveys may have caused some students’ responses to be influenced by the presence of other students (Kreuter, Presser, & Tourangeau, 2008). To enhance the validity of students’ responses and mitigate their tendency to misrepresent themselves, the students were urged to be honest and were told that their responses would be anonymous.
Secondly, the findings of this study cannot be widely generalized. This limitation results from the fact that study participants were all university students, and only from three Nigerian universities. It would be informative for future studies to examine the relations between science self-efficacy and innovative behavior among professional innovators, or employees in industries that are known for being innovative. In addition, the self-reported innovative behavior scales used in this study may not have adequate predictive validity. Thus, the self-reported innovative behavior scales used for this study have not been demonstrated to predict innovative behavior in other studies or in an actual science and technological profession.

**Conclusion and Implications**

An individual with a high perceived sense of science self-efficacy will be more likely engage innovatively in science and technology than an individual with a low sense of science self-efficacy. As Bandura (2000) contended, “efficacy beliefs affect self-motivation through their impact on goals and aspirations” (p. 120). It may be possible to boost the science self-efficacy of Nigerian students (or, by extension, professionals) in STEM. Future interventions that are aligned with Bandura’s four sources of self-efficacy (mastery experience, vicarious experience, social persuasion and emotional experience) may yield important results.

In the Nigerian context, I suggest that STEM students be exposed to new experiences and graduated practical educational activities. Such activities would constitute a mastery experience for them and enhance their sense of self-efficacy for science and technology. Nigerian STEM students should be exposed to local and international innovators as social models. Vicarious experiences may boost the students’
self-efficacy beliefs as they watch these innovative models in either actual or virtual environments. It is also important that Nigerian STEM students experience social persuasion by receiving encouraging and specific feedback from each other and from professionals who are familiar with the challenges in STEM study and application. Finally, it will be important to diminish stress and promote positive emotional reactions from Nigerian students in STEM. For example, it might be valuable to organize cordial science and technological innovation and invention competitions within program departments, between program departments, and between university institutions in Nigeria.

In conclusion, it is imperative that scientific skills and knowledge enable Africans, including Nigerians, to find solutions to problems and promote the potential for innovation in science and technology, thereby creating sustainable socio-economic and political development. It is hoped that the findings and implications drawn from this study will assist other researchers in developing interventions to enhance science efficacy in the context of scientific and technological innovation in Nigeria specifically and Africa in general. Conceivably, results of this study may contribute to the educational pipeline of training and supporting upcoming scientists and inventors in the Nigerian socio-educational context.
References


ATPS (2010). African technology policy studies. Under Science, Ethics and Technological Responsibilities in Developing and Emerging Countries (SETDEV) Project. Available at:


*Journal of Educational Psychology, 82*, 51-59.
Appendix A: The Complete Survey Form

Full Dissertation Survey

Thank you for your interest in this study. Before you begin, please read the following carefully and indicate your consent to participate. Your participation is voluntary and if at any time you feel that you do not want to complete the survey, you may withdraw. There are no consequences for failing to complete the entire survey. However, we appreciate it if you complete the entire survey if you decided to participate.

The purpose of the study is to appreciate how science self-efficacy among college students in science, technology, engineering and mathematics (STEM) fields in Nigeria predicts their “Innovative Behavior” (IB). The scholarly aims of the research are to understand the complex interplay between personal perceived science efficacy and the possible innovative behavior of future scientists and inventors in Nigeria. We are recruiting participants to fill out a survey that will take approximately 20 to 30 minutes to complete.

Your participation and responses are private and voluntary and your responses are appreciated. As a gesture of appreciation, four respondents from this university will receive 3000.00 Naira. If you agree to participate in this evaluation, you will be provided with an e-mail address where you can send information to be included in the drawing for the cash give away. Your email address will only be used for the drawing and will be removed after the drawing. There is no way to match your email address with your survey responses.

If you have any questions about the research study, please contact the Principal Investigator, Prof. Eric Anderman, at 614-688-5721, USA. For questions about your rights as a participant in this study or to discuss other study-related concerns or complaints with someone who is not part of the research team, you may contact Ms. Sandra Meadows in the Office of Responsible Research Practices at 1-800-678-6251 at the Ohio State University, USA.

After carefully reading the above material, please indicate your consent below.

I consent I do not consent

Default Question Block
This questionnaire is designed to help us gain a better understanding of the kinds of things that create difficulties for students in science, technology, Engineering and mathematics. Please indicate your opinion about each of the statements as it relates to your "Course or Major" area of study. Please respond to all item to the best of your knowledge. Your answer are confidential and thanks for your help.

What is your "Course or Major" area of study (e.g, Biochemistry, electrical engineering)?

____________________________

PART 1 (21 questions)

Please think about your "Course or Major" when answering these questions.

