MULTI-LEVEL STUDENT PEER ASSISTED MENTORING (MSPAM) OF COMPUTER SCIENCE FEMALE STUDENTS AT UNDERGRADUATE

By

CHALWE MUSONDA

A dissertation submitted to the University of Zambia in partial fulfilment of the

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Declaration

I, Chalwe Musonda, do hereby declare that this dissertation is my own original work and has not been submitted to any other college, institution or university other than the University of Zambia.

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Certificate of Approval

This dissertation of Chalwe Musonda has been approved as partial fulfilment of the requirements for the award of Master of Science in Computer Science by the University of Zambia

Examiner 1

Name: DR. M. NYIRENDA

Signature:

Date: 8/6/23

Examiner 2

Name: DR. E. LAMPI

Signature:

Date: 16/6/2023

Examiner 3

Name: DR. JACKSON PHIRI

Signature:

Date: 16/06/2023

Chairperson (Board of Examiners)

Name: DN I.D. TEMBO

Signature:

Date: 26/06/2023

Supervisor

Name: MUNDE KABEMBA

Signature:

Date: 16/06/2023

Abstract

The percentage of female students majoring in computer science is lower than that of male students. Computer science has one of the lowest shares of women degree recipients among the broader field of Science and Engineering, with reports of only nineteen percent of the computer science degrees in 2016 been awarded to women. As such, fewer women than men enter the computing profession, leading to a gender disparity in the computing workforce. One way to improve the current state is to mentor female students in the field of computer science at both undergraduate and in industry.

This study explored the current state of mentorship programs in institutions of higher learning in Zambia with the aim to develop a structured mentoring program for enhancing the performance of undergraduate computer science female students. The study used interviews and observations to gather qualitative data in order to review mentorship program that the universities are running for the female computer science students at undergraduate. The study found that the informal type of mentorship was used by 35 percent of individual lecturers without being aware of its application and structure. After reviewing the mentorship programs in the universities the results show that mentorship programs were 100 percent non-existent in the Zambian universities. While mentoring was something that would improve the performance, it still however, presented these two challenges, lack of clear definition for mentorship and structuring the program to be used to improve the number of female computer science students.

This study has led to Multi-level Student Peer Assisted Mentoring (MSPAM) framework for a 4 year computer science undergraduate program. MSPAM optimises peer mentoring by drawing mentors from other students in different years of learning and organising these mentors into different levels of mentorship.

The lower female graduation rates in the field of computer science contribute to continued disparities in which women only account for nineteen percent of the computer science workforce. Offering Multi-level Student Peer Assisted Mentoring would help close the gap.

Keywords: mentor/mentee, peer, computer science, multi-level, female, mentorship

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List of Abbreviations and Acronyms

CDC	Curriculum Development Centre
CS	Computer Science
DRGS	Directorate of Research Graduate Studies
ENIAC	Electronic Numerical Integrator and Computer
ICT	Information Communications and Technology
IEEE	Institute of Electrical and Electronics Engineers
IT	Information Technology
MOHE	Ministry of Higher Education
MSPAM	Multi-level Student Peer Assisted Mentoring
SPAM	Student Peer Assisted Mentoring
STEM	Science, Technology, Engineering and Mathematics
UNZA	University of Zambia
WAVE	Women Accepted for Volunteer Emergency Service

CHAPTER ONE

INTRODUCTION

1.0 Introduction

Only a small percentage of computer scientists and computer professionals are female. However, the concerns are due to the growing gender disparity in the field of computer science. The field of computing has increasingly developed a gender gap which has made the field become more male dominant with a decline in the number of females pursuing education or working within the field. This has brought in lack of diversity in the field of computer science. Concerns of improving perspective in the field, creating more diversity, and attempting to close the gender gap motivated public policy debates addressing gender equality due to the growing importance of computing and technology in society [1]. Providing a mentor to guide the learning and to help shape the professional growth of the women, as well as to serve as a positive role model enables the students to enhance their formal and informal educational performance. When women are under-represented in this field, novel solutions that diversity brings in addressing real world problems such as climate change, renewable energy, and universal access to education and health services are missed out.

Definitions of mentoring in education should be dependable and appropriate to the educational setting. One of the most apparent problems within the mentoring literature was the lack of consistency in defining mentoring among organizations and universities that design mentoring programs not only in Zambia but also abroad. [2] Conferring to Jacobi this absence of an operational definition leads to less effective research. Furthermore, peer-mentoring programs appear to define their programs based on older and commonly used business and organizational definitions. Definitions ranged from coach to mentor to career sponsor, or in the context of higher education, peer counsellor. [3] Encompass this entire range by quoting [4], who defines a mentor as someone "who oversees the career and development of another person, usually a junior, through teaching, counselling, providing psychological support, protecting, and at times promoting or sponsoring".

Mentoring has never been clearly defined and if clearly defined it would have been easy to adopt in our Zambian universities. It is believed that, "*if you are seeing further it's that you are standing on the shoulders of the giants*". Various Scholars have come up with the

definition of mentoring in different ways and applications. One on one instruction or mentoring is one of the oldest forms of teaching. Our parents and grandparents are our earliest mentors; later, we may be mentored by or act as mentors to our brothers, sisters, and friends. Mentorship programs work because they provide encouragement and guidance to each individual that participates in it.[4]

After reviewing literature, the following key definitions favour my study: a more advanced or experienced individual guiding a less experienced individual; an older individual guiding a younger individual; a faculty member guiding a student; an individual providing academic advising; an individual who shares their experience with another individual; an individual who actively interacts with another individual; an experienced individual guiding a group of individuals; and an experienced, older individual who guides a younger, less experienced individual.

