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Botswana Mentor Experiences in a STEM-based eMentoring Program

Session III: Higher Education/Faculty Focus

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Abstract

In the spring of 2021, North Carolina State University formed a partnership with Botswana in an effort to help the African nation meet goals it articulated in its Vision 2036 initiative (Denson & Jones, 2020). This partnership aligned with the goals set forth by the Ministry Tertiary Education, Research, Science and Technology which sought to transform Botswana's economy from a resource-based economy to that of a knowledge-based economy (Vision, 2016). Economists contend that two major factors needed to be addressed; one was to improve the teaching and learning of STEM content in secondary settings and two, Botswana needed to contend with a lack of women participants in STEM careers (Kennedy & Odell, 2014; Koketso, 2015). In an effort to address both of these issues NC State and BIUST (Botswana International University of Science and Technology) developed the eSTEM Botswana program. This distance mentoring program, or eMentoring program was designed to support female high school students who have expressed an interest in pursuing a STEM career. As an intervention, eMentoring has been shown to support women in STEM though exposure to industry professionals and training in the workplace and is particularly useful for attracting female secondary students excited about STEM (Single et al., 2005). This paper will report on the experiences of the mentors participating in the eSTEM Botswana program. While many studies are focused on the impact of mentoring on mentees, research has provided evidence that mentoring has benefits specifically for the mentors (Banks, 2010).

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 reimaging 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).

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).

eMentoring

eMentoring, or distance mentoring, is a specialized form of mentoring that is uniquely positioned to support URMs in rural communities who lack immediate access to higher education institutions and networks due to economic and geographical barriers (Dappen & Iserhagen, 2002). eMentoring is also able to mitigate the need for synchronicity during communication in face-to-face mentoring relationships (Stoeger, et al., 2013). Research has provided evidence that eMentoring can be used to recruit and retain URMs in STEM. For example, eMentoring has been shown to support women in STEM through exposure to industry professionals and training in the workplace and is particularly useful for attracting talented female secondary students excited about STEM (Stoeger et al., 2017; Single et al., 2005). Participation in eMentoring has also shown to increase participants' self-confidence and STEM career aspirations (Single et al., 2005).

The ability of eMentoring to overcome issues of geographic centrality and mitigate the requirements of synchronicity makes it an ideal platform for forging a relationship between STEM majors who have a demanding workload and underrepresented students who live in rural areas (Stoeger et al., 2013). Moreover, Ghods & Boyce (2013) contend that eMentoring is uniquely suited for addressing social inequities by providing mentoring opportunities to those who would not otherwise receive them due to geography, costs, and/or physical limitations. Finally, eMentorship has been especially beneficial cultivating the professional profiles of future STEM workers, fostering practical skills and abilities of the mentee, and supporting knowledge transfer of inexperienced workers (Martin et al., 2011), consistent with competencies for the STEM labor market.