<table>
<thead>
<tr>
<th>Very poorly</th>
<th>Poorly</th>
<th>Average</th>
<th>Well</th>
<th>Very well</th>
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<tbody>
<tr>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. To what extent can you explain the scientific laws and theories in your “Course or Major” area of study?
   1  2  3  4  5  6  7  8  9

2. How well can you choose an appropriate formula to solve a in your “Course or Major” area of study?
   1  2  3  4  5  6  7  8  9

3. How well can you establish the relationship between your “Course or Major” area of study and other sciences?
   1  2  3  4  5  6  7  8  9

4. How well can you describe the structure of an atom?
   1  2  3  4  5  6  7  8  9

5. How well can you work with lab material in your “Course or Major” area of study?
   1  2  3  4  5  6  7  8  9

6. How well can you describe the properties of elements by using periodic table?
   1  2  3  4  5  6  7  8  9

7. How well can you read the formulas of elements and compounds?
   1  2  3  4  5  6  7  8  9

8. To what extent can you propose solutions to everyday problems by using your “Course or Major” area of study?
   1  2  3  4  5  6  7  8  9

9. How well can you interpret equations in your “Course or Major” area of study?
   1  2  3  4  5  6  7  8  9

10. How well can you explain the particulate nature of matter?
    1  2  3  4  5  6  7  8  9

11. How well can you construct laboratory apparatus in your “Course or Major” area of study?
    1  2  3  4  5  6  7  8  9
12. To what extent can you explain everyday life by using theories in your “Course or Major” area of study?
   1 2 3 4 5 6 7 8 9

13. How well can you collect data in your “Course or Major” area of study laboratory or workshop?
   1 2 3 4 5 6 7 8 9

14. How well can you interpret graphs/charts related to your “Course or Major” area of study?
   1 2 3 4 5 6 7 8 9

15. How well can you use the equipment in the laboratory or workshop in your “Course or Major” area of study?
   1 2 3 4 5 6 7 8 9

16. How well can you understand the news/documentary you watched on television related to your “Course or Major” area of study?
   1 2 3 4 5 6 7 8 9

17. How well can you interpret data during the laboratory or workshop sessions in your “Course or Major” area of study?
   1 2 3 4 5 6 7 8 9

18. How well can you write a laboratory or workshop report in summarizing main findings in your “Course or Major” area of study?
   1 2 3 4 5 6 7 8 9

19. How well can you solve problems in your “Course or Major” area of study?
   1 2 3 4 5 6 7 8 9

20. How well can you carry out experimental procedures in the laboratory or workshop in your “Course or Major” area of study?
   1 2 3 4 5 6 7 8 9

21. How well can you recognize the careers related to in your “Course or Major” area of study?
   1 2 3 4 5 6 7 8 9

**PART 2 (20 questions)**

Use the scale below to indicate whether you believe each statement accurately describe how well much you accomplished the following activities ranging from “Never” to “Always”. Your answers are confidential. THANKS FOR YOUR HELP.

Never                                             Always
   1 2 3 4 5 6

1. In your current academic program, how often do you search out new technologies, processes, techniques, and/or product ideas?

2. In your current academic program, how often do you generate creative ideas?

3. In your current academic program, how often do you champion and promote ideas to my professors and colleagues.
4. In your current academic program, how often do you investigate and secure funds needed to implement new research ideas?

5. In your current academic program, how often do you develop adequate plans and schedules for the implementation of new research ideas?

6. In your current academic program, how often do you innovate?

7. In your current academic program, how often do you look for opportunities to improve an existing process, technology, products, services or work relationship?

8. In your current academic program, how often do you recognize opportunities to make a difference in your work, research application?

9. In your current academic program, how often do you define problems more broadly in order to gain greater insight into them?

10. In your current academic program, how often do you experiment with new ideas and solutions?

11. In your current academic program, how often do you test out ideas of solutions to address unmet needs?

12. In your current academic program, how often do you evaluate the strengths and weaknesses of new ideas?

13. In your current academic program, how often do you try to persuade others of the importance of a new idea or solution?

14. In your current academic program, how often do you push ideas forward so that they have a chance to become implemented?

15. In your current academic program, how often do you take the risk to support new ideas?

16. In your current academic program, how often do you implement changes that seem to be beneficial?

17. In your current academic program, how often do you work the bugs out of new approaches when applying them to existing process, technology, product or service?

18. In your current academic program, how often do you incorporate new ideas for improving an existing process, technology, product or service into daily routines?

19. In your current academic program, how often do you pay attention to non-routine issues in your work, studies and research?
20. In your current academic program, how often do you generate ideas or solutions to address problems?

**PART 3 (2 questions)**

Use the scale below to indicate whether you agree with the following statement ranging from “Strongly Disagree” to “Strongly Agree”. Your answers are confidential. THANKS FOR YOUR HELP.

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Strongly Agree</th>
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<tbody>
<tr>
<td>1</td>
<td>2</td>
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<td>3</td>
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<td>5</td>
<td>6</td>
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<td>7</td>
<td>8</td>
</tr>
</tbody>
</table>

1. I have a science occupational field in mind that I want to work in.

2. I am fully satisfied with the progress I am making toward my career decision.

Gender

- Male
- Female

Age

- Under 30
- 30 - 39
- 40 - 49
- 50 - 59
- Over 60

What is your State of Origin/Ethnic Group?

______________________
What year are you in your program?
  First Year
  Second Year
  Third Year
  Fourth Year or more
Are you in a full time or part time program?
  Full Time
  Part time

What is the highest educational attainment of your father?
  No secondary school education
  Secondary education
  Ordinary National diploma (Two degree)
  Bachelor (First degree)
  Masters degree
  Doctoral degree (PhD.)