However, various scholars have defined mentoring/mentorship and the following are their definitions:

Mentorship is a relationship in which a more experienced or more knowledgeable person helps to guide a less experienced or less knowledgeable person. The mentor may be older or younger than the person being mentored, but he or she must have a certain area of expertise. It is a learning and development partnership between someone with vast experience and someone who wants to learn. Interaction with an expert may also be necessary to gain proficiency with/in cultural tools. Mentorship experience and relationship structure affect the "amount of psychosocial support, career guidance, role modelling, and communication that occurs in the mentoring relationships in which the protégés and mentors engaged. 'The person in receipt of mentorship may be referred to as a protégé, a protégée, an apprentice or, in the 2000s, a mentee. The mentor may be referred to as a godfather or godmother.[3]

Mentoring is a process for the informal transmission of knowledge, social capital, and the psychosocial support perceived by the recipient as relevant to work, career, or professional development. Mentoring entails informal communication, usually face-to-face and during a sustained period of time, between people who are perceived to have greater relevant knowledge, wisdom, or experience (the mentor) and a person who is perceived to have less (mentee).[4]

Mentoring is a relationship that meets a development need, helps develop full potential, and benefit all partners, mentor, mentee and the organisation. [4]

Mentoring is a protected relationship in which learning and experimentation can occur, potential skills can be developed, and in which results can be measured in terms of competencies gained.[4]

Mentoring is " A mutual relationship with an intentional agenda designed to convey specific content along with life wisdom from one individual to another. Mentoring does not happen by accident, nor do its benefits come quickly. It is relationally based, but it is more than a good friendship." [4]

Mentoring is a supportive learning relationship between a caring individual who shares knowledge, experience and wisdom with another individual who is ready and willing to benefit from this exchange, to enrich their professional journey.[4]

Mentoring is an important adult relationship since it creates a legitimate and special space where people can take chances by trying to be authentic about, and find meaning within their real-life professional experience. [4]

The purpose of mentoring is always to help the mentee to change something – to improve their performance, to develop their leadership qualities, to develop their partnership skills, to realise their vision, or whatever. This movement from where they are, ('here'), to where they want to be ('there').[3] [4]

Mentoring involves primarily listening with empathy, sharing experience (usually mutually), professional friendship, developing insight through reflection, being a sounding board, encouraging". [4]

Mentoring is an intense work relationship between senior and junior organisational members. The mentor has experience and power in the organisation, and personally advises, counsels, coaches and promotes the career development of the protégé.[4]

A mentor is…"an accomplished and experienced performer who takes a special, personal interest in helping to guide and develop a junior or more inexperienced person".[4]

A mentor facilitates personal and professional growth in an individual by sharing the knowledge and insights that have been learned through the years. The desire to want to share these 'life experiences' is characteristic of a successful mentor.[4]

A mentor is a more experienced individual willing to share knowledge with someone less experienced in a relationship of mutual trust. [4]

A mentor is someone who can patiently assist with someone's growth and development in a given area. This assistance can come in the form of guidance, teaching, imparting of wisdom and experience. [4]

This dissertation proposed the Multi-level Student Peer Assisted Mentoring (MSPAM) program of female computer science students at undergraduate, as a method that would help female computer science students at undergraduate in many areas of Computer Science related technologies. The advantage of Multi-level student peer assisted mentoring is that mentors and mentees are close in age, almost found in the same campus or environment, same experience, educational level, and they may overlap in their personal identities. Female students who participate in a peer-mentoring program would twice stay in university than those who did not participate in the program. This system can support new female student's entrants from higher level that would be third or fourth year students. Without adequate peer support, women are likely to leave computing programs at higher rates than men [5]. When a department's gender composition is unbalanced, women have less access support from female classmates. This lack of support leaves women particularly vulnerable to unfavourable departmental conditions. However, lack of peer support can be overcome when the faculty and the larger environment create favourable conditions for females. Mentoring programs in universities provide first-year undergraduate students with adequate and timely access to support services and opportunities to become part of the community that is 'a university' [6].

1.1 Success of Mentorship Program

There has been no detailed data about mentorship program existence in Zambian universities. During the literature review few trace of data indicate that the mentorship program is either new in the higher education system or not in existence at all. Mentoring can add great richness to the university experience through the valuable dimensions of informal guidance, role modelling, support and encouragement that enriches students' ongoing undergraduate academic and social development [7]. Mentoring assists in the development of academic and social competence both on the part of the mentor and mentee [7] and is linked with favourable attitudes and lower attrition [8]. Even within these limitations, as [2] pointed out

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in her review of the literature of 1990 on mentorship program, she adds that there is a wide variety of such programs, differing in their methods, focus, and theoretical orientation and this is the situation in Zambian universities. Jacobi also stressed the need for evaluative research "to measure the effectiveness of formal mentoring programs". The few evaluations that have been reported have focused on either the link between mentoring and academic success as evaluated by [9] or on the impact of mentoring on adjustment to university life [10]. [9] Rodger and Tremblay in their research found that, students who used the peer-mentoring program gained higher grade point averages than those who did not and that the program worked particularly well for students scoring high in anxiety because they tend to settle as soon as they are enrolled in peer mentoring program of the university.

1	Clear, functional definition of mentoring
2	Definition of success for mentoring relationships
3	Detailed context for the mentoring relationship
4	Detailed list of the roles mentors are playing
5	Attributes for effective mentoring relationships
6	Account of who is doing the mentoring
7	Metrics for assessing knowledge, skills, and effectiveness of relationships
8	More methodologically rigorous studies

Table 1.1 What Is needed for the Success of the Mentoring Program at Undergraduate in Computer Science Department

With the full support from the Government of Zambia, The ICT sector has recently seen tremendous growth and has made deliberate efforts to prioritize ICTs in the Sixth National Development Plan (SNDP). The focus of the Government is to establish an environment that encourages networking of services and applications; promoting e-commerce, e-government and trade promotion programs for goods and services, furthermore, promoting ICT access to exchange and access digital content; establishing e-government online services; promoting e-education and e-health. The sector has achieved remarkable development in the past decade with major reforms and formation of an ICT policy. The sector has recorded huge penetration levels of about 35% as compared to 0.02% growth 14 years ago. [12].

If the untapped potential of women continues to be ignored and under-utilised, this will have an adverse major impact on Zambia's economy in future. Women are needed in Computer Science to ensure that Zambia continues to prosper as a technology hub and remains an attractive centre for technology companies to locate and remain here.

1.2 The Current Local Situation

Peer mentoring programs are an important component in the strategy to increase and maintain the number of female computer science students at undergraduate. Many Universities and Colleges have deficiencies includes lack of a clear definition for mentoring and structuring the program to be used in increasing and maintaining the number of female computer science students.

