Integrating Technological and Educational Collaborations:
Enhancing Leadership and Participation in STEM Fields

Lineo Lynnette Toolo

Department of Educational Leadership and Management,
University of South Africa South Africa
toololl@unisa.ac.za,

Abstract

This study investigates the advancement of underrepresented groups in leadership roles within the fields of Science, Technology, Engineering, and Mathematics (STEM), areas traditionally dominated by their male counterparts. Through a convergent sequential mixed method, data was collected using 105 questionnaires and six semi-structured interviews involving students, lecturers, government officials, and university admissions administrators in the STEM disciplines. A concurrent triangulation strategy was applied for simultaneous quantitative and qualitative data analysis, utilizing MS Excel for the numerical data and thematic analysis for the narrative information. The research also examined statistical documents to assess the enrollment disparity among underrepresented groups and the presence of specific development programs in universities aimed at addressing this imbalance. Findings suggest that targeted and culturally informed collaborative efforts can effectively encourage the ascent of underrepresented demographics into STEM leadership roles in South African universities. The implications of the study are broad, given that the research spanned two distinct universities, implying that the strategies identified could inform actions across different educational institutions to foster inclusivity and equality in STEM leadership.

Keywords: *STEM Leadership Advancement, Underrepresented Groups, Collaborative Efforts, Convergent Sequential Mixed Method, Afrocentric Approach*

INTRODUCTION

According to the Accenture Consulting Technology Outsourcing (ACTO) Report (2014), the world is facing socioeconomic challenges and food security anxiety, as a result of climate change. I argue that these challenges already exist in South Africa. Scholars are advised to find solutions from the research in the STEM fields, to overcome these crises (ACTO, 2014: i). On the other hand, the National Development Plan (NDP) 2030 recommends that for the country to sustain its democracy and make it flourish, it should grow an inclusive economy through partnerships within the South African community (The Presidency, 2011:17).

The ACTO Report, however, is warning the world about the significant low number of young women in the STEM fields, since there is a trend in the world, and throughout the European Union, signifying that between only 6% and 7% of technical careers are occupied by women (ACTO, 2014: i). Consistent with the above, in 2012, women in South Africa comprised 79.3%, 73.8% and 73.7% in the health, education, and welfare sectors, respectively, which are signified as gender-distinct areas (Department of Women, 2015:43). Moreover, although the end of apartheid saw a slight poverty deterioration, women

remained poorer than men. Rural women were far inferior to the ones in the urban areas. Coloured and African women were more vulnerable, compared to White and Asian ones (Department of Women, 2015:10). Therefore, Black young women should be developed to take part in resolving the current socioeconomic challenges mentioned above and claim their leadership positions in the STEM sector.

The above scenario propelled this article to outline critical questions to be responded to, the theories associated with the problem of young women who are studying the STEM fields and the findings of the research conducted, to understand the root-causes. The outcome will serve to guide processes on how the stakeholders in the STEM fields can collaborate and contribute towards a common goal, i.e., to empower young women to participate more in that sector and take up their leadership positions towards their socioeconomic sustainability.

Problem Statement

The South African economy cannot grow inclusively if young women's statistics are so low in the fields of STEM, as compared to young men. This creates an overflow of social skills and shortage of STEM skills, resulting in high female graduates' unemployment rate, as opposed to young male graduates. At the same time, technology has become more advanced to mothers as primary providers for families, to the level that their food security can no longer depend on subsistence farming, due to global warming (ACTO, 2014: i).

Young women's low statistics in the STEM fields in South Africa, inspired me to initiate encouraging stakeholders in that sector to enable young women to partake more, in the future.

This article aims to describe ways in which stakeholders in the STEM fields and beyond may collaborate efforts and resources, to assist young women to participate more and assume leadership roles in the STEM fields, by responding to the questions: 'How can stakeholders in the STEM fields and beyond collaborate to empower young women to increase their numbers in the STEM fields? What programmes may be implemented to enable young women in South Africa to undertake their leadership positions in the STEM fields, for socioeconomic empowerment?'

This article proffers stakeholders in the STEM fields, in particular, the government, the STEM primary and secondary school educators, universities, non-government organisations and the STEM private companies, to collaborate strategically to support Black South African young women, since the percentage of women graduates in engineering, manufacturing and construction were just 28.5%, before 2012 (Department of Women, 2015:43). This can be done by implementing the guidelines developed as an outcome of this article, for example, initiating Black women-specific programmes in the STEM fields.

THEORETICAL FRAMEWORK

One of the theories used in this research was the classist theory. According to Shin and Lee (2017:3), this theory means "prejudice and discrimination based on social class resulting from different social classes". These authors, explain the classist theory as the most fundamental and significant variable that serves as an obstacle in the decision-making process of a person's career and its outcomes. In Marx's analysis of the class theory, as explained by Sociology 250 (1999), the working class and the capitalist class cannot exist without each other. Their relationship is such that there is a clash, as well as incompatibility between the two. In the case of a social class, the structure and core may be explained as clusters that are common regarding property or the methods of production. However, in Marxism, these classes have value in society and historically stand in their own interests, and in opposition to other classes.

