



Systematic Approach to Diversifying Botswana's STEM Population

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Work in Progress:
Systematic Approach to Diversifying Botswana's STEM Participants.

Abstract

On October 1st, 2016 Botswana formed the Ministry of Tertiary Education, Research, Science and Technology with the explicitly stated goal of transforming Botswana from a resource-based to a knowledge-based economy. In order to achieve this goal Botswana has to contend with two major factors; One is the improved teaching and learning of science, technology, engineering, and mathematics content (STEM) content (Kennedy & Odell, 2014) and the other factor is the lack of women participants in STEM careers for Botswana (Koketso, 2015). With its combination of economic success and social development unique to many African states, Botswana has been hailed as an African developmental state (Hillbom, 2011). Consequently, Botswana lays claim to the continent's oldest continuous democracy and boasts one of the world's fastest growing economies. These factors contribute to a political and social environment conducive to technological advances and entrepreneurial opportunities. Yet, Botswana has continued to struggle in creating a robust STEM professional population with women in particular being seriously underrepresented (Koketso, 2015).

In order to address these issues, North Carolina State University's Department of STEM Education recently formed a partnership with Botswana to meet these stated challenges. This work-in-progress reports on a developing international collaborative research project between Botswana and North Carolina State University's Department of STEM Education. This paper will highlight the latest civilian-to-civilian strategic engagements between North Carolina and Botswana as part of the U.S. Department of Defense's State Partnership Program. The Department of STEM Education participated as a delegate in the program, along with North Carolina's National Guard, Department of Transportation, and Department of Public Instruction. The result of this meeting included forming a burgeoning research collaborative that will culminate in the submission of a grant proposal to the National Science Foundation's ADVANCE solicitation. The goals of this research project align with ADVANCE's mission which seeks to create a more diverse and equitable engineering workforce (nsf.gov., 2019).

Introduction

With its combination of economic success and social development unique to many African states, Botswana has been hailed as an African *developmental state* (Hillbom, 2011). Consequently, Botswana can lay claim to the continent's oldest continuous democracy and boasts one of the world's fastest growing economies. Yet, Botswana's continued dependence on natural resources to build and sustain its economic growth puts its economy at risk (Hillbom, 2011). In response, Botswana seeks to fundamentally transform its economy from that of a resource based one-dependent on finite gems and precious metals- to one based on scientific and technical knowledge acquisition. Scientific and technical knowledge, the keys to spurring innovative advances, is seen by many as the fundamental source for economic progress

(Rothwell, 2013). This new focus on scientific and technical knowledge is key to reimagining Botswana's economy, for it is innovation that will drive Botswana towards sustainable economic growth, global competitiveness, and improved quality of life (Atkinson & Mayo, 2010).

On October 1st, 2016 Botswana formed the Ministry of Tertiary Education, Research, Science and Technology with the explicitly stated goal of transforming Botswana from a resource-based to a knowledge-based economy. The impetus for such an initiative was set forth in Botswana's Vision 2036. Set forth in 2016, this new "vision" for Botswana was predicated on the mapping of a transformative agenda that reflected the aspirations and goals of the nation. For this vision to come to fruition it was imperative that Botswana create a strategic plan to help with redefining their resource-based economy to that of a knowledge-based economy (Vision, 2016). In order to achieve this goal economist contended that Botswana had to contend with two major factors is redefining their STEM workforce; one, Botswana needs to improve the teaching and learning of science, technology, engineering, and mathematics content (STEM) content in secondary environments (Kennedy & Odell, 2014), and two, Botswana has to contend with a lack of women participants in STEM careers (Koketso, 2015).

Vision 2036

Economy of Botswana

Over the years Botswana has experienced a significant decline in their gross domestic product (GDP). From 1976 to 1996, the country experienced an average economic growth of 9.2% making it one of the fastest growing economies in the world at that time. This growth rate has slowed precipitously with the next projected growth rate expected at around 3.1%. Much of this has to do with the country's heavy reliance on diamond reserves and government spending and the main catalyst for the economy. Continued dependence on natural resources has put the country's economy at risk with many initiatives focused on promoting economic diversity with a particular focus on spurring the private sector and entrepreneurship (Vision, 2016).

In an effort to make the transformation to a knowledge-based economy, Botswana developed the Ministry of Tertiary Education, Science and Technology (cite). In its strategic foundation, Botswana has focused on three pillars of transformation to include; collaboration, co-production, and consumerism. As stated in the Vision 2036 (pg. 13), "*Adequate structures and resources will be put in place to promote and support R&D as an anchor for excellence and production of high quality and competitive goods and services.*" It is well noted that one of the key factors in economic growth is the improved teaching and learning of science, technology, engineering and mathematic (STEM) content (Kennedy & Odell, 2014). In Botswana's Vision for 2036 (2016), they state that there is a need to provide an environment conducive to scientific and technological innovation. Leadership acknowledges the fact that the development and nurturing of a culture of innovation and entrepreneurship is critical to developing and sustaining long-term economic growth (Vision, 2016).