What is the highest educational attainment of your mother?
  No secondary school education
  Secondary education
  Ordinary National diploma (Two degree)
  Bachelor (First degree)
  Masters degree
  Doctoral degree (PhD.)

What is your father’s occupation?

____________________________________
What is your mother’s occupation?

______________________________________

What was your JAMB Score used for enrollment into your Program?

Under 100 points
101 - 200 points
201 - 300 points
Over 300 points

What is the combined monthly income of your parents?

Under 50,000 Naira
51,000 - 100,000 Naira
101,000 - 200,000 Naira
201,000 - 500,00 Naira
501,000 - 1,000,000 Naira
1,000,000 - 10,000,000 Naira
Over 10,000,000 Naira

If you have your own family, what is the combined monthly income in your household?

Does not apply
Under 50,000 Naira
51,000 - 100,000 Naira
101,000 - 200,000 Naira
201,000 - 500,00 Naira
501,000 - 1,000,000 Naira
1,000,000 - 10,000,000 Naira
Over 10,000,000 Naira
Appendix B: IRB Research Protocol and Application for Exemption

Science Self-Efficacy and Innovative Behavior

Anderman & Okonkwo

I. Objectives

The purpose of study is to investigate how science self-efficacy among college students in science, technology, engineering and mathematics (STEM) fields in Nigeria; predict their “Innovative Behavior” (IB). Specifically, the study will examine how predictor variables like: general self-efficacy; science self-efficacy and career decision of college students in the STEM field in Nigeria are related to the outcome variable of innovative behavior (IB) in science and technological innovations. In controlling for the variation in the innovative behavior of these college students, the following control variables will be considered including: age, gender, social economic status, ethnic/state of origin, academic achievement (using a Nigerian SAT equivalent: JAMB or college GPA) and lastly the big five personality trait (openness, consciousness, agreeableness, extraversion and neuroticism). The scholarly aims of the research are to understand the complex interplay between personal perceived science efficacy and the possible innovative behavior of these future scientists and inventors in the Nigerian social context. The study is embedded in the agentic viewpoint of social cognitive theory (Bandura, 1986, 1997).

II. Background and Rationale

A nation’s economic change and sustainable development are to a large measure accounted for by investments in science, technology and innovation. It is not the simple
buildup of physical capital and natural endowment that transforms economies and stimulates human development, but the capability of countries to create, apply and intelligently use scientific knowledge and associated technological innovations (Kogut, 1991). Indeed there is an explicit correlation between a country’s scientific and technological capabilities and its economic performance and affluence (NEPAD, 2007).

As Bandura (1997) espoused with clarity that “Societies of today are undergoing extraordinary informational, social and technological transformations…these changes are not new over the course of history, but what is new is their magnitude and accelerated pace” (p. 1). As such in keeping up with the demand of this information age, people’s sense of efficacy has to play a crucial role in managing the science, technology and innovational changes taking place in our globalized world.

The definition of innovation has several concepts ranging from newness, novelty, to commercialization and/or implementation, basically if an idea has not been developed and transformed into a product, process or services that is implemented or commercialized; it is not technically defined as innovation. A comprehensive conceptualization of innovation was described by Urabe (1988):

“Innovation consists of the generation of a new idea and its implementation into a new product, process or service, leading to the dynamic growth of the national economy and the increase of employment as well as to a creation of pure profit for the innovative business enterprise. Innovation is never a onetime phenomenon, but a long and cumulative process of a great number of organizational decision-making processes, ranging from the phase of generation of a new idea to its implementation phase… Through the implementation process the new idea is developed and commercialized into a new marketable product or a new process with attendant cost reduction and increased productivity” (Urabe, 1988, p.3)

Juma and Yee-Cheong (2005), fittingly reasoned that a nation’s capabilities in scientific and technological innovations is a function of their efficacy for the sustenance
and maintenance of the country’s infrastructures; as well as the nation’s ability to solve policy problems of national development. Africa in general and Nigeria as a case in point, lack in this area of scientific and technological innovations which has contributed substantially to the poor economic transformation and sustainable development in general.

In their seminal study Pouris & Pouris, (2008) reported on the state of science and technology in Africa in the period of 2000 to 2004. Their finding indicated that of the number of technological research publications and the number of patents awarded in the world. Africa produced 68,945 publications over the 2000-2004 periods, which represent just 1.8% of the world’s publications. Similarly, in patents awarded to African inventors in the 2000-2004 periods, Africa had only 633 of 817,197 a 0.1% representation. Additionally, with particular reference to Nigeria Pouris and Pouris (2009) showed that Nigeria ranks fourth with just 5.9%, (in the context of the 1.8% of Africa) behind South Africa with highest publications (30.1%), followed by Egypt (20.2%) and Morocco (7.9%). Likewise, only 17 utility patents were awarded to Nigerian inventors in the 2000-2004 periods; against the background of 633 in Africa and 817,197 in the entire world.

Perceived self-efficacy is a fundamental component of Bandura’s social cognitive theory (Bandura, 1986), which emphasizes the role of observational learning and social experience in the development of personality. Social cognitive learning theory attributes learning to the occurrence of transactional relationships between behavior, environmental factors and personal factors that consist of cognitive, affective and behavioral processes (Bandura, 1986). The construct of self-efficacy has been tested in a multitude of studies and diverse fields; ranging from academic motivation and self-regulation (Pintrich &
Schunk, 1995); teachers’ self-efficacy (Tschannen-Moran & Woolfolk-Hoy, 2001); social skills (Moe & Zeiss, 1982); clinical phobias (Bandura, 1993); depression (Davis & Yates, 1982); sports (Barling & Abel, 1983) etc.