Department of Women (2015:10) reports that although participation of women in higher education improved at the end of apartheid government in South Africa, the pass rate for male learners was higher in mathematics, science and technology in Grade 12, than for the female learners. That contributed

20

Integrating Technological and Educational Collaborations:
Enhancing Leadership and Participation in STEM Fields
Lineo Lynnette Tool

to low numbers of young women who participated in the STEM fields in South African universities. Moreover, Black women remained poorer than the Asians and White women. This led to the female students underperforming in the STEM fields in schools and stayed at the bottom of the developmental pyramid. Akinsowon and Osisanwo (2014:8) believe that the development and economy of all nations is significantly reliant on STEM and that it is the basis upon which different emerging technologies and world activities revolve. Considering the role played by girls in society as future mothers, their development in STEM fields is therefore essential.

The feminist theory also helped in understanding the behaviour of women and their life experiences, which seem to have an impact in the choices they make, as explained by Terre Blanche *et al.* (2006:502–503). An example provided by Gutsell and Remedios (2016:28) outlines a scenario involving a woman who had requested a recommendation letter from one of them. When questioned about plans for her career, she said "my father was a doctor and I wanted to be one too, but I also wanted children. So, I'll probably choose a less demanding field." Her response implied that it was because her father was a man, that he was able to become a doctor, because despite him having had children, he didn't need to take care of them as she would be expected to if she became a mother.

The distinction made, above, of the father and the daughter (male and female) is further acknowledged by Ferguson (2017:269–271), that the feminist theory is concerned with the world, not just with women. It is consistently sceptical of dualistic thinking and simplifies overlapping relations into clear-cut boundaries, for example, reason and emotion, mind and body or male and female. Dualistic thinking also creates hierarchies when one side of the conflict gains influence over the other, adopting existing power dynamics and making them more difficult to resist.

METHODOLOGY

According to Terre Blanche *et al.* (2006:7), methodologies explain how researchers can go about investigating what they believe is knowable. The choice to use a mixed research methodology enabled me to examine both qualitative and quantitative information to gain a comprehensive outlook on the subject matter. Considering that the number of young males enrolled in universities across South Africa is notably less than the number of young women enrolled in these tertiary institutions, I wanted to investigate why the number of young women pursuing studies or careers in STEM fields was significantly lower than that of young men.

Research Paradigm

According to Creswell (2014:35), paradigms are "a basic set of beliefs that guide action." They are perspectives or outlooks chosen by researchers to provide a philosophical positioning about the world in order to conduct research.

These viewpoints are a derivative of historical research, orientations from different disciplines and preferences by student advisors. My choice of the mixed method research approach to ultimately answer the main research question, was informed by my experiences of beliefs, orientations, and literature review to better understand achieve the outcome of the study.

Creswell and Plano-Clark (2011:41) argue that 'positivism/post-positivism', 'constructivism/ interpretivism' and 'participatory assumptions', to be discussed under the Research Design, have common elements but only differ in the nature of reality, 'ontology', how we gain knowledge of what we know, 'epistemology', the role value played in the research, 'axiology', the process of research, 'methodology' and the language of the research 'rhetoric'. This research used four of them (ontology, epistemology, methodology and axiology) since they were important and necessary for its completion.

Ontology

21

Integrating Technological and Educational Collaborations:
Enhancing Leadership and Participation in STEM Fields
Lineo Lynnette Tool

The reasons for the status quo were the cause for the investigation. As a result, young women and young men were given the opportunity to present their cases themselves. On the other hand, it was necessary for lecturers in the STEM fields to provide information on their experiences when dealing with both young women and young men during the lessons and assessments. Government officials, whose jobs are to support universities, were also interviewed to disclose their understanding of the system and what might be the cause of the existing gaps. There are substantially fewer young women participating in STEM fields across South African universities as compared to young men.

Epistemology

It is noted by ACTO (2014: i) that socioeconomic challenges and escalating concerns about food security due to climate change are an unchanging reality, which is why it has become imperative to encourage scholars to pursue careers in STEM fields, to alleviate or ease these potentially calamitous circumstances. Literature by Freeman, Marginson and Tytler (2015:36) revealed that countries such as North Korea have designed and implemented mechanisms such as policy programmes, that have successfully supported women in STEM fields and provided control measures to manipulate this reality. Inspired by this approach, I have developed a programme aimed at improving the participation of young women, specifically, in STEM fields across South African universities.

Axiology

Kivunja and Kuyini (2017:28) refer to axiology as the ethical issues that need to be considered when planning a research proposal, for example, privacy of the participants. Right from the proposal of this research, I had adopted the axiology standpoint by writing letters to the identified participants, explaining what the research was about and why their participation was regarded as important. They were also informed of their rights to withdraw from the research, at any stage, should they find any conduct to be inappropriate. Participants were reassured of the confidentiality of their details and information they would provide and were given consent letters to sign if agreeing to be part of this research. After data collection, they were given the recordings and manuscripts, to check if data was recorded as presented, to which they had the right to give a green light for me to use such or withdraw it.