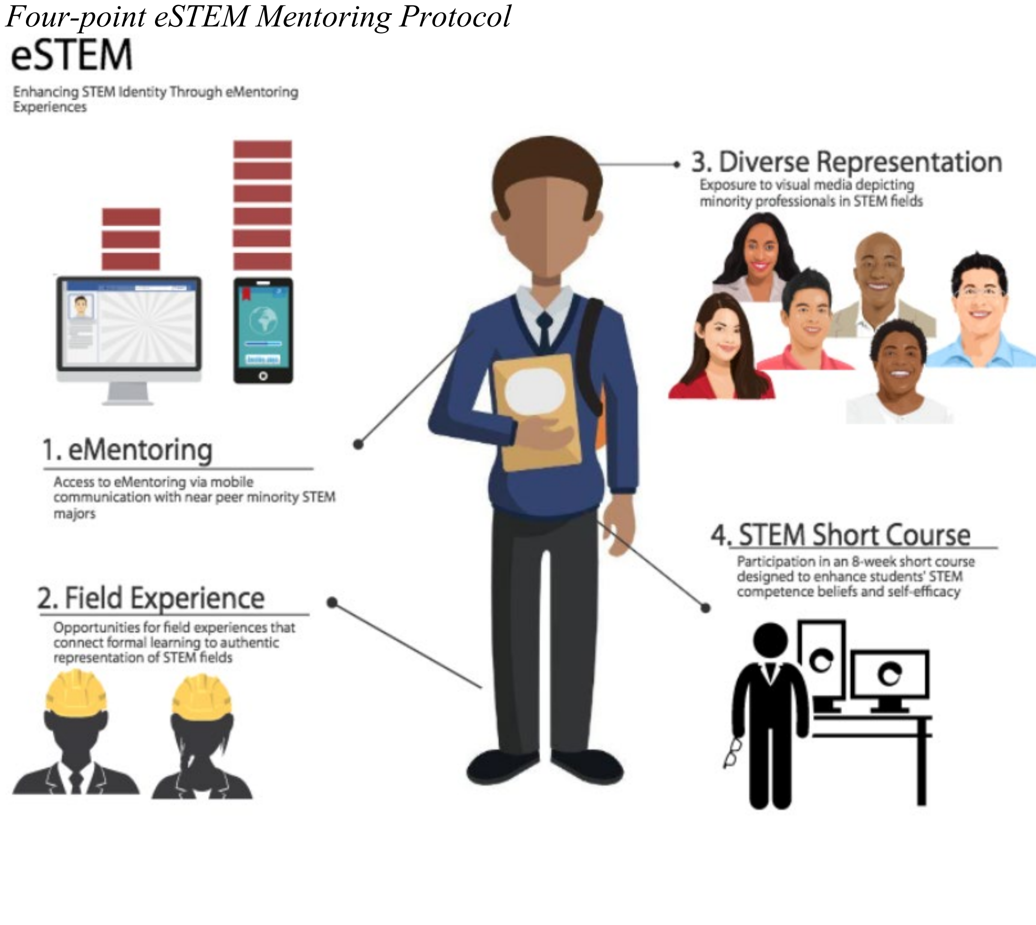
eSTEM Botswana

eSTEM Botswana is a 16-week program which relies on an innovative research-based four-pronged mentoring protocol (Denson & Hill, 2010) that features: 1) access to eMentoring via mobile communication with near-peer minority STEM majors, 2) opportunities for field experiences that connect formal learning to the authentic representations of STEM fields, 3) exposure to visual media depicting minority professionals in STEM fields, and 4) participating in an 8-week short course designed to enhance student's STEM competence beliefs and self-efficacy (see Figure 1). In this model students' self-efficacy and value for STEM and their STEM intentions, enrollment, and persistence are supported through one-on-one near-peer mentoring sessions, shared STEM experiences with a relatable model of STEM success, and engagement in a STEM short course. The *eSTEM* program engages URMs in engineering-related experiences supported by near-peer relationships with college mentors of similar backgrounds, experiences, and interests to bolster students' STEM identity.

Based in the rural city of Palapye, eSTEM Botswana included mentees from Swaneng Hill School and mentors from the Botswana International University of Science and Technology (BIUST). *eSTEM* Botswana was a 16-week program that followed a similar curriculum as the eSTEM program implemented in the U.S. However, one particular difference to note is that the eSTEM Botswana program was facilitated through the WhatsApp software application in lieu of the *STEM Squad* app. *STEM Squad*, the proprietary software created for the *eSTEM* program, was only accessible to iOS users in Botswana. Due to its accessibility in Botswana and participants' familiarity with the software, WhatsApp was chosen to facilitate the program.