Bandura (1993) defines self-efficacy as “people’s beliefs about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives. (p. 71). A person with high sense of self-efficacy is most likely to be confident of their capabilities to accomplish difficult task. Furthermore, a personal sense of efficacy will propel them to move forward in the face of difficulty and self-assured that that they are capable to tackle any challenging task. In fact Zimmerman (1995) posits that an individual’s self-efficacy beliefs in many cases can more accurately predict their performance than their actual ability.

Bandura (1997) recognized and articulated a likely connection between self-efficacy, innovation and creativity by postulating “innovativeness requires an unshakable sense of efficacy to persist in creative endeavor when they demand prolong investment of time and effort, progress is discouragingly slow, the outcome is highly uncertain, and creations are socially devalued when they are too incongruent with pre-existing ways” (p. 239).

The principal investigator and co-investigator in this proposed study intend to further the research on science self-efficacy; as it relates to scientific and technological innovations. Explicitly, the study will explore how science self-efficacy among college students in science, technology, engineering and mathematics (STEM) fields in Nigeria; predict their “Innovative Behavior” (IB). The scholarly aims of the research are to understand the composite relationship between personal perceived science efficacy and the
possible innovative behavior of the upcoming scientists and inventors in the Nigerian socio-educational context.

III. Procedures

A. Research Design

The study will use a descriptive quantitative and self-report survey research design. Participants will take a one-time online survey that includes questions from instruments that measure the predictor, control and outcome variables:

Outcome Variable:

- Innovative Work Behavior (IWB) in science and technological innovation of Nigerian College students. (6-Item Innovative Behavior Scale (Scott & Bruce, 1994)

Predictor Variables:

- Science self-efficacy of college students in STEM fields in Nigeria (Modified Version of 21-Item College Chemistry Self-Efficacy Scale (CCSS) (Uzuntiryaki & Çapa Aydı̇n, 2009)

- Moderating role of Career decision (The 2-item Decidedness Scale of the Career Decision Profile (CPP) (Jones, 1989)
Control Variables:

- Age; Gender; Social Economic Status (SES); State and ethnic group and Academic achievement (Using a Nigerian SAT equivalent (JAMB score) or college GPA)

B. Sample

The sample will consist of college students in science, technology, engineering and mathematics (STEM) fields in four public universities in Nigeria. Two of the universities (University of Nigeria, Nsuka and University of Lagos) are located in the southern province of Nigeria. The other two universities (University of Jos and University of Abuja) are located in the northern province of Nigeria.

Charles Okonkwo, the co-investigator, will travel to Nigeria and subsequently visit the four universities during the period of May to July, 2013. The purpose, potential benefits, and potential risks of the study will be explained to the participants, in an introduction and informational meeting. The co-investigator will indicate that he will be sending a recruitment email to invite students to participate in an online survey. Study volunteers will provide anonymous responses to the online survey and their identities will not be recorded. Those who are willing to participate in the study will complete the online survey which will be linked to the email. There will be no limitation on the number of participants.

C. Measurement / Instrumentation

Innovative Work Behavior.

Innovative Behavior (IB) will be measured by combining two scales, the 6-items Innovative Behavior Scale developed by Scott and Bruce (1994) and the 14-items Innovative Behavior Scale constructed by Kleysen and Street (2001). The 6-items scale developed by Scott
and Bruce was a one-dimensional scale and they reported Cronbach’s alpha of 0.89. The scale is anchored with a 5-point Likert-type scale, where $1 = \text{not at all}$ and $5 = \text{to an exceptional degree}$. An example item in the scale is, “In the course of my studies I will always champion and promote ideas to my professors and colleagues.” (See appendix D for complete scale).

The 14-items scale developed by Kleysen and Street is a single factor measure based on items representing five dimensions (opportunity exploration, generativity, formative investigation, championing and application) of innovation behavior factors of resulted in an alpha reliability of 0.95. The scale contained 6-point behavioral frequency scale anchored with one as “never” and six as “always”. An example item in the scale is, “define problems more broadly in order to gain greater insights into them.” (See appendix D for complete scale).

In the combination of the two scales I will preface the nineteen items by, “In your current academic program, how often do you…?”

**Science Self-Efficacy**

The scale that will be used to measure the science self-efficacy of these college students in STEM fields in Nigeria will be a modified version of the 21-Item College of Chemistry Self-Efficacy Scale (CCSS) developed by Uzuntiryaki & Çapa Aydn, (2009). There are three dimensions that emerged in the CCSS: self-efficacy for cognitive skills, self-efficacy for psychomotor skills, and self-efficacy for everyday applications. The alpha ranged from 0.82 to 0.92. Each dimension of the CCSS had moderate and significant correlations with student chemistry achievement and differentiated between major and non-major students. The scale was administered on a 9-point rating scale, where $1 = \text{very poorly}$ and $9 = \text{very well}$. An example item in the scale is “How well can you establish the relationship between chemistry and other sciences”.