Mentoring for STEM Advocacy

In creating a viable workforce to sustain this new envisioned economy, Botswana must contend with issues of gender disparity particularly in STEM fields (Koketso, 2015). Similar to the U.S., Botswana's lack of women representation in STEM fields can be attributed to issues of discrimination- and research has helped illuminate damaging stereotypes of STEM ability which favor men over women (Hayes & Bigler, 2012). Factors such as a rigid patriarchal social structure (Koketso, 2015) point to a cultivated environment and society that is primarily responsible for deterring women from entering or persisting in STEM (Single et al., 2005). As a response, mentoring has displayed the ability to attract, and sustain women's interest in STEM careers (Stoeger, Hopp, & Ziegler, 2017). Despite their success, these types of mentoring relationships are less readily available to women students who lack an adequate pool of female mentors (Single et al., 2005). In an effort to expand the mentoring pool, there has been some promise in the area of distance mentoring or e-mentoring which studies indicate is an appropriate measure for promoting women's development in STEM (Stoeger et al., 2013). In fact, online mentoring or e-mentoring has been particularly useful for building and sustaining interest in STEM fields for females at the secondary level (Stoeger, et al., 2017).

Botswana Mentoring Model

Botswana seeks to produce an environment conducive to change that includes initiatives focused on policy, institutional, regulatory, and legal framework. These initiatives need the support of informal learning environments that focus on psychological as well as academic challenges of pursuing STEM careers. Botswana has recently launched a STEM Mentorship programs in Gaborone, Francistown and Palapye in an effort to bolster its STEM population.

Starting in 2019 Botswana developed a pilot program for a STEM Mentorship Club with the following stated program objectives:

1. Assist students in developing the skills and positive attitudes towards STEM subjects required to succeed academically and succeed at the tertiary level.
2. Connect secondary school students with experienced STEM professionals to guide them through their career planning.
3. To get more female students interested in STEM fields.
4. Increase United States Government (USG) alumni exposure to the concept of mentoring and how they individually and collectively might assist Botswana in achieving sustainable development through employment opportunities for youth.
5. To advocate for Science and Maths clubs in schools across the country to be renamed STEM Clubs for the inclusion of Technology and Engineering fields.

The following Logic Model guided the implementation of their pilot program.

RESOURCES/INPUTS	ACTIVITIES	OUTPUTS	OUTCOMES	LONG-TERM IMPACTS
<p>Funding: Fully supported by US Embassy, Botswana.</p> <p>(30 March 2019 – 30 March 202)</p> <p>Major Costs;</p> <ul style="list-style-type: none"> • Travel • Lodging • Catering • Internet • Communication • Conference Material • Branded merchandise • Mentor Training workshop • Venue • Career Days • Catering 	<p>The project will target Junior Secondary School students interested in exploring STEM careers.</p> <p>USG exchange alumni in STEM fields will mentor students (with more emphasis on the girl child) with the goal of fostering in them the confidence to enter STEM fields.</p> <p>Through group mentoring sessions and additional STEM enrichment activities- presentations, workshops, career fairs and a speaker series: we hope to expose students to inspiring scientists, physicians and other medical professionals, engineers, and conservationists who represent a variety of careers and education pathways.</p>	<p>1. <u>Group Mentoring sessions</u></p> <ul style="list-style-type: none"> • Each school will be assigned 5 alumni as STEM mentors per 30 students (majority being female) in each school. • The alumni mentors will select 30 students to join the STEM Mentorship Program. Selections will be based on student applications explaining why they are interested in a field and what they hope to gain from a mentor. • The mentors will engage with the 30 students through a series of presentations, workshops and guest speakers for a period of 2 months. • Each session will last 90 minutes. • The group will discuss the different STEM fields and have an opportunity to meet women professionals in STEM fields in Botswana and interact with them one-on-one. 	<p>Short Term (upon completion of program):</p> <ol style="list-style-type: none"> 1. Reach at least 1500 young people discussing the importance of STEM in the development of Botswana and the role of women in STEM. For each of the 3 schools the alumni will address the school assembly to fully explain their project and what it entails. 2. Expose students to more STEM careers and offering a learning opportunity to other students not in the mentorship program to learn about STEM fields. Alumni will share what it is like to work in their field and explain the necessary steps to enter their chosen profession. <p>Immediate Outcomes (1 year):</p> <ul style="list-style-type: none"> • The number of mentees who go on to form STEM peer-mentoring groups within their school. • The number of students who commit to pursuing a STEM degree at the tertiary level. 	<ol style="list-style-type: none"> 1. Mentees commit to pursuing STEM studies at the tertiary level and see studying in the US as a viable option. 2. Mentors reinforce the value of reaching back to their communities and see the USG as their valued partner in an enabling business environment and employing opportunities for young graduates. 3. Increase awareness regarding the importance of STEM to Botswana economy.