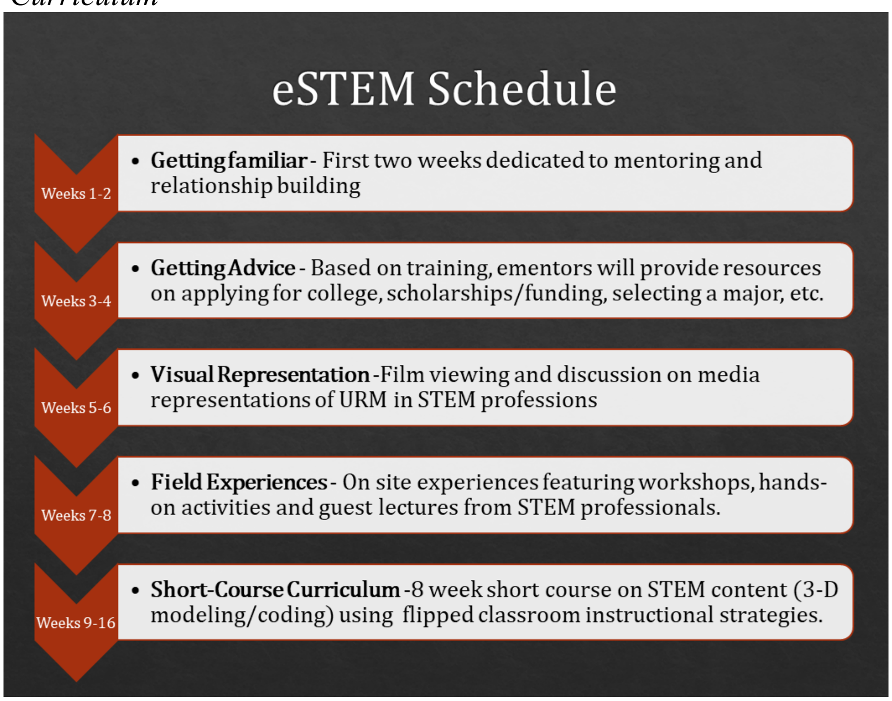
Figure 1

Four-point eSTEM Mentoring Protocol



As mentioned previously the *eSTEM* program in Bottswana lasted for 16 weeks and was facilitated using the WhatsApp in lieu of the *STEM Squad* mobile application. Figure 2 shows the sequence of the activities beginning with eSTEM dyads relationship building and ending with a 3D modeling or coding short course. Weeks 1-2 were dedicated to relationship building and becoming familiar with the eSTEM tools. The dyads also co-generated a set of expectations that were used to guide the eMentoring experience. Weeks 3-4 focused on advising related to applying for colleges, scholarships/funding, and selecting a STEM major. Weeks 5-6 concentrated on the diverse media representation of underrepresented inventors, engineers, and designers in which participants watched a film depicting a URM in a STEM profession (e.g., *Hidden Figures* or *The Man Who Knew Infinity*) and reflected on the implications of seeing people they identify within these roles. Weeks 7-8 featured hands-on Arduino units in which mentees were scaffolded through building and coding individual Arduino units. The activities were designed such that mentees completed an activity on their own following a step-by-step tutorial created by the research team (mentee solo activity) and completed an activity along with their mentor (mentee/mentor activity). Each week consisted of these two activities for a total of four activities. Finally, in weeks 9 -16, the mentors scaffolded mentee learning through completion of a 3D modeling.

Figure 2
eSTEM Curriculum



3-D Modeling Short Course

A unique aspect of the *eSTEM* program is the 8-week 3D modeling curriculum. This short course provides students with a comprehensive introduction to 3D modeling, specifically featuring OnShape as the authoring software. Throughout the 8-week short course students deepen their understanding of sketching with constraints, dimensions, and tools and learn advanced techniques like the mirror command and creating revolved parts. Student mentees apply their skills to design a 3D phone case, and continue working this project throughout the course supplementing their design work with videos on diversity in STEM and engineering's real-world implications. In the final week, students finalize and submit their phone case designs for 3D printing. This course blends practical application, mentorship, and broader STEM exploration to offer a holistic understanding of 3D modeling.

Methods

Considering that our purpose was to explore how eSTEM mentors in Botswana experienced the STEM-based eMentoring program, we used focus group interviews (rather than one on one interviews) due to their ability to elicit rich qualitative data from multiple participants within a social context (Krueger & Casey, 2014). A semi-structured interview technique was used to allow flexibility in probing participants' ideas, posing additional questions, and asking for clarification. Qualitative analysis revealed several emergent themes from the mentor experience.

Participants

An invitation was distributed via email to the 8 eSTEM Botswana mentors that participated in the program. Participants were offered a $50 gift card upon completing the focus group interview. Seven of the eight eSTEM Botswana mentors volunteered to participate in the focus group interview.

Data Collection

Focus group interview transcripts served as the data source for this study. The interview data was collected following an open-ended interview protocol which included the following questions: (1) what did you enjoy most about the eSTEM program, (2) please tell us about your experiences in the eSTEM program, (3) what would you like to see done differently to improve the eMentoring experience, (4) which aspects of the short-course were most enjoyable for you, (5) which aspects of the short course were most challenging for you, and (6) is there anything else you would like to add in regards to your experience? Each focus group interview lasted approximately 45-minutes and were audio recorded and transcribed verbatim.

Data Analysis

We used qualitative content analysis (Schreier, 2014) to analyze the focus group interview transcripts inductively and deductively. First, two researchers developed a coding frame that consisted of concept-driven and data-driven categories (Schreier, 2014). The concept-driven categories were developed *a priori* based on our four-point mentoring protocol (i.e., eMentoring, field experience, diverse representation, and STEM short course) and data-driven categories were developed through open coding. The coding frame was revised through an iterative negotiated agreement process in which two coders independently coded the data, compared their coding, and discussed and resolved coding discrepancies as they arose (Forman & Damschroder, 2008).

Findings

The qualitative content analysis of mentor focus group interview transcripts revealed several emergent themes about how the mentors in Botswana experienced the eSTEM program. Most notably the mentors discussed *Building relationships, Hands-on Learning*, and *Challenges of distance mentoring* in Botswana. Below we have included direct quotes highlighting support for the emergent themes.