93
Career Decision

The scale will play a moderating role in the study. It is a 2-item Decidedness Scale of the Career Decision Profile (CPP) developed by Jones, (1989). It is use to assess students’ level of decidedness with regard to a future career in science. In their study to understand the trajectories of science self-efficacy beliefs during the college transition and academic and vocational adjustment in science and technology program Larose et al (2006) had an alpha at Time I (.87), Time 2 (.88), and Time 3 (.83). The scale was used on an 8-point scale, where 1=strongly disagree and 8=strongly agree. An example is “I have a science occupational field in mind that I want to work in”.

Demographic and Control Measures

The following demographic data will also be assessed: age, gender, social economic status (SES), academic achievement (using a Nigerian SAT score equivalent “JAMB score” or college GPA), State/ethnic group. In respect to the the to the Big-Five personality trait which Sung and Choi (2009) observed had positive effects on creativity. The measure that will be used is McCrae and Costa’s (1987) NEO Personality Inventory. Each of the dimensions in the inventory had four to six items. The Cronbach alpha values for the five personality dimensions were 0.73 (agreeableness), 0.75 (openness), 0.78 (conscientiousness), 0.78 (neuroticism), and 0.80 (extraversion).

D. Detailed study procedures

As an international study, the co-investigator will be travelling to Nigeria in the month of May, 2013. The duration of his stay will be approximately nine to ten weeks. In Nigeria the co-investigator will travel to the four selected universities (University of
Lagos; University of Nigeria, Nsuka; University of Jos and University of Abuja). The co-investigator will spend approximately ten days in each of the universities’ campuses.

In each of the universities’ the co-investigator will hold individual introduction and informational sessions with various stakeholders in the college or faculty of science and engineering (student union heads, dean, department and section heads), these meetings will be followed by informational flyers about a group gathering of interested science and engineering student, that will potential participate the in the study. On the third or fourth day on any of the participating university, the co-investigator will hold a group introduction/informational session with interested science and engineering students.

In the group introduction/informational meeting, the co-investigator will inform the group that a recruitment email will be sent out. We will collect data through an online survey tool developed by The Ohio State University’s Office of Technology-Enhanced Learning (OTEL). The survey will be opened right immediately after the distribution of the recruitment emails. Those students who receive the recruitment emails and are willing to participate in the study will complete the survey which will be linked to the email. Data collection will be continued for twelve weeks.

Participants’ informed consent will be obtained from the first web page of the survey. The consent page will contain an explanation of the purposes of the research, a description of the survey, the expected duration of the participation, a statement that participation is voluntary and that participants may discontinue participation at any time without penalty or loss of benefits, a statement that confidentiality will be maintained, contact information, and the informed consent statement.
To encourage participation in the research, participants’ would voluntarily select to be entered into a drawing that will require they send an email to: 

NigerianInnovators.drawing@gmail.com and eight winners will receive $25 (# 3,750.00) cash by a random drawing after the data collection period in each of the participating university.

After the data collection, all the survey responses will be coded and the responses collected by the survey will be password-protected on the survey website. Once the data is imported into SPSS for analysis, it will be stored on a password-protected computer. No identifiers will be linked to responses; the data will not be connected with any specific participants. participants’ emails for a drawing will be saved in the Co-Investigator’s e-mailbox (principalsoffice.drawing@gmail.com) until the data collection period is over, and will be permanently deleted from the e-mailbox after the drawing.

E. Internal Validity

To strengthen the internal validity and reliability of the modified version of the measures, so that the items are worded better a “Cognitive Interviews” process will be conducted with five to ten Nigerians that are enrolled in STEM field here at Ohio State University. The cognitive interviews would conducted to assure that Nigerian respondents’ interpretation of the items in the various measures were consistent with the construct the item was modified from (Karabenick, et al., 2007) as well as to address general issues of comprehension. The possible threat to external validity is the fact that the students participating in the four universities in Nigeria may not be representative of the entire population of university students in Nigeria.

F. Data Analysis
Most survey responses will be analyzed using quantitative methods. Specifically, hierarchical regression will be used to analyze the results of the study. Correlations will be examined to analyze the relation among variables. Regression analysis will indicate the predictive strength of the variables, in terms of both the unique variance each independent variable explains and the overall variance in the innovative behavior of the Nigerian students that the set of independent variables explains. Additionally, descriptive statistics and frequency distributions will be examined to determine the mean responses, standard deviation, and assumptions of normality.

I will try to discover how these Nigerian college students create and articulate the associated meanings of science self-efficacy and innovative behavior. The meaning of the focus group discussion will be sorted out using the technique of scissors-and-sort coding system. This coding system will be used to determine the unit of analysis of the focus group discussion, which in turn will be driven by the purpose of the study (Krippendorf, 2004). Transcriptions of the focus group dialogs will be used to identify important themes and sub-themes. Most notable quotes will be highlighted and any unexpected findings will be discussed. Specifically, using the positivist epistemological paradigm, the transcribed data will undergo meaningful unit of analysis. I will try to discover how these Nigerian college students create and articulate the associated meanings of science self-efficacy and innovative behavior.
C. Script of Email Recruitment (Survey)

Subject: Online Survey: Science Self-Efficacy and Innovative Behavior in Science and Technology

Dear Science and Engineering students at XX University,

My name is Charles Okonkwo a doctoral student in Educational Psychology at the School of Educational Policy and Leadership at the Ohio State University. My dissertation advisor, Professor Eric Anderman and I are conducting a study about how science self-efficacy among college students in science, technology, engineering and mathematics (STEM) fields in Nigeria; predict their “Innovative Behavior” (IB). The scholarly aims of the research are to understand the complex interplay between personal perceived science efficacy and the possible innovative behavior of these future scientists and inventors in the Nigerian.