LITERATURE REVIEW

Concerted Afrocentric Collaborative STEM Leadership

STEM stakeholder collaboration, in this article, refers to an effort synergy of all institutions that are working towards the realisation of equality in the STEM fields, by breaking unhealthy cultural and traditional myths that categorise these fields as masculine and not meant for women. These are stakeholders who would contribute to the increase of girls and young women's participation and leadership in the STEM sector, where their numbers are currently very low compared to their male counterparts, to enable them to take up their leadership role in this sector. This idea of stakeholder collaboration is supported by the explanation provided by Crosby and Bryson (2004:8) that stakeholders are brought together to share power arrangements, activities, information and resources towards the achievement of a common goal. The focus, however, should be on the beneficiaries who should be regarded as the key stakeholders, whose "social needs" and "public problem" have to be dealt with. For the project to be maximally achieved, there is a need for more stakeholder involvement and advocating for the adoption of funding, and new policies and programmes. Therefore, as part of the team, a strong feminist stakeholder will have to be identified to create awareness and advocate against the unhealthy cultural and traditional myths, like "the STEM fields are for men, not women".

22

Integrating Technological and Educational Collaborations:
Enhancing Leadership and Participation in STEM Fields
Lineo Lynnette Tool

Stakeholder Collaboration in STEM Leadership Incubation

The rise of the "out-of-school time" (OST) is said to be the latest transformations in the STEM educational setting. It provides high quality programmes that empower young people with skills, to combine learning experiences with STEM concepts and practical activities. Strategic partnerships are also emerging in this new initiative among the researchers, policy developers and experts. The aim is to enable young people, especially from disadvantaged backgrounds, to access the STEM fields, as well as increasing the number of youths who choose careers in this sector. These authors have focused on how the OST field could be the front-runner in transforming the national STEM education, through robust partnerships with schools, businesses, and STEM institutions, by developing high quality data systems and common measurements for sustainable development (Allen *et al.*, 2020:1–2). Figure 1, below, presents the agreement on the system by partners, resulting in the common goal.
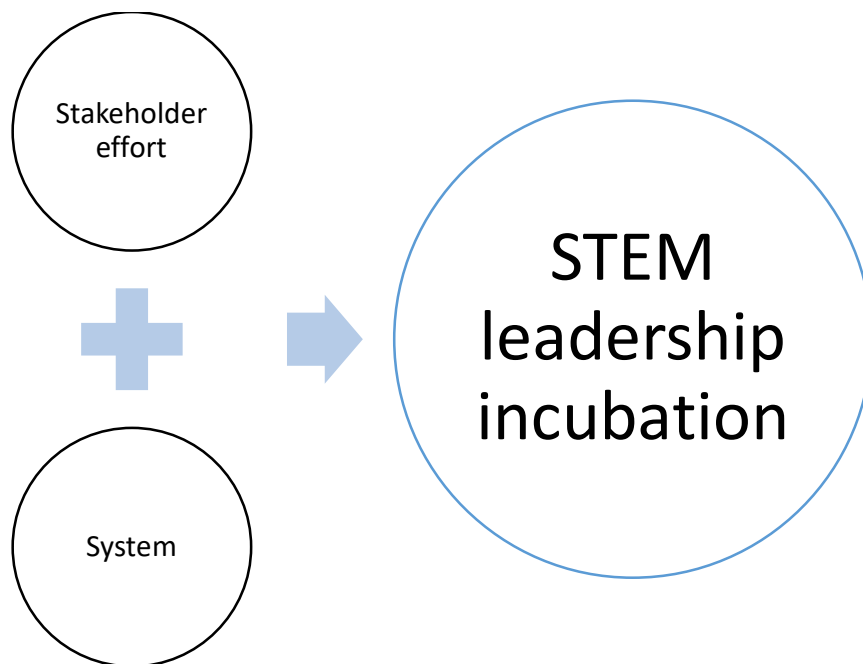

Figure 1: Stakeholder Collaboration in STEM Leadership Incubation

The above report supports collaboration of stakeholders, in order to transform the current gender imbalance in the STEM fields. When outlining Shin and Lee's (2017:3) idea of the classist theory, i.e., different social classes that are born from prejudice and discrimination, this theory played a bigger role during the apartheid era in South Africa, to the extent where black women's level of poverty led to the female students underperforming in the STEM fields in schools, as compared to their Asian and White counterparts. This calls for total transformation in the STEM fields in general, through the identification of relevant stakeholders, government, the STEM primary and secondary school educators, universities, non-government organisations and the STEM private companies.

Young Woman's Socioeconomic Empowerment

23

Cummings (2015:25) suggests that in order to improve the underrepresentation of women in the fields of science, technology, engineering agricultural sciences and mathematics (STEAM), women must be encouraged to continuously acquire and develop their professional proficiencies or skillset in different stages and at different levels of their careers in order to access opportunities to participate in decision-making as leaders in senior positions.

We argue that this should be done right from the beginning of their education, in primary schools, for smooth transition to secondary schools and tertiary education, where they can choose their future careers with confidence and constant support from the relevant stakeholders.