By 2017, The University of Zambia had a total number of 22,598 Students of which 7,231 (32%) were males and 15,367 (68%) were females. [13].
Copperbelt University is a public university in Kitwe, copperbelt province, Zambia. It is the second-largest public university. The Copperbelt University has 15,900 students and produces an annual average of 1, 500. The total number of students in 2017 was 11,900, of which 37% (4, 403) were males and 63% (7,497) were females. [13]

Mulungushi University is public university in Kabwe, central province of Zambia has the student population of 13,500 of which 6,345 (47%) were females and 7,155 (53%) were males. In 2016 there were 900 students who graduated at undergraduate in all disciplines offered by the university, out of the number only 16 graduated from computer science of which, 12 male students and 4 females students. In 2017, 20 computer science students graduated, 15 male students and 5 female students. [13]

Research suggests that supplemental instruction in the form of peer assisted learning can have a positive effect on student learning [14] and result in improved academic performance [15]. Programs of this nature have been found to be effective in producing positive differences in student performance and retention rates [16]. In Australia, researchers [17], [18], [19], [20] have examined various peer-mentoring programs and their findings provide further evidence of the existence of benefits in terms of student performance, retention and satisfaction. After conducting a research in Zambian universities it was established that the universities luck the motivation programs like mentorship more especially to female computer science students.

Below is the model of the current situation of Zambian Universities.
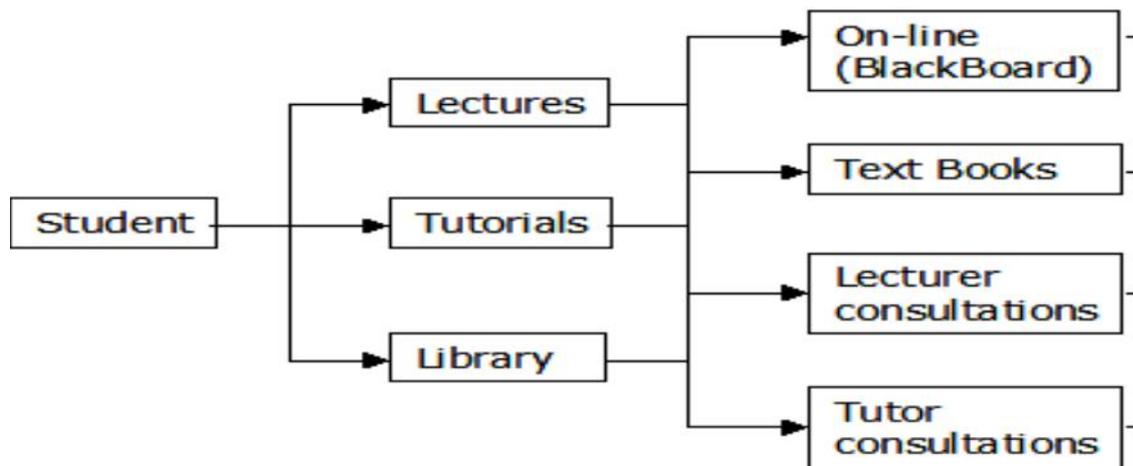
Figure 1.2 Model of current situation in Zambian Universities

Referring to figure 1.2 above, the students at first level are exposed to formal education experience. The female student interacts with the lecturers, tutorials and library. That is formal education support with limited sources of educational material, she gets the online materials, Textbooks from the library and where possible they consult the lecturers who are busy most of the time. If we were to produce a all-rounder computer science female, this model is incomplete because it looks at formal educational support, excluding the informal aspect of education of which this research is proposing as multi-level student peer assisted mentoring which goes beyond the formal education experience support.

The basic distinction between formal and informal mentorships lies in how these relationships are arranged. Informal mentorships are not managed, structured, nor formally recognized by the university. These relationships occur spontaneously without external constraints from the organization. In contrast, formal mentorships are programs that are arranged, managed, and sanctioned by the university. These structured programs vary widely in their administration and scope. While informal and formal mentorships can take place simultaneously, the university may view them quite differently.

1.3 Significant of the Study

Females bring a different perspective to innovation and problem solving and can ensure that concerns unique to females will not be overlooked and so multi-level student peer assisted mentoring is a method that will help the computer science department at undergraduate to increase and maintain the number of female graduates in the field and related technologies and hence increase the number. Also females tend to be social oriented than males, so they can easily mix their technical skills with social and communication skills which are crucial when dealing with computer science in a business environment. This will ultimately result in products that will be designed to be more representative of all users.

1.4 Research Question

The main area of research for this dissertation is to study,

- "What is the structure of student peer mentoring program in Computer Science?"
- "To what extent can we develop the student peer assisted mentoring program in Computer Science program?"
- "How can we integrate Multi-level Student peer Assisted Mentoring and to what degree does mentoring contribute to academic success?"

For the purpose of this study the term 'Computer Science' encompasses courses such as Computing, Computer Applications, Computational Thinking, Multimedia, Mobile and Web Development, Software Engineering, Information Technology, Computing that are on offer in various Zambian universities at undergraduate for first, second, third and fourth level/year.

1.5 Problem Statement

While mentoring is something that can improve the performance, it however presents these two challenges, lack of a clear definition for mentoring and structuring the program to be used to improve the performance of female computer science students.

1.6 Aim and Objectives

The aim of this study is to develop a structured peer mentoring program for enhancing the performance of undergraduate computer science female student. In order to undertake the research, the following objectives were identified:

- To review the structure of student peer mentoring programs.
- To develop the student peer mentoring program in computer science program.
- Propose an integrated multi – level student peer assisted mentoring framework for a 4-year computer science program.

1.7 Contributions

Recently, considerable literature has built up around the theme of student peer assisted mentoring as a solution to close gender disparity in computer science and computer industry but the majority of these studies are focused on developed countries and not on developing countries like Zambia. This study explores the structure of student peer mentoring program in computer science and "How can we integrate female student peer assisted mentoring and to what degree does mentoring contribute to academic success?" why female student are not choosing to study Computer Science at first or second level in university.

1.8 Chapter Summary

Mentoring is not only important because of the knowledge and skills gained, also students can learn from peer mentors, because mentoring provides professional, socialization and personal support to facilitate success in graduate school and beyond. Mentoring greatly enhances student's chances for success. Females are important in the field of computer science and related technologies in that they bring a different perspective to innovation and problems solving and can ensure that concerns unique to females are not overlooked. This will result in the products designed to be more representative of all the users. Among the many reasons cited by researchers for the scarcity of females in Computer Science, negative stereotypes and curriculum had been cited to explain why females are not choosing to study Computer Science.

According to Teague and Clarke, states that, this perception can make Computer Science seem insinuating and repellent. Findings from the various bodies of literature suggest that females have a desire to work in more people orientated careers and do not feel that a career in Computer Science can fulfil this. [22] [23].

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

Various researcher have discussed on the topic, this study has taken a different dimension on the value and importance of mentoring programs. In the most recent years, both global and local statistics are available, women received a third of the bachelor's degrees in computer science, 27 percent of master's degrees, and 13 percent of PhDs. Not only do women make up just 7.8 percent of computer science and computer engineering faculties, only 2.7 percent of tenured professors are female [24].