The study will consist of an online survey that will take approximately 20 minutes to complete. The survey will be open from May 7th to June 30th. Your participation is anonymous and voluntary and your responses on the survey are entirely confidential.

At the end of the data collection period, 8 participants from your university will be randomly selected to receive $25 (#3,750.00) cash by a random drawing.

Click here to go to the online survey. If the link does not work, copy and paste this URL into your browser: http://www.thesurveyaddresswillgohere.org

Thank you for taking the time to consider taking part in this study. Your participation is valuable and will contribute to understanding how we can boost scientific and technological innovation in Nigeria.

Best regards,

Charles

Charles O. Okonkwo, Ph.D. Candidate
Educational Psychology GTA
School of Educational Policy & Leadership
Ohio State University
250G Younkin Success Center
1640 Neil Avenue
Columbus, OH 43201
USA
(614) 487-1139
okonkwo.1@buckeyemail.osu.edu
**C. Script/Instructions (Focus Groups)**

Thank you for agreeing to participate in this focus group. My name is Charles Okonkwo and I am a PhD candidate at Ohio State University. I am here today to talk about how, as students in science, technology, engineering and mathematics (STEM) fields, you view your role in the development and sustainability of science and technological innovation in Nigeria.

What we are going to do now is to have a group discussion about how your experiences in this university and your personal ideas inform your opinion in respect to your role in the development and sustainability of science and technological innovation in Nigeria. I will ask you some questions about your thoughts and opinions and I’d like for you to share whatever responses you’d like to share with me and the rest of the group. If someone in the group says something you want to respond to or if you’d like to ask them a question about something they’ve said you should also feel free to talk to them directly or to ask a question.

To facilitate the analysis of our dialogue today, I have a recorder and am recording our conversation. This is so I can pay attention to you while we talk instead of taking notes and later remember what you all have to say and report it correctly. Everything you say will be confidential.

On a related note, due to the nature of a focus group, confidentiality can only be guaranteed to the extent that all members of the focus group maintain one another’s confidentiality. Since we want everyone to feel comfortable sharing personal experiences, anything said in this focus group should be kept confidential.

If you are still interested in participating in this focus group, please fill and hand back to me the your consent forms.

Do you have any questions for me?

Let’s begin.

**D. Informed Consent (Survey)**

This is an online consent form for research participation. It covers important information about the policy and expectations of this study if you decided to participate. Your participation is voluntary and if at any time you feel that you do not want to complete the survey, you may withdraw. There are no consequences for failing to complete the entire survey. However, we will appreciate it if you complete the entire survey if you decided to participate.

The purpose of the study is to appreciate how science self-efficacy among college students in science, technology, engineering and mathematics (STEM) fields in Nigeria; predict their “Innovative Behavior” (IB). The scholarly aims of the research are to understand the complex interplay between personal perceived science efficacy and the possible innovative behavior of the future scientists and inventors in the Nigerian. We are recruiting participants to fill out a survey that will take approximately 20 minutes to complete.

Your responses on the survey are entirely confidential. As a gesture of appreciation, eight respondents from this university will receive $25 (#3,750) cash. If you agree to participate in this evaluation, you will be provided with an e-mail address where you can send information to be included in the drawing for the
If you have any questions about the research study, please contact the Principal Investigator, Prof. Eric Anderman, at 614-688-3484, USA. For questions about your rights as a participant in this study or to discuss other study-related concerns or complaints with someone who is not part of the research team, you may contact Ms. Sandra Meadows in the Office of Responsible Research Practices at 1-800-678-6251 at the Ohio State University, USA.

CONSENT FOR PARTICIPATION IN RESEARCH

By clicking on “I consent” below you are indicating, I consent to the research entitled: Scientific and Technological Innovation how Science Self-Efficacy and Innovative Behavior relates. I acknowledge that I have had the opportunity to obtain additional information regarding the study and that any questions I have raised have been answered to my full satisfaction. Furthermore, I understand that I am free to withdraw consent at any time and to discontinue participation in the study without prejudice to me. No identifying information will be collected from me at any time. My confidentiality and anonymity will be protected “I consent.”

D. Informed Consent (Focus Groups)

The Ohio State University Consent to Participate in Research

Study Title: Science Self-Efficacy and Innovative Work Behavior (IWB) in Nigerian College Students.

Principal Investigator/Advisor: Prof. Eric M. Anderman
Co-Investigators: Charles Okonkwo
Sponsor: Educational Policy and Leadership

This is a consent form for research participation. It contains important information about this study and what to expect if you decide to participate.

Your participation is voluntary. Please consider the information carefully. Feel free to ask questions before making your decision whether or not to participate. If you decide to participate, you will be asked to sign this form and will receive a copy of the form.