STEM INTEGRATION

The acronym STEM represents the disciplines of science, technology, engineering, and mathematics, which are completely independent, but provide better results when jointly applied. Muchie (2015:4) reports about a new unity of knowledge and related disciplines comprising science, technology, engineering, and mathematics, i.e., the STEM integration. They are cohesive and it is imperative to consider the extent of their interconnectedness when seeking learning resources or means of invention. This is a new and dynamic education landscape, and its multi-disciplinary knowledge and resource integration is enriching for learners. It enables them to broaden their worldviews by providing an expansive disciplinary lens instead of continuing to perpetuate traditional isolated, limited, and linear perspectives.

The International Missing Talent in STEM

According to Jakes (2013: 1,7,18-19), the US Department of Commerce released the latest data on the gender gap in the science and technology fields, when trying to establish the economic impact thereof on women. Findings revealed that approximately 50% of all jobs in the US were occupied by women, however, the STEM fields accounted for less than 25% of them, even though women with careers in STEM fields earned 33% more, on average, than those in other fields. The data also revealed that while 40% of men with academic qualifications in STEM fields work in science and technology fields, only 26% of women who had held similar qualifications worked in those fields. This author reported that women blamed a "chilly environment" in the STEM fields, and he recommended that partnerships be established with schools, colleges and other tertiary institutions to bridge that gap, as well as creating smooth transitions between those institutions. Consistently, Akinsowon and Osisanwo (2014:11) suggested the conduction of research within the STEM sector, to enable flexibility to balance home and work. This created amendment in the curriculum and integration in its delivery to ensure wide-ranging, extensive, and inclusive access to STEM fields that would accommodate the women's roles, at work and at home.

Policies, Programmes and Partnership on STEM

As per Freeman, Marginson and Tytler (2015:36), in view of the above situation, the Korean government established the Korea Advanced Institute of Supporting Women in Science, Engineering and Technology (WISET), and implemented policies at different phases, i.e., 2004–2008 and 2009–2013, to support and foster science and engineering. There were inclusive projects forming the main policy programmes within this master plan, for example, designing a programme targeted at establishing mentoring networks and relationships between prominent women in STEM and female students from foundation phase to tertiary education phases or levels. Based on the impact analysis, these projects have proven successful at encouraging female students to pursue studies in science, technology, engineering, and other careers in STEM fields (Freeman, Marginson and Tytler, 2015:36).

UNESCO conducts research on the education of girls in science and mathematics and investigates their global participation in related fields. It also reports its work on projects that build momentum around the call for girls and women to participate in STEM fields across the world. One such initiative was the

24

Integrating Technological and Educational Collaborations:
Enhancing Leadership and Participation in STEM Fields
Lineo Lynnette Tool

establishment and launch of the International Day of Women and Girls in Science on the 11th of February 2016 (2016:2–3). The organisation's Institute for Statistics embarked on a STEM and Gender Advancement project, intending to reduce the gender gap in STEM through analysis and development of new indicators and by understanding reasons the majority of women do not participate in STEM fields to assist with evidence-based policymaking.

Cummings (2015:28–29) notes an initiative focused on "the powerful use of a digital community" and references the "STEM Camp for African Girls on Robotics and Renewable Energy" as an example of where collaboration produced satisfactory results for associates and partners towards achieving the same objective. This is an initiative of the Working to Advance STEM Education for African Women Foundation (WAAW), which had undertaken to take 10,000 girls from secondary schools and college to participate in STEM programmes. Additionally, the organisation also trained 120 college partners and awarded scholarships to 17 colleges. Furthermore, 12,000 women in 40 countries at senior levels were provided with 100 digital networks by the European Platform of Women Scientists. Evidently, it is imperative that partnerships are forged between different countries to enable the successful integration of women in STEM.

South African Perspective

Young women's attainment of socioeconomic leadership is necessary to grow an inclusive economy, and rid the country of poverty and deprivation, and indeed, this can be attained by promoting leadership and partnerships throughout society (The Presidency, 2011:17). However, there are already emerging challenges against the socioeconomic sphere and food security. The solution is said to be in the STEM fields (ACTO, 2014:i). Therefore, to take up socioeconomic leadership, young women should get into the STEM fields in big numbers, since this report says their numbers are significantly low in these fields.

There are successful programmes implemented by non-government organisations (NGOs) like UWESO, the "Techno Girl" programme, from 2005. According to UWESO (2015:2), this NGO reports that the identification of secondary school girls from disadvantaged areas is done through the Department of Basic Education (DBE) and these girls are exposed to the STEM world of work, by being placed in job shadowing programmes in different organisations during school holidays. For instance, in 2015, the Techno Girl programme saw 1391 girls successfully complete job shadowing and write Grade 12 National Senior Certificate examinations. Of the 1280 (92%) that could be contacted, 824 (64%) qualified to pursue a bachelor's degree, 272 (21%) qualified to pursue a Diploma and 66 (0,05%) qualified to pursue a Higher Certificate. This partnership among UWESO, DBE and corporate companies has achieved good results, since participating companies provide future vacancies to those who want employment after matric and give bursaries to those who want to further their studies (UWESO 2015:2).