Extensive research conducted by Sax Linda etal [25] in United States shows that the representation of women in the computing field has declined over the past thirty years. Currently, women only make up 18 percent of graduates with a degree in computer science. In a study based in the United States, "Anatomy of an Enduring Gender Gap: The Evolution of Women's Participation in Computer Science", researchers found an overall decline in women's intent to major in computer science field. They found that by 2011 only 0.4 percent of women planned to major in computer science compared to 3.3 percent of men. The study also found, as of 2011, only 15 percent of women were computer science majors. [25]

2.1 Global statistics

The previous researches demonstrates that, in the United States, the proportion of women represented at undergraduate computer science education and the white-collar information technology workforce peaked in the mid-1980s, and has declined ever since. In 1984, 37.1% of Computer Science degrees were awarded to women; the percentage dropped to 29.9% in 1989-1990, and 26.7% in 1997-1998. [26]. Figures from the Computing Research Association Taulbee Survey indicate that fewer than 12% of Computer Science bachelor's degrees were awarded to women at United States. PhD-granting institutions in 2010-11. ("Computing Degree and Enrollment Trends", 2010-2011 CRA Taulbee Survey). According to National Science Foundation, Division of Science Resources Statistics 2021, when looking at the percentage of women earning master's degrees, it peaked around 2000 at 33% and dropped to 27% in 2013. Computer science holds one of the lowest proportion of women holding a doctorate's degree in the field. [27]

Although teenage girls are now using computers and the Internet at rates similar to their male peers, they are five times less likely to consider a technology-related career or plan on taking post-secondary technology classes. [28] [25]. The National Center for Women & Information Technology (NCWIT) reports that of the SAT takers who intend to major in computer and information sciences, the proportion of girls has steadily decreased relative to the proportion of boys, from 20 percent in 2001 to 12 percent in 2006. [29].

2.1.0 Workforce perspective

Women's representation in the computing and information technology workforce has been falling from a peak of 38 percent in the mid-1980s. From 1993 through 1999, Nation Science Foundation's Scientists and Engineering Statistic reported that the percentage of women working as computer/information scientists (including those who hold a bachelor's degree or higher in an S&E field or have a bachelor's degree or higher and are working in an S&E field) declined slightly from 33.1percent to 29.6 percent while the absolute numbers increased from 170,500 to 185,000. Numbers from the Bureau of Labor Statistics and Catalyst in 2006 indicated that women comprise 27-29 percent of the computing workforce. [30], [31]. In support of [30], Laura Sydell, shows that, a National Public Radio report in 2013 stated that about 20 percent of all United States computer programmers are female. In open source fields, only 10 percent of programmers are women. [32]

Corbett C and Hill C, supports that, student peer mentor might also increase a university student's self-esteem and academic self-efficacy, as well as general satisfaction with their academic program. [33]

Comgos & Schopes recommends that supplemental instruction in the form of peer assisted learning can have a positive effect on student learning [14] and He is supported by [15], that the result improve academic performance [15]. Programs of this nature have been found to be effective in producing positive differences in student performance and retention rates [16]. In Australian researchers [17], [18], [19], [20] have examined various student peer-mentoring programs and their findings provide further evidence of the existence of benefits in terms of student performance, retention and satisfaction. After conducting a research in Zambian universities found that they lucked the motivation programs like mentorship more especially to female computer science students.

Mentorship program is a mechanism that will maintain or close up the gap of gender disparity in the Computer Science sector. This is well-documented and researched issue and despite increases in the numbers of women in some of the other stereotypical male industries such as science and maths, Computer Science is not following the same trend. For some reason, it has struggled to entice women into the industry, which is in contrast to all other STEM (Science, Technology, Engineering and Maths) disciplines [27].

Jenepher Lennox Terrion & Dominique Leonard investigated that, Student peer assisted mentoring in higher education have regarded as an effective intervention to ensure the success and retention of vulnerable students. Many universities and colleges have therefore, implemented some form of mentoring program as part of their student support services. [34].

One of the main benefits of mentoring women is that women perceive mentoring as critical to the development of their career [35], [36], [38]. For example, research conducted on Hispanic women showed that they thought mentoring was extremely important for their career development, and that this importance was exemplified by the fact that it is very difficult for Hispanic women to receive traditional mentoring [35], [38] also found that in dyads where the mentor was male and the mentee was female, the mentee reported a higher amount of career development than any other arrangement of mentoring dyads.

Jacobi's assertion that there is no research on how mentoring actually improves academic achievement is valid. Most of the research and articles on mentoring in higher education draw from the business mentoring literature. [2]. According to Jacobi, it means that mentoring introduced in higher education can help far better than it has done in business circles.

According to Ralph, Peer mentoring programs have been widely adopted by universities and colleges as important components of their strategies to enhance the experience of first year students to assist them in making the transition from secondary school to university level. These programs involve senior students mentoring entrants. Using senior students as mentors rather than faculty members takes advantage of their ability to share their own recent experiences as students, and thus the process does not involve the status differences that may exist between faculty and students. Academic achievement is, however, just one indicator of the success of a peer-mentoring program and is not necessarily applicable to all such programs.

[39], described lack of student peer mentoring program to contributing to gender disparity in computer science at undergraduate.

[40] presented that peer assisted mentoring can be effective in other careers and industries apart from higher education. [40] Interviewed managers involved in mentorships and concluded that mentors provide two distinct functions for their mentees. One function is a career function and is directly related to the mentee's career advancement. Through the career function, a mentor sponsors and coaches the mentee by providing challenging assignments and ensuring the mentee receives good exposure and visibility to others. The second function is the psychosocial function and is more concerned with the mentee's self-image and competence. Through the psychosocial function, the mentor is a friend who counsels and confirms the mentee's role in the organization.

Besides being popular in the business and organizational setting, mentorship programs are also abundant in high schools, middle schools, and pre-schools. These programs typically pair a teacher or an older student with a K-12 student in order to increase self-esteem, academic achievement, goal setting, and relationship building [41]. According to Ryan, Whittaker, and [42], successful mentoring programs with younger students require facilitating the growth of mentee/mentor relationships that produce social, emotional, academic and/or economic development for students involved in the program.