Building Relationship

Several mentors discussed the importance and relevance of *building relationships* and how this was a mutually beneficial aspect of the program. As one mentor notes, "I enjoyed the relationship that I built with my mentee. Yes, I liked that it was not just a one-way stream. We got to learn from each other…. I got to explore 3D modeling." This supports the claim that near-peer mentoring relationships can support a mutual learning experience. Furthering this claim another mentor chimed in to state, "This program actually enabled me to execute and exercise what I love most." Finally, one mentor spoke of the culture of learning that the program cultivated, stating, "I would say this eSTEM program has given me an opportunity to cultivate knowledge among students using technology. This, in a way, it promotes a culture of learning."

Hands-on Learning

When speaking about their experience in the program the mentors reflected on the *hands-on learning experience.* As one mentor proffered, "I'd say this hands-on online training is quite interesting to students for learning … as students prefer hands-on, they prefer interactive learning." This was championed by another mentor who stated, "Yes, everything she did, which involved designing hands-on, making things for themselves was really good and energetic for her compared to reading your notebook…". Finally, the mentors spoke about how the online training was able to equip students with authentic STEM skills. S one mentor stated, "..more so that the project was more hands-on. Yes, it really gave a meaningful online experience to students, while at the same time equipping them with the technical skills and experiences."

Challenges of distance mentoring

While ementoring has many attributes that work to overcome geographical barriers there are still many challenges that mentors in Botswana faced. The majority of the challenges revolved around *access to requisite hardware and software* needed for the program. As one mentor elucidated, "Online mentorship was good, however, I would advise your team that next time before starting the mentorship program actually look at the applications that are accessible in the country." While the research team was able to address issues in regard to accessible software applications there were still problems that the mentors faced when it came to access to hardware needed for the program. As one mentor illustrated, "... like my mentee, didn't have the laptop to actually communicate, and all those stuff, to do the online 3D course, which was a setback." This was a common theme as several mentors commented on this challenge. One mentor stated, "..there was a period where the mother was using the laptop for work, so she had to pause,...". Finally, this challenged was reiterated by another mentor who commented, "..I discovered that my mentee was using her father’s phone. … I would say limited access to resources is also one challenging factor for this program.”

Conclusion and Discussion

Our findings provide valuable insights into the program elements that influenced successful implementation of the *eSTEM* program in Boswana, and they contribute to the broader literature on effective near-peer, technology-mediated STEM mentoring programs (e.g., Garcia-Melgar & Meyers, 2020). First, our findings highlight the importance of facilitating relationships between mentors and mentees through a near-peer model. Prior research has provided evidence that near-peer mentoring relationships, particularly in regards to gender and race, can lead to improved academic and vocational outcomes for underrepresented mentees (Stoeger et al., 2013; Thomas, 2001; Timpe & Lunkenheimer, 2015). Furthermore, research shows that near-peer mentoring can have positive personal, educational, and professional impacts on the mentors including an increased interest in pursuing STEM (Ragins & Scandura, 1999; Tenebaum et al., 2014).

Additionally, this study supports the notion that mentoring has unexpected benefits for mentors from traditionally underrepresented backgrounds in STEM (Trujillo et al., 2015). Particularly, our findings support the benefits of the mutual learning experience and the development of 3D spatial visualization skills which is often cited as one of the key skills required for STEM careers (e.g., Khine, 2017) and as a key predictor of STEM success and interest (Khine, 2017; Buckley et al., 2018). Our findings reaffirm the importance of engaging mentors and mentees in visual and spatial reasoning skills to support STEM motivation.

Specifically, our findings provide evidence that a distance mentoring model can help provide a *culture of learning* that can be scaffolded and supported through the use of communication technology. Additionally, our study provided evidence that shared experiences were key in developing underserved students’ STEM identity. Moreover, exposing students to authentic STEM experiences remains an important feature in supporting the recruitment of underrepresented populations to STEM fields. While study participants were able to largely overcome the *technical issues* throughout the program it still was a theme throughout the dyads. While the extant literature has acknowledged some of the technical challenges of mentoring at a distance (Pillon & Osmun, 2013) more studies are needed to understand how these difficulties impact the mentoring relationship.

This research has important implications for addressing the serious lack of STEM-based resources and opportunities available to URMs in rural communities. To bridge this gap, this study sought to identify program elements that influenced successful implementation of the eSTEM program. While our findings show that near peer relationships had a positive impact on participants’ experiences, it indicates a need for improvement in engagement activities between dyads to further support building long-term relationships. This study addressed the barriers facing URMs in rural communities through an eMentoring program that can foster students’ motivation, persistence, and mobility in STEM.

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