RESEARCH METHODOLOGY AND DESIGN

Research Assumptions

According to Creswell (2014:35), researchers bring beliefs into their research, i.e. pragmatism, transformative, post-positivism (positivism) and constructivism. This enables them to acquire the much-needed knowledge and understanding of what they intend to share. In this research, the reality is that the

25

Integrating Technological and Educational Collaborations:
Enhancing Leadership and Participation in STEM Fields
Lineo Lynnette Tool

number of young women in the STEM fields is significantly low in South African universities, resulting in gender disparity in this sector (O'Dea & Corcoran, 2014:i).

'Constructivism', referred to as social constructivism, upholds that individuals seek understanding of the world in which they live and work. Their experiences are used to develop subjective meanings, based on a certain lifestyle that forms part of the people's historical background and are attached to certain things. These meanings are used by researchers to look for the complexity of views, which they rely on to understand the participant's world and discover that their own backgrounds influence their interpretation (Creswell, 2014:37). 'Constructivism' was adopted in this study, to help with an understanding on how different theories, such as classist and feminist, led to the choice of careers by young women. Young women's experiences and how they shaped their future, believing that childbearing and mothering were their biological roles, and that it was their task to plan such, irrespective of their children's fathers, also determined their choice of careers (Toolo, 2018:93). This was also based on the historical background of South African women during the apartheid regime, which influenced women's choice of careers, as per the report (Department of Women 2015:10), that there was separate work for men and women.

Population and Sampling

According to Taylor (2005:186), population is a collection of all the elements that are being studied, which will assist the researcher in trying to draw conclusions. For this study, the focus was on young male and female students who are between 18 and 35 years, and also registered in the STEM fields in South African universities, their lecturers, the university administrators responsible for student admissions, as well as government officials who are working directly with university students.

Two South African universities located in different provinces, with diverse historical backgrounds were selected. One is a historically open distance learning institution, enrolling students from South Africa, Africa and other continents. The other one is a previously White South African serving university, which historically used Afrikaans as the only medium of instruction. The aim was to check if the trends of young women, who choose careers mostly in the social and not STEM fields, were the same in these institutions or not. If the trends were different, it would mean that tradition and culture of institutions do have an influence in the career choices of young women, since these institutions have different traditions and cultures. If the trends were the same, it would require investigation on the cause for such choices.

Data Collection

In this research, the convergent sequential mixed method was used. Data was collected quantitatively by means of questionnaires and qualitatively, through semi-structured interviews. Out of the 132 questionnaires sent out, 105 were completed and returned. There were different questionnaires for: 4 STEM lecturers, 100 female and male students, and 1 student admissions administrator. Regarding interviews, 2 lecturers, 2 female students and 2 government officials who work directly with universities were interviewed. Another technique used was to source data on university statistics from relevant documents and later analyse.

The concurrent, triangulation design was implemented. Therefore, data was collected at the same time, since the submission and collection of completed questionnaires were done at different occasions. At the same time, interviews were scheduled as per availability of interviewees, which coincided with the processing of questionnaires, i.e., while questionnaires were distributed to the respondents and responses awaited, the interviews also continued, because there was a delay in the return of questionnaires from some respondents. That also led to simultaneous interpretation of data collected, as explained by Creswell and Plano-Clark (2007:85).

Data Analyses

Integrating Technological and Educational Collaborations:
Enhancing Leadership and Participation in STEM Fields
Lineo Lynnette Tool

Concurrent data analysis plan was implemented. Analysis of data was done quantitatively and qualitatively through excel and thematic analysis instruments. Equally, this research had to find out young women's experiences and reasons for not taking up careers in STEM fields in big numbers. There was also a need to verify the statistics of young women against those of their male counterparts in the STEM fields, by analysing documents with such information, which was done in addition to the above processes.

For the quantitative process, analysis of data from questionnaires assisted to test the theory that gender disparity in the STEM fields could be because of the negative sex-based stereotypes. That was aligned with Creswell's (2014:32) idea that quantitative researchers build in protection against bias and control alternative explanations, in order to generalise and replicate the findings. The view mentioned earlier in the study that most young women choose careers in the social fields, while few choose from the STEM fields, was analysed through comments like, "young women prefer social rather than STEM fields as careers". Qualitatively, themes grew from the particular to the general state and interpretations on the meaning of the analysed data were made. That led to the development of an awareness programme established from the findings, as advised by Creswell (2014:32).

FINDING DISCUSSION

Point 1: Results of Questionnaires and Interviews

Point 1a: Youth Development

This section's goal was to see if young people understood the notion of youth development and that economic empowerment is a precondition for social revolution, for achievement of their holistic/sustainable development. The results indicate that most young people are aware of these factors, meaning other variables influenced young women's employment choices away from the STEM professions. The mean value and standard deviation for "holistic/sustainable youth development" were 2,29 and 0,92, respectively, based on 99 respondents. This suggested that there was a general agreement that in order for young people to be holistically developed, they needed to be economically empowered and leading sustainable social lives.

A government official characterised holistic youth development as leadership development at universities and collaboration with the youth development department. Youth are people between the ages of 18 and 35, and universities have a high youth population, therefore, universities can contribute to development in ways other than education and qualifications. That may be convenient for universities, since according to Department of Women (2015: 43) young women are already in big numbers at universities in South Africa, although they are mostly taking up careers in the health, education, and welfare sectors.