2.2 Female's history in computer science and related field

Regrettably, computer science was not always the male-dominated industry. Female had a long history in computing and a very significant presence in the early days when they constituted, almost exclusively, the first programmers and operators of computers.
Ada Lovelace recognised as the first female programmer worked with Charles Babbage on his mechanical computer back in the 1840s. She was an accomplished mathematician and foresaw that Charles Babbage's machine could go beyond the task of number crunching and that it could be used for other computational applications. Her vision eventually became a reality in the 1940s when there was a move away from 'number crunching' to the use of symbols and rules, what we acknowledge as a 'programming language' today. [43].

Grace Hopper was named an IEEE Fellow in 1962 "for contributions in the field of automatic programming" (IEEEGHN, 2014) and went on to win the first 'Computer Science Man of the Year' award in 1969 (Carter and Jenkins, 2001). In 1991, she was awarded the National Medal of Technology for her pioneering accomplishments in the development of computer programming languages that simplified computer technology and opened the door to a significantly larger universe of users (Office of Public Affairs, 2014).

During World War II (1939 – 1945), there were two revolutionary computing projects, the 'Colossus' in the United Kingdom and the 'Electronic Numerical Integrator and Computer' (ENIAC) in North America. Both projects had women at the forefront, operating the machines. Finding jobs in the computer science field allowed women to find higher opportunities in the workforce. Early programmers on machines such as ENIAC, were mostly women. [44]. The Colossus project was part of an allied effort to decode messages that were sent by Germany to Japan during the war. Women were recruited to work on Colossus from the Women's Royal Naval Service by interview and no previous mathematics or computer qualification was required. Since the Colossus project was top secret, these women did not know what they were being assigned to, yet they were perfectly able to operate the machines after the appropriate training [45].

In contrast, women made a specific choice to work on the ENIAC project. ENIAC was an electronic digital computer designed to calculate artillery firing tables for the United States army, a job that then required approximately 200 women or human computers as they were known, to do the job by hand. To program the ENIAC, the United States army hired six women, four qualified mathematicians and two with prior experience in programming [45]. These women were at the forefront of technology. It was a choice they made because it excited and challenged them. In 1997, these six women were inducted into the Women in Technology Hall of Fame (WITI, 2014).

Another very prominent and pioneering female computer scientist was Grace Hopper who earned her Master's and Doctorate Degrees in mathematics from Yale University before joining the US Navy WAVES (Women Accepted for Volunteer Emergency Service) program in December 1943. She became one of the first programmers of the Harvard Mark I computer, a computer built at Harvard University in 1944 to assist the US navy during World War II.

Hopper went on to develop the first compiler for a computer programming language [46]. She was involved with the development of COBOL programming language and she was accredited with coining the ubiquitous computer term 'debugging' after finding that a real bug had caused a malfunction in the Harvard Mark I.

Anita Borg is a more recent computer scientist who was a champion for tackling the issue of the under-representation of women in computing. Borg received her Doctorate in Computer Science from New York University in 1981. She co-founded the 'Grace Murray Hopper Celebration of Women in Computing' conference in 1994 to bring the research and interest of women in IT together. In 1997 she established the 'Anita Borg Institute for Women and Technology', a not for profit organization aimed at helping to introduce and retain women into IT [47]. Borg was inducted into the Women in Technology Hall of Fame in 1998 (WITI, 2014b) and has been awarded several other accolades such as the 'Melitta Bentz Woman of Innovation Award' in 1999 and the 'National Organization for Women, Excellence in Education Award' in 2002 [47].

Marissa Mayer is currently one of the most prominent women in the world of computing. Marissa earned a Bachelor of Science degree in symbolic systems and a Master of Science degree in Computer Science with a specialization in artificial intelligence from Stanford University. She was one of the first female engineers hired at Google in 1999 and worked there for thirteen years before going on to become the CEO of the company Yahoo! Mayer is also one of only 23 women running a Fortune 500 company.

Studies have shown that women have been involved in computing for at least more than 150 years, their history is well ignored, if not almost erased. Few of their achievements are known to the general public or even employees in the computing industry. Highlighting the history of women in computing and celebrating their contribution is critical to changing the current male dominated culture that pertains in computing today.

2.3 Self-confidence and Self Efficacy

Numerous studies have found that female have lower levels of self-efficacy than males when it comes to stereotypical male dominated subjects such as mathematics, engineering and computers [48]. That it is this lack of self-confidence, not ability that is the most significant difference between male and female science students [49].

Expectations of Computer Science students are very high and this can be discouraging for females who may automatically feel they are not good enough [49]. Even if females do develop positive computer beliefs and apply to second year to study Computer Science, they can lose their confidence and interest in computers because of the unaccommodating culture and environment they have entered, [49].

Self-confidence is crucial for females and, if not nurtured, can have detrimental effects. "It may decrease the likelihood that female will choose to major in Computer Science and increase the likelihood that female Computer Science majors will drop out of Computer Science" [48].[50] found that for female to develop a confidence in themselves, it was crucial that others had to believe in them and show that they had confidence in them.

Low self- confidence levels and poor self-efficacy beliefs can influence females' choices to study, enter or remain in a career more especially in Computer Science. Self-efficacy beliefs are a cognitive evaluation of an individual's ability to successfully perform tasks and reach goals. [51]

2.4 Role Models and Mentors

Role modelling is one of the methods most schools use to encourage students in a particular field of study. Mentoring has not been used in the past though it is another effective method of encouraging students in a particular field of study. A role model is "a person who serves as an example of the values, attitudes and behaviours associated with a role" [52]. When thinking of role models in the Computer Science and technology industry the names of people who are at the forefront of the exciting technologies are Steve Jobs from Apple, Bill Gates from Microsoft, Mark Zuckerberg from Facebook and Larry Page and Sergey Brin from Google, all of whom are male. These men are regularly discussed in the media and popularised as icons of the technology industry, thereby reinforcing the misconception that men are better than women when it comes to computer science and IT. Role modelling is like the informal mentoring where the mentee do not know that indirectly is been mentored by looking at the model. Having many male role model in computer science does not mean that we do not have female as role model in the field of computer science and related field. [53]

2.5 Key Nominal Strategies Employed

The admissions policy at mentioned university gave preference to students who had previous computing experience. It concluded that this policy was influencing negatively on the number of female students since females were less likely than males to have previous experience in Computing. The university changed its marketing and admission policies to remove the restriction that directly resulted in the recruitment of more female students.

The Professor from one of the university found that culture plays an important role within the Computer Science department. Stereotypical attitudes and behaviours can have a negative impact on attracting and retaining female students. The university paid particular attention to the culture within the Computer Science department to ensure that no particular student group was dominating. It aimed to cater for not only female who really feel can do it temperament, but also for the student who has an interest in the broader gamut of computer application use in a harmonious environment.