Purpose: The purpose is to examine how general self-efficacy, science self-efficacy and career decisions are related to innovative behavior (IB) in science and technological innovation in the Nigerian socio-educational context.

Procedures/Tasks: You will be asked to participate in a focus group where you will be asked to share how your experiences and personal ideas inform your opinion in respect to your role in the development and sustainability of science and technological innovation in Nigeria.
**Duration:** About an hour and thirty minutes.

You may leave the study at any time. If you decide to stop participating in the study, there will be no penalty to you, and you will not lose any benefits to which you are otherwise entitled.

**Risks and Benefits:** The main risk in participating in this study is that you may feel uncomfortable sharing your ideas and opinion. The information you provided will not be associated with your name or other identifying information. The primary benefit of participating in the study is that your responses will help us to understand how general self-efficacy, science self-efficacy and career decisions are related to innovative behavior (IB) in technology and scientific innovations in the Nigerian socio-educational context.

**Confidentiality:** Efforts will be made to keep your information confidential. Digital recordings will be kept in a locked room, until data is transferred to a password-protected computer. Participants will be given pseudonyms so no personally identifying information will link the transcripts with individual students. If anything you say is included in a future report, your name will not be connected to the data. Please note that, due to the nature of a focus group, confidentiality can truly be guaranteed if all participants maintain the confidentiality of the group.

**Incentives:** A certain amount ($4 = #600 equivalent in Nigerian currency) of monetary will be given to all participants in the focus group.

**Participant Rights:** You may refuse to participate in this study if you so choose without any consequences. In course of your participation in the study, you may discontinue at any time without penalty or loss of benefits. By signing this form, you do not give up any personal legal rights you may have as a participant in this study.

**Contacts and Questions:**

For questions, concerns, or complaints, or if you feel you have been harmed as result of study participation you may contact the Principal Investigator, Prof. Eric M. Anderman, at 614-292-4145.

For questions about your rights as a participant in this study or to discuss other study-related concerns or complaints with someone who is not part of the research team, you may contact Ms. Sandra Meadows in the Office of Responsible Research Practices at 1-800-678-6251.

**INFORMED CONSENT**

I have read (or someone has read to me) this form and I am aware that I am being asked to participate in a research study. I have had the opportunity to ask questions and have had them answered to my satisfaction. I voluntarily agree to participate in this study.

I am not giving up any legal rights by signing this form. I will be given a copy of this form.

I affirm that I am at least 18 years old.
Appendix E. Survey Items

IF YOU WOULD LIKE TO BE INCLUDED IN THE DRAWING FOR A $25 (3,750) CASH GIVE AWAY, PLEASE SEND AN E-MAIL WITH YOUR CONTACT INFORMATION TO: NigerianInnovators.drawing@gmail.com THE E-MAIL ADDRESS WILL BE PROVIDED AGAIN AT THE END OF THE SURVEY.

Instruments (e.g., questionnaires or surveys to be completed by participants)

PART 1 (21 questions)

The College Chemistry/Biology/Physics/Engineering Self-Efficacy Scale.
Directions: This questionnaire is designed to help us gain a better understanding of the kinds of things that create difficulties for students in chemistry. Please indicate your opinion about each of the statements below as it relates to your specific area of study. Please do not skip any item. Your answers are confidential.
THANKS FOR YOUR HELP

<table>
<thead>
<tr>
<th>Very poorly</th>
<th>Poorly</th>
<th>Average</th>
<th>Well</th>
<th>Very well</th>
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1. To what extent can you explain the scientific laws and theories in chemistry/Biology/Physics and Engineering?
2. How well can you choose an appropriate formula to solve a chemistry/Biology/Physic and Engineering problem?
   1 2 3 4 5 6 7 8 9
3. How well can you establish the relationship between chemistry/Biology/Physic/ Engineering and other sciences?
   1 2 3 4 5 6 7 8 9
4. How well can you describe the structure of an atom?
   1 2 3 4 5 6 7 8 9
5. How well can you work with lab material in Chemistry /Biology/Physic and Engineering?
   1 2 3 4 5 6 7 8 9
6. How well can you describe the properties of elements by using periodic table?
   1 2 3 4 5 6 7 8 9
7. How well can you read the formulas of elements and compounds?
   1 2 3 4 5 6 7 8 9
8. To what extent can you propose solutions to everyday problems by using chemistry/Biology/Physic and Engineering?
   1 2 3 4 5 6 7 8 9
9. How well can you interpret chemical/Biological/Physic and Engineering equations?
   1 2 3 4 5 6 7 8 9
10. How well can you explain the particulate nature of matter?
    1 2 3 4 5 6 7 8 9
11. How well can you construct laboratory apparatus in chemistry/Biology/Physic and Engineering?
    1 2 3 4 5 6 7 8 9
12. To what extent can you explain everyday life by using chemical/Biological/Physic and Engineering theories?
    1 2 3 4 5 6 7 8 9
13. How well can you collect data during the chemistry/Biology/Physic and Engineering laboratory or workshop?
    1 2 3 4 5 6 7 8 9
14. How well can you interpret graphs/charts related to chemistry/Biology/Physic and Engineering?
    1 2 3 4 5 6 7 8 9
15. How well can you use the equipment in the chemistry/Biology/Physic and Engineering laboratory or workshop?
    1 2 3 4 5 6 7 8 9
16. How well can you understand the news/documentary you watched on television related to chemistry/Biology/Physic and Engineering?
    1 2 3 4 5 6 7 8 9
17. How well can you interpret data during the laboratory or workshop in chemistry/Biology/Physic and Engineering sessions?
    1 2 3 4 5 6 7 8 9
18. How well can you write a laboratory or workshop report in chemistry/Biology/Physic and Engineering summarizing main findings?
    1 2 3 4 5 6 7 8 9
19. How well can you solve chemistry/Biology/Physic and Engineering problems?
    1 2 3 4 5 6 7 8 9
20. How well can you carry out experimental procedures in the chemistry/Biology/Physic and Engineering laboratory or workshop?
    1 2 3 4 5 6 7 8 9
21. How well can you recognize the careers related to chemistry/Biology/Physic and Engineering?
    1 2 3 4 5 6 7 8 9