Point 1b: Economic Empowerment and Social Transformation

The results of the theme, "Economic empowerment is a requirement for social transformation", with 102 responses; 2,08 mean value and 0,90 standard deviation, supported the association between economic empowerment and social transformation. This gave the idea that social revolution would be impossible to achieve without economic empowerment. Kenneth (2022:1) emphasises this notion by reporting that several research are suggesting that one of the reasons for women to not choose careers in the STEM sector is that women are interested more in working with people, unlike men. With this baseline, it was predicted that the

awareness programme established, as a result of this study, would be successful in identifying ways in which young women could be economically empowered.

Point 1c: Career Choice

The results revealed that participants were aware of the benefits of STEM areas for young women, therefore, the question was whether young women were concerned about being culturally ostracised, since the STEM disciplines were said to be for men rather than women, or if their socialisation influenced their choice of study.

Here, the findings showed that parents were important stakeholders, since they proved to have influence in young people's career choices, based on the following responses to the question: "What are young women's reasons for not choosing careers in the STEM as compared to social fields in South African universities?".

A male student said:

"I grew up with a father who works in these fields, so I grew up learning and getting passionate   about the STEM fields."

The response from a female student was very direct:

"I did not choose the STEM fields. I was bullied by my parents to study them."

Teachers also need to change their attitudes, as they seem to be bullying the young women out of the STEM fields. When responding to the same question, another female student complained,

"teachers 'automatically' allow entry to a subject by boys when they choose the STEM subjects at high school, even if they do not have the potential, but girls must get their approval to do so."

Consistently, one other participant said that girls are more exposed to cooking and boys to cars. A scientific perspective on the entire concept of exposure would be more useful, such as exposing girls to cooking from farming, where food is planted, to processing and finally cooking. Girls should be exposed to the "science of food throughout the value chain" in the same way that males are exposed to driving and automobiles, which results in understanding of the science of cars, rather than just the opportunity to drive them. Furthermore, medicine should begin with plants that are used to manufacture medicine, rather than just the idea of being a doctor.

This respondent praised the study's conduct, saying, "Since there is a scarcity of young women, this research is vital for that." This section covers the subject of mentoring young women in STEM disciplines. This approach is believed to have produced positive results in the countries where it has been implemented (O'Dea & Corcoran, 2014: 1). Participants were asked to provide ideas on what female role models should bring as an expectation when mentoring young women in the same disciplines at universities. As one female student put it, "Role models are a small field. People are presumed to be ideal, yet the impact may not be as anticipated." My interpretation was that some role models do not always perform what is expected of them for the mentees, therefore, the process tends to produce primarily negative rather than positive outcomes.

As a result of instances like the one described above, mentor training was recommended to limit the accomplishment of unanticipated effects. It was also suggested that training be delivered to as many

28

Integrating Technological and Educational Collaborations:
Enhancing Leadership and Participation in STEM Fields
Lineo Lynnette Tool

teachers and STEM professionals as possible, in order to generate widespread interest across the country. This should happen at all levels, including early childhood development (ECD).

Point 1d: University Education

This section sought to determine whether universities were intentionally encouraging and enabling young women to participate in STEM fields, to curb the current situation. The question, "Your university has a role to play in improving the participation of young women in the STEM fields", had these results: 101 responses, mean value of 2,15 and standard deviation of 0,93. In this case, there seemed to have been a general agreement to the question. The next question, "Research shows that the enrolment of young women at universities, in general, is higher than that of young men, and that the number of young women is significantly lower in the STEM fields, because most of them register to study in the social fields", had 102 responses, with a mean value of 2,62 and a standard deviation of 0,91. The respondents here were mostly unsure, indicating a need to raise awareness about the unequal distribution of young women among different career fields, with STEM being the most neglected.

Government officials were probed on how government could help universities increase the participation of young women in STEM disciplines. The responses were that government should intentionally implement programmes and bursaries for young women in the STEM disciplines, and universities for teaching of the STEM subjects. Kenneth (2022) however, suggests that attention should be given to the STEM education as early as in the early childhood space, to nurture the ability to excel, as well as to curb the emergence of gender differences in mathematics and science later in the children's lives. The author also highlights that, early provision of STEM education tend to be attractive for both genders.

Point 1e: Developmental programmes

This section of the questionnaire included questions that allowed participants to expand on and substantiate their answers. The responses were organised around the major theme, "Developmental Programmes", with only two questions in this category. These questions were designed to elicit information about the respondents' ideas for an ideal programme to increase participation of young women in the STEM fields.

This revealed that relatively few students altered their opinions, even after participating in university-sponsored first-year student programmes. I then concluded that the influence of programmes designed to enlighten students about various vocations, including those in the STEM fields, was limited. My understanding, based on those questions, was that the programmes given by universities to first-time students were not appealing enough to persuade young women who had passed STEM subjects in Grade 12, but did not intend to study in such fields to change their career choices to STEM fields. That called for the development of such a programme, with relevant stakeholders taking part in its design and implementation.