2.6 Review of Structure of Student Mentoring Program

There are many structures of mentoring will review the various structures used by different universities outside Zambia. According to the literature reviewed, the following are the structures reviewed.

2.6.0 Mentorship structure of Texas San Antonio School of medicine

The University of Texas San Antonio, School of Medicine initiated Veritas, a student-advising program, in 2006 with a goal of enhancing the professional development of medical students by fostering relationships and assisting students to make informed decisions about their careers. Approximately 220 students enter the medical school each year. At enrolment, students are randomly assigned to one of 20 Veritas groups. This assignment occurs with each incoming class so that across the 4 years of medical school, there are total of 44 medical students per Veritas group (11 each of MS1-4 students). Each Veritas group has a faculty mentor (see Fig. 2.6.0 below).
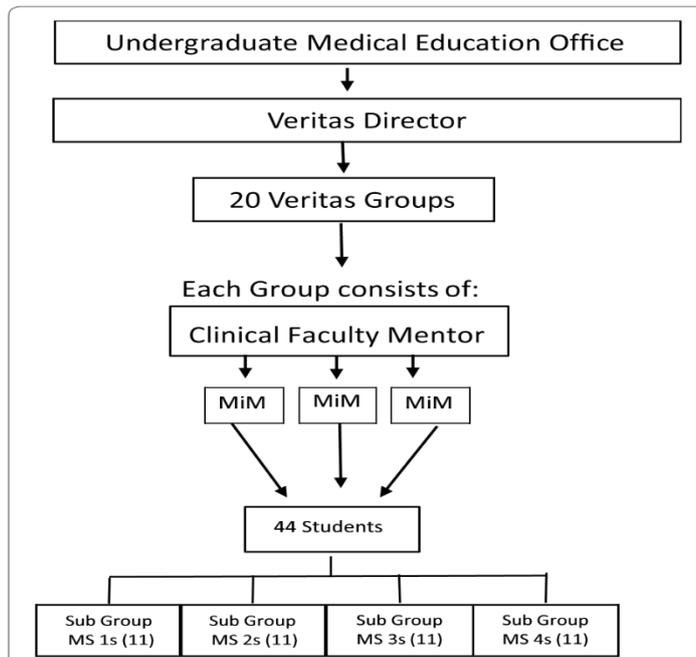
Figure 2.6.0: Mentorship structure of Texas San Antonio School of medicine

Students receive mentorship through group and one-on-one activities. Meetings of subgroups of Veritas students (i.e., MS1s or MS2s classes as shown in fig 2.6.0) occur at least monthly. A subset of meetings are combined so students across classes can share experiences, in addition to choosing a career, study strategies, professionalism, and how to plan for life as a 3rd and 4th year. There are also events for all students within a class year, such as MS4 mock-interview night or MS3 boot camp. At least twice per year, all 44 students in each Veritas group come together for a social event. Finally, Veritas-wide events such as charity drives or theme days are sponsored.

2.6.1 Conceptual framework of the Student Peer Assisted Mentoring (SPAM)

Ross Kirkham and Damian proposed the student peer assisted mentoring conceptual framework; it was not specifically looking at the female computer science students but both females and males in all courses. Student Peer Assisted Mentoring (SPAM) works on two distinct levels one for the student mentees and the other for the student mentors. The mentoring model works for the student mentees because the sessions are conducted in an informal setting and focus on the learning needs of the student mentees. The nature of the approach is proactive rather than reactive and is aimed at providing learning techniques to

equip the student mentees with the ability to solve problems not just answer questions. Student mentees are encouraged to ask and discuss their learning needs and to develop good study techniques including the formation of study groups or networks even outside the SPAM program as shown below in figure 2.5.2. [53].
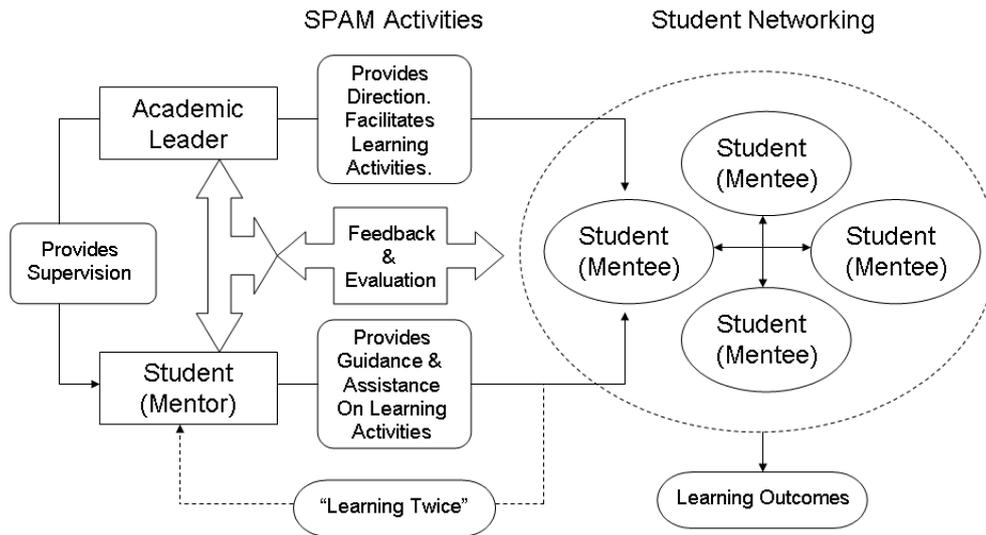
Fig 2.6.1. Conceptual framework of the Student Peer Assisted Mentoring (SPAM)

The model works for the student mentors by attracting them to become involved, which it achieves by providing them with a formal recognition of their involvement. The mentors are provided with guidance and training for the development of pertinent skills and abilities. [53].