PART 2 (6 questions)

Use the scale below to indicate whether you believe each statement accurately describe how well much you accomplished the following activities ranging from “Never” to “Always”. Your answers are confidential. THANKS FOR YOUR HELP.

Never                                  Always
1                                      2 3 4 5 6

1. In your current academic program, how often do you search out new technologies, processes, techniques, and/or product ideas?
2. In your current academic program, how often do you generate creative ideas?
3. In your current academic program, how often do you champion and promote ideas to my professors and colleagues.

4. In your current academic program, how often do you investigates and secures funds needed to implement new research ideas.

5. In your current academic program, how often do you develop adequate plans and schedules for the implementation of new research ideas?

6. In your current academic program, how often do you innovative

7. In your current academic program, how often do you look for opportunities to improve an existing process, technology, products, services or work relationship?

8. In your current academic program, how often do you recognize opportunities to make a difference in your work, research application?

9. In your current academic program, how often do you define problems more broadly in order to gain greater insight into them?

10. In your current academic program, how often do you experiment with new ideas and solutions?

11. In your current academic program, how often do you test out ideas of solutions to address unmet needs?

12. In your current academic program, how often do you evaluate the strengths and weaknesses of new ideas?

13. In your current academic program, how often do you try to persuade others of the importance of a new idea or solution?

14. In your current academic program, how often do you push ideas forward so that they have a chance to become implemented?

15. In your current academic program, how often do you take the risk to support new ideas?

16. In your current academic program, how often do you implement changes that seem to be beneficial?

17. In your current academic program, how often do you work the bugs out of new approaches when applying them to existing process, technology, product or service?

18. In your current academic program, how often do you incorporate new ideas for improving an existing process, technology, product or service into daily routines?

19. In your current academic program, how often do you pay attention to non-routine issues in your work, studies and research?

20. In your current academic program, how often do you generate ideas or solutions to address problems?

PART 3 (2 questions)

Use the scale below to indicate whether you agree with the following statement ranging from “Strongly Disagree” to “Strongly Agree”. Your answers are confidential. THANKS FOR YOUR HELP.

<table>
<thead>
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<th>Strongly Disagree</th>
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</tbody>
</table>

1. I have a science occupational field in mind that I want to work in.

2. I am fully satisfied with the progress I am making toward my career decision.

PART 1 (6 questions)
1. Gender
   a) Male  b) Female

2. Age
   a) Under 30  b) 30-39  c) 40-49  d) 50-59  e) Over 60


4. JAMB Score Used for Enrollment into my Program
   a) Under 100  b) 101-200  c) 201-300  d) Over 300

5. I am Enrolled in:
   Chemistry (Y/N)
   Biology (Y/N)
   Physic (Y/N)
   All Engineering Specialization (Y/N)
   Other Combination of Science

6. What is the monthly income of your household?
   a) Under #50,000  b) #50,000 to #100,000  c) #101,000 to #200,000
   d) #201,000 to #500,000  e) #501,000 to #1,000,000  f) Over #1,000,000

Focus-Group Interview Schedule (Not part of dissertation)

Stage One: Welcome participants and indicate appreciation.

Stage Two: Do an overview of the purpose of the focus group (Restate some aspect of the script of the focus group).

Stage Three: Discuss the ground rules of the focus group, basically restating the instruction of the focus group and assuring confidentiality.

Stage Four: Ask the questions (see question outlines).

Stage Five: Obtain background information (year of study, gender, age full/part time status).

Focus-Group Question Outlines

Opening Question: What do you think are the reasons why Nigeria in not technologically developed?

Introductory question: Do you think that science and technological innovation will make a difference in the development of Nigeria?

Transition questions: What roles can an individual play in the development of science and technology in Nigeria?
Key questions: (1). Have you had experiences of thinking or discussing about your personal role as a science student to the development or advancement science and technological in Nigeria?

Key questions: (2). Do you believe that you have the capability to innovate and contribute to science and technological development of Nigeria in spite the poor infrastructures and lack of encouragement in Nigeria?

Ending question: How do professors in your program encourage you to be scientifically innovative?

THANK YOU FOR TAKING THE TIME TO COMPLETE THIS INSTRUMENT. IF YOU WOULD LIKE TO BE INCLUDED IN THE DRAWING FOR A CASH GIVE AWAY, PLEASE SEND AN E-MAIL WITH YOUR CONTACT INFORMATION TO: NigerianInnovators.drawing@gmail.com