Point 2: Document Analysis

A comparison was performed between the numbers of young women who are enrolled in STEM professions and the social fields. Undergraduate (UG) female students between the ages of 18 and 35 years at one participating university in the departments of science, engineering and technology totalled 9 836 in 2015 and 8 440 in 2016. The headcount in the education sector at the same university, with the same specifications in the age range of young women was 41 917 in 2015 and 38 343 in 2016. These were e-mail data purportedly derived from the HEMIS submittal to the Department of Higher Education and Training (DHET, 2015).

29

Integrating Technological and Educational Collaborations:
Enhancing Leadership and Participation in STEM Fields
Lineo Lynnette Tool

The field of education is only one of several social science fields from which the aforementioned figures were derived, but it already enjoyed a difference of 32 081 in 2015 (78.0%) and 29 903 in 2016 (76.5%), between itself and three departments within the STEM subjects. Despite improvements of roughly 8.5% and 14% between these years, the number in the social sciences remains unacceptably high. This motivated for an intervention in the form of a young women-specific programme through collaboration of relevant stakeholders.

RECOMMENDATIONS

Based on the findings above, no stakeholder can work alone to improve participation of young women in the STEM fields. Therefore, the following recommendations were made:

- Young women, as the main stakeholders, should be made aware of their low numbers in the STEM fields and be enabled, through developmental programmes, to take up their leadership positions in that sector.
- There should be seminars where parents and community members are informed about the importance of the STEM fields and also erase issues of patriarchy that discourage young women to participate more in them.
- University STEM lecturers may mentor the secondary school educators, who will also mentor the primary school teachers, to ensure smooth transition of learners and students from elementary to tertiary levels.
- The South African government departments, e.g., DBE, Higher Education and Training, and Science and Technology (DHET & ST), may independently integrate programmes of young women in the STEM into their medium-term strategic frameworks (MTSFs) and policies, since all have a role to play in developing young women.

CONCLUSION

The findings of this research managed to respond to the questions of this investigation, not only by guiding how stakeholders may collaborate to empower young women to increase their numbers in the STEM fields, but also by identifying the undocumented roles that some stakeholders play, to influence the choice of careers of young women, e.g., how the parents, through their lifestyles, as well as their parenting principles direct their daughters' future careers. The teachers as well, appeared to be holding the bar on who chooses what subject, between boys and girls in secondary schools, without noticing the decision they take on behalf of young men and young women's future careers.

On the other hand, the question, "What programmes may be implemented to enable young women in South Africa to take up their leadership positions in the STEM fields, for socioeconomic empowerment?", presented the need for an awareness programme for young women and communities at large, to improve the situation of young women in the STEM fields. If young women are not aware of the predicament they are in, they will not be able to resolve it. Moreover, if there are no female role models that they can relate to and associate with, they might think the STEM fields are indeed not meant for women. Therefore, the stakeholders mentioned in the recommendations of this work should collaborate and do as advise, in order for young women to improve their participation in the STEM fields and take up their leadership positions, for their socioeconomic development.

The results of this research can be transferable, since the research was conducted in two universities, from different provinces, historical backgrounds, and modes of curriculum delivery. This means that the findings might serve as guidelines for stakeholders in the education sector and beyond, to collaborate effort and resources, to enable young women to take up their leadership positions in the science, technology, engineering, and mathematics fields.

30

Integrating Technological and Educational Collaborations:
Enhancing Leadership and Participation in STEM Fields
Lineo Lynnette Tool

REFERENCES

Accenture. 2014. *Accenture Technology Vision 2014 Identifies Six IT Trends Driving Digital Power Shift as Large Enterprises Assume Role of Digital Disrupters.* Newsroom. 2014. https://newsroom.accenture.com/news/2014/accenture-technology-vision-2014-identifies-six-it-trends-driving-digital-power-shift-as-large-enterprises-assume-role-of-digital-disrupters.

Powering economic growth: *Attracting more young women into science and technology*. Silicon Republic.

Akinsowon, O.A. & Osisanwo, F.Y. (2014). Enhancing interest in sciences, technology and mathematics (STEM) for the Nigerian female folk. *International Journal of Information Science*, 4(1):8–12.

Allen, P.J., Lewis-Warner, K. & Noam, G.G. (2020). *Partnerships to transform STEM learning*. https://files.eric.ed.gov/fulltext/EJ1249559.pdf [Accessed 13 July 2022].

Botha, J., Kiley, J., Truman, K. & Tshilongamulenzhe, M.C. (2013*). Practising training and development in South African organisations*. (2nd edition). CapeTown: Juta.

Corporate Planning and Policy Directorate Natural Sciences and Engineering Research Council of Canada. *Women in Science and Engineering in Canada*. www.nserc-crsng.gc.ca/_doc/Reports-apports/WISE2017_e.pdf [Accessed 28 November 2017].

Creswell, J.W. (2014). *Research design: Qualitative, quantitative and mixed-methods approaches*. Thousand Oaks, CA: Sage.

Creswell, J.W. & Plano-Clark, V.L. (2007). *Designing and conducting mixed methods research*. Thousand Oaks, CA: Sage.