2.6.2 Model of educational aspects of mentoring

The proposed model looks at the four educational aspects that is formal educational experiences, formal educational support, informal educational experience and educational outcomes. In this model, the mentor is a student, who is in any level of study.
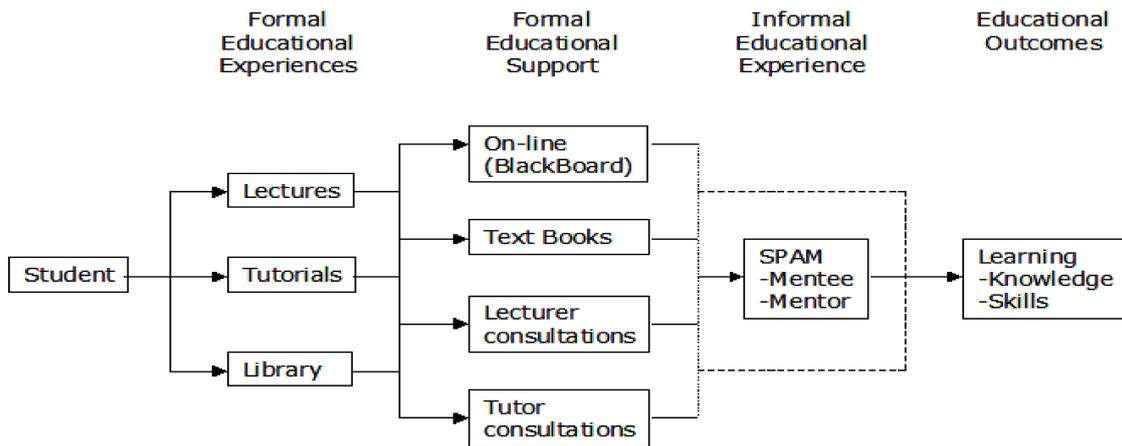
Figure 2.6.2 Model of educational aspects of mentoring

With this structure of mentoring approach consisted of one full time academic leader with the support of one sessional academic leader providing supplemental instruction. This is became the nucleus for the development of the Student Peer Assisted Mentoring SPAM program. Two of the students from this initial group became mentors in the following year. Effectively, the two students who had undertaken the SPAM program in the previous year volunteered to act as mentors for students who were having difficulties with understanding the first year any course and topics. This was the embryonic stage of the student peer-assisted mentoring approach. These mentors were supervised by the academics who acted in the capacity of supervisors. However, the program did not continue in the same format after 1992 due to difficulties in attracting and retaining student mentors. Under the original format, mentors were available at a prearranged time each week, so that students could ask questions about the topics covered by the lectures and discuss problem solving skills for homework. These sessions, were aimed at providing a form of supplemental instruction on a more individual basis than would occur in a tutorial. Students were able to ask questions without any fear of being ridiculed for their lack of understanding of the topic. The Mentors were required to keep a record of attendance so that the mentored students' academic progress in normal course assessments such as assignments and review quizzes could be monitored. This was particularly useful for monitoring whether the students had gained an understanding of the topic or whether they were still encountering problems. At the end of semester, students were asked if they were satisfied that the mentoring program had assisted their learning and whether their learning requirements had been, met. [53].
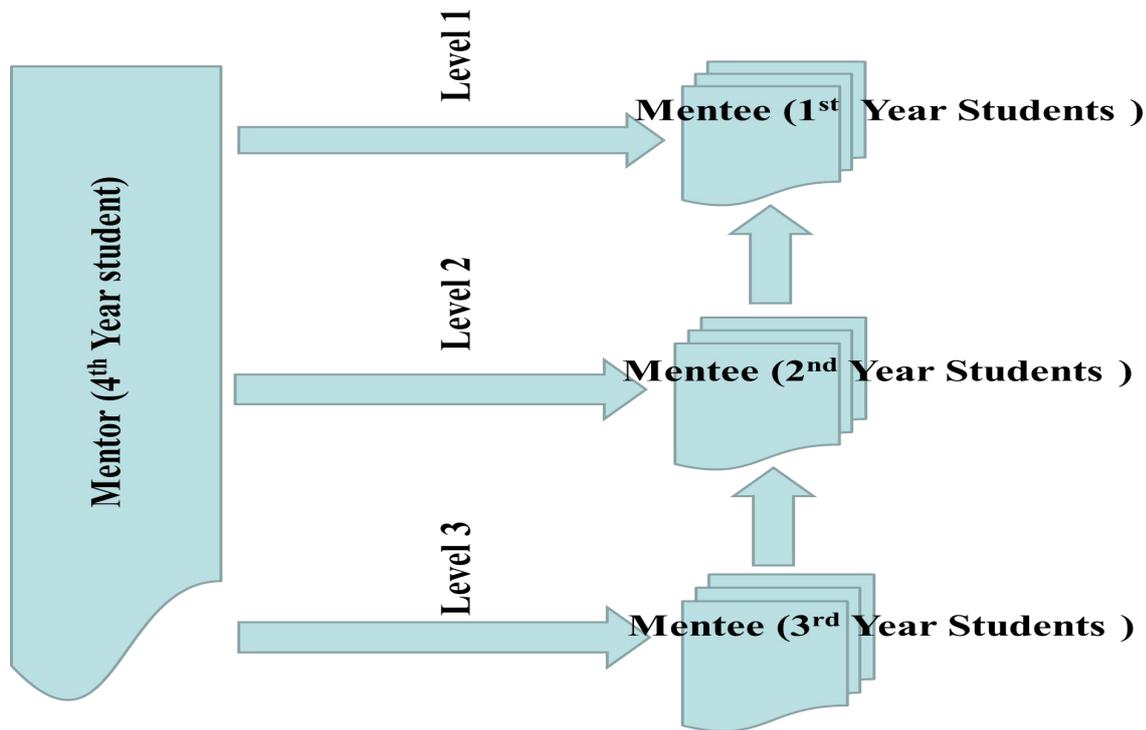
Figure 2.6.3 Conceptual Framework of a proposed Integrated Multi-level Student Peer Assisted Mentoring for a 4 year Computer Science Female student Program

2.7 Literature findings

This chapter reviewed the literature in the area of student peer mentoring of female computer science students at undergraduate, with particular reference to maintaining the number of female student in computer science. Programs of this nature have been found to be effective in producing positive differences in student performance and retention rates [16]. The Australian researchers [17] have examined various student peer-mentoring programs and their findings provide further evidence of the existence of benefits in terms of student performance, retention and satisfaction. After conducting a research in Zambian universities found that, the universities luck the motivation programs like mentorship more especially to female computer science student. The history of women in computing highlighted the fact, that it was not always the male-dominated environment that exists today; women were at the forefront of Computer Science/IT from its appearance. Existing literature indicates that, there are a number of factors that contributes to the maintenance of females in the computing industry.