		<p>2. <u>STEM enrichment activity- STEM Career Fair</u></p> <ul style="list-style-type: none"> • Education USA will give a presentation and have a booth to share information about studying in the U.S. and the various STEM fields available to students in the U.S. • Available Fulbright Scholars and Top Achievers will also share their experiences and share information about their programs. • Mentees showcasing their STEM Projects 	<ul style="list-style-type: none"> • The number of female students joining Maths and Science clubs in their respective schools. • The number of mentors who commit to mentoring again. 	
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The mentoring model developed by Botswana includes nine (9) different ninety (90)-minute mentoring sessions over a two (2)-month period. In this pilot study, the mentoring program worked with three (3) different locations throughout Botswana including the capital city of Gaborone, Palapye, and Francistown. The sessions are as follows;

- Session 1 Introducing STEM, Mentors & Programs,
- Session 2 Science and Technology,
- Session 3 Engineering and Mathematics,
- Session 4 The Leader from Within,
- Session 5 STEM for Botswana,
- Session 6 Group projects,
- Session 7 Job Shadowing,
- Session 8 Field Trip, and
- Session 9 STEM Career Day.

Prior to the beginning of the STEM session the program provided mentor training for prospective mentors. This includes the mentors' **criteria, responsibilities, and objectives**.

Mentors training objective sought to share STEM knowledge, resources, skills and opportunities with the mentors, teachers and facilitators. Therefore, ensuring that they are guiding the content creation and delivery of the program in eight (8) mentorship sessions that will occur within the STEM Clubs with the mentees in the chosen schools. As thus they will be sure to have the intended impact with the program.

Role of STEM Education at NC State

Currently researchers at N.C. State are developing, implementing, and testing an innovative distance-mentoring model focused on the unique challenges of underrepresented student populations in rural parts of the U.S. Results from this study will go into further informing the current mentoring model utilized in Botswana. In addition, this study will provide insight into the best practices for facilitating a virtual-mentoring experience through the use of a software application in facilitating long-distance mentoring relationships. Researchers will investigate its viability to serve as a mentoring tool in Botswana. Finally, this research study will develop formative and summative evaluation tools that will help investigate the impact of the Botswana mentorship program on female students' self-efficacy, interests, and perceptions of STEM careers.

NC State is uniquely positioned to assist Botswana in this transformation. The Department of STEM Education at N.C. State boasts one of the most research active departments in the College of Education thus increasing the likelihood that the partnership with the Botswana STEM organization will result in the successful funding of an NSF grant. This is particularly important to the sustainability of these mentoring programs. Finally, the coordinating professor for the N.C. State and Botswana partnership has developed a growing expertise in developing, implementing, and evaluating formal and informal mentoring programs.

Discussion

In order to address the aforementioned issues, North Carolina State University's Department of STEM Education recently formed a partnership with Botswana to meet their stated challenges. This paper highlights the latest civilian-to-civilian strategic engagements between North Carolina and Botswana as part of the U.S. Department of Defense's State Partnership Program. The Department of STEM Education at North Carolina State participated as a delegate in the program, along with North Carolina's National Guard, Department of Transportation, and Department of Public Instruction. The result of this meeting included provided a memorandum of understanding (MOU) between NC State and Botswana that would focus on a proposed three-pronged strategic approach to economic transformation, which includes;

- 1) establishing a Visiting Professor Initiative in STEM Ed.,
- 2) laying the foundation for a bilateral student exchange program, and
- 3) identifying research opportunities that establish evidence-based, best teaching practices for STEM educators.

In one of the first steps to actualize many of the above stated goals, professors from North Carolina State University have been meeting with representatives from Botswana via Zoom in hopes of developing strategies for implementation of the three-pronged approach. The result of this meeting included forming a burgeoning research collaborative that will culminate in the submission of a grant proposal to the National Science Foundation's ADVANCE solicitation. The goals of this research project align with ADVANCE's mission which seeks to create a more diverse and equitable international engineering workforce (nsf.gov., 2019).

Investigators for this project are not dependent upon external funding and as a part of their commitment to Botswana, researchers from N.C. State are developing a research design model that will investigate the impact of the mentoring program on students' interest, self-efficacy and perceptions of STEM careers. The investigators are interested in these constructs due to their ability to predict success in STEM careers. The lack of participation of minorities in STEM careers is due in part to low self-efficacy in science and mathematics and multiple studies describe the importance of interest and its relationship to self-efficacy (Denson, MESA). Additionally, literature reflects that a child's perception of an occupation coupled with their self-efficacy greatly influences the decision of said child to pursue the occupation (Bandura, Barbaranelli, Vittorio, & Pastorelli, 2001). Both Botswana and NC State understand the importance of mentoring in order to encourage the participation of underserved minorities in STEM fields. These converging interests make the partnership between Botswana and NC State appropriate and convenient. Outcomes from this project include providing local and state representatives with final reports including empirical data on the impacts of their STEM mentoring program.

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