Crosby, B.C. & Bryson, J.M. (2004). *A leadership framework for cross-sector* collaboration.https://www.tandfonline.com/doi/abs/10.1080/14719030500090519. [Accessed 13 July 2022].

Cummings, L.M. (2015). *USAID from the American people, gender equality in science, technology, engineering agricultural sciences and mathematics (STEAM) academic pipeline: challenges transferring knowledge to practice*. 30 September.https://www.usaid.gov/sites/default/files/USAID-Report-Sep-30-2015-Final [Accessed 30 September 2017].

Desjardins, L.M. (2019). *The Present State of Things: Class Struggle in the 21st Century*. University of South Florida, St. Petersburg.

Ferguson, K.E. (2017). *The Annual Review of Political Science*. University of Hawaii Honolulu.

Freeman, B., Marginson, S. & Tytler, R. (2015). *The age of STEM: Educational policy and practice across the world in science, technology, engineering and mathematics*. New York: Routledge. https://www.routledge.com/The-Age-of-STEM-Educational-policy-and-practice-across-the-world-in-cience/Freeman-Marginson-Tytler/p/book/9781138696068

Gutsell, J.N. & Remedios, J.D. (2016). *When men lean out: Subtle reminders of child- raising intentions and men and women's career interests*. Brandeis University, USA, Tufts University. Journal of Experimental Social Psychology; 28-33. USA. https://pdfs.semanticscholar.org/3e46/553440df19429d3a65c6bef024ccad19fab3.pdf.

31

Integrating Technological and Educational Collaborations:
Enhancing Leadership and Participation in STEM Fields
Lineo Lynnette Tool

Jakes, P.J. (2013). *Dual enrolment as a factor from women transitioning into STEM majors in Montana two-year colleges.* University of Montana.

Kenneth, A. (2022). Gaps in STEM Education: Why is there a decline in Women Participation. *International Journal on Research in STEM Education.* Volume 4. No 1. 55 – 63. May 2022. https://doi.org/10.31098/ijrse/v4i1.369.

Kivunja, C. & Kuyini, A.B. (2017). *Understanding and Applying Research Paradigms in Educational Contexts. University of New England*. Australia. Online Published: September 5, 2017. https://doi.org/10.5430/ijhe.v6n5p26.

Kusmawan, U. (2018). Online Microteaching: a Multifaceted Approach to Teacher Professional Development. *Journal of Interactive Online Learning*.

Kusmawan, U. (2022). A Virtual Lab As A Vehicle For Active Learning Through Distance Education. *International Journal of Research in STEM Educatio*n (IJRSE), 4(2), 18–38.

Muchie, M. (2015). STEM for African development'. DST/NRF research professor on Innovation and Development, TUT, *Human Sciences Research Council Seminar*. 7 May 2015.

O'Dea, A. & Corcoran, M. (2014). Powering economic growth: Attracting more young women into science and technology. Silicon Republic: *Women Invent Tomorrow.*

Research Council of Canada. (2010). *Women in Science and Engineering in Canada*. Canada. Ottawa, Ontario. November 2012.

Shin, Y. & Lee, J. (2017). Predictors of career decision self-efficacy: Sex, socioeconomic status (SES), classism, modern sexism and locus of control. *Journal of Career Assessment*, 1–16. doi:10.1177/1069072716658649.

Sociology 250. (1999). Marx's Theory of Social Class and Class Structure. https://uregina.ca/~gingrich/s28f99.htm [Accessed 10 August 2022].

South Africa. Department of Higher Education and Training. (2015). *Staffing South Africa's universities framework: A comprehensive, transformative approach to developing future generations of academics and building staff capacity.* Pretoria. Government Printer.

South Africa. Department of Women. (2015). *The status of women in the South African economy*. Pretoria: Government Printer.

South Africa. National Planning Committee. (2011). *National Development Plan: A vision for 2030*. Brand South Africa.

South Africa. The Presidency. (2011). *National Development Plan 2030: Executive Summary*. Pretoria: Government Printer.

Taylor, G.R. (2005). *Integrating quantitative and qualitative methods in research*. US: University Press of America.

Terre Blanche, M., Durrheim, K. & Painter, D. (2006). R*esearch in practice: Applied methods for the social sciences.* (2nd edition). Cape Town: University of Cape Town Press.

32

Integrating Technological and Educational Collaborations:
Enhancing Leadership and Participation in STEM Fields
Lineo Lynnette Tool

Toolo, L.L. (2018). *An Awareness Programme to Improve the Participation of Young Women in the Science, Technology, Engineering and Mathematics Fields in South African Universities*. Pretoria. University of South Africa.

UNESCO. (2016). Closing the gap in STEM: Drawing more girls and women into science, technology and engineering. *Education Thematic Brief*. August. (Asia Pacific, UNESCO).

UWESO Consulting. (2015). *Techno-Girl: 2015. Alumni Milestone Report*. Johannesburg. South Africa.

33

Integrating Technological and Educational Collaborations:
Enhancing Leadership and Participation in STEM Fields
Lineo Lynnette Tool