The portrayed image of people working in the Computer Science/IT industry has created a stereotype that women find hard to relate to them. A computer scientist is typically depicted as somebody who is unsocial different from the woman's make up by creation. The resulting stereotype threat is influencing women's career choices with regard to Computer Science. [54]

Kutoma Jacqueline Wakunuma investigated that, there is no compulsory Computer Science course/subjects on the curriculum in primary or secondary schools in Zambia, it does not promote or encourage students to study Computer Science at university level. [55]

The literature reviewed shows that, there are a number of people who hold influencing roles in helping females choose their career path such as parents. Parents play a very important part and can be among the most influential people in their children's life. However, parents, specifically mothers, are biased in relation to what they expect their children to be good at, depending on their gender. [54]

Male-dominated fields can be highly intimidating and unwelcoming places for females. Many females who accept a place on second level Computer Science courses find themselves in a minority. This can be unsettling and can be further compounded if the majority of their lecturers are male also [49]. It is widely accepted that exposure to successful females in Computer Science would show females that they can indeed be successful in the field [56], [57]. Females should be able to relate to female role models and it would promote confidence among them that they too can be successful in a Computer Science career. Female role models show that it is possible for women to succeed in this male-dominated industry. [56] [57].

A study by Craig [58] showed that women studying in an undergraduate business computing course who participated in a peer-mentoring programming were twice as likely to stay in university then those who did not participate in the program. The program was fully supported by Victoria University of Technology who allocated time and facilities to those participating. The mentors were female students in third and fourth year of the course as they could assist and support new students as they had already been through the experience. The retention rate for those participating in the program was 90 per cent while the retention rate for non-participants of peer-mentoring programming was only 45 per cent. [58].

2.8 Identified gaps of the current Mentorship

There was informal type of mentorship used by 35 percent of individual lecturers without being aware of its structure and application, since mentorship has not being clearly defined and so many educators are not sure of it.

There is no defined structure, methods, focus and theoretical orientation. There is no focus on female students at undergraduate computer science to be specific.

The conclusion was that there was lack of integration and social academic support, it is the most appropriate for this program that focuses on engagement rather than instruction.

Of all the three mentorship structure reviewed, the mentorship program structure of Texas san Antonio school of medicine is favourable to my study, because with Multi-level student peer assisted mentoring would be used by the 2nd, 3rd, and 4th year female computer science students that would be of different levels being mentors and the 1st year female computer science students as mentees whereas, mentorship program of Texas San Antonio school of medicine starts at enrolment where first year students (mentees) are randomly assigned to either 2nd year or 3rd year students (mentors) and receive mentorship through group and one-to-one which is done by the lecturers and the head of section.

CHAPTER THREE

RESEARCH METHODOLGY

3.0 Introduction

This was a qualitative study in which different methods were used to collect primary and secondary data which included observations, interviews and literature review.

To achieve the objective number one (1), interviews and literature review was conducted. Literature review highlighted the fact that the Deans and Heads of Department are an important influencing factor for students with regards to their career choices. To explore this theme, a semi-structured interview checklist was designed to gather qualitative data to review mentorship program that the universities are running for the female undergraduate and how many female students get to second year in Computer Science field of study.

Five (5) interview sessions were conducted with the deans and Heads of Department of computer science for the three (3) public universities. Participants were invited to attend a face-to-face interview at a time and location that was convenient for them. Two (2) interview sessions took place face-to-face while three (3) were conducted by phone due to constraints on the part of the interviewees. Interviews took approximately 20 minutes. Visited the universities and reviewed various literature on the structure of mentorship programs.

Objective number two (2), the analogy of multi-level student peer assisted mentoring is borrowed from the cache memory hierarchy. The purpose of cache memory is to store program instructions and data that used repeatedly in the operation of programs or information that the Central Processing Unit (CPU) is likely to need next. The cache are divided into blocks that increase the access time and speed and in reference to that analogy, the multi-level student peer assisted mentor would be fast and have speed accessing the mentee who happens to be their fellow student. During the read cycle operations, the access time and speed determines how memory blocks mapped to the cache line, when students interact around the campus, they automatically peer mapped in their groups of association. The operation of cache memory gives full ideas of the Academic leader and the Mentor to mentee operation. Academic leader (lecturer) stands in as a Central Processing Unit and the peer (student) to a mentee (fellow student).

The third objective, which was set, achieved on the proposed framework, (shown in figure 4.0) the academic leader happens to be a lecturer. This is in order to reduce the cycle of consultations and the gap between the student and the lecturer. The mentors and mentees are close in age, experience, educational level, and they may overlap in their personal identities.

This chapter reviewed the different research methodologies used and identified the research philosophy most appropriate to the research, namely, pragmatism. The strategies used for primary data collection were interviews and the literature review, which helped to achieve the second objective by asking questions, gathering information and then presenting the facts. However, it is also the process of collecting, analysing, and interpreting data in order to understand a phenomenon [59]. To conduct research, a number of factors need to be taken into consideration such as research philosophies, research approach, research strategy, research choices and timelines as well as steps taken to conduct the research.

3.1 Data Validation

Data validation refers to the process of ensuring the accuracy and quality of data. It is implemented by building several checks into a system or report to ensure the logical consistency of input and stored data. In automated systems, data is entered with minimal or no human supervision. For this system it was ideally supposed to be taken back to the universities to use it for 4 years. However due to time and resource the framework itself was used.

3.2 Research Philosophies

A research philosophy forms the foundation to any research question. It can be defined as "the development of knowledge and the nature of that knowledge" [60]. There are a number of business research philosophies available for consideration when carrying out a research project and the philosophy chosen depends mainly on the researcher and other practical considerations and constraints, such as time, location and costs. Researchers have diverse views on what is important and what is useful with respect to their particular research question.

The following research philosophies are widely accepted:

- Positivism

- Interpretivism

- Realism

- Pragmatism

3.2.0 Positivism

Positivism is an "epistemological position that advocates the application of the methods of the natural sciences to the study of social reality and beyond" [61].The independent researcher collects data and uses methods of observation and measurement to describe the event. Positivists takes a "realist position and assume that a single, objective reality exists independently of what individuals perceive" [62]. Positivists assume that subjects can be taken out of their natural environment and observed in a controlled setting. They would then assume that the behaviour observed is representative of behaviour in the natural environment [62].

3.2.1 Realism

Realism uses a scientific approach for the gathering and development of knowledge. "The philosophy of realism is that there is a reality quite independent of the mind" [60]. Realism is similar to positivism in that a scientific approach should apply to the collection of data and to explaining or understanding these data. It also takes the view that there is an external independent reality, separate from the individual's perceptions [61].

There are two types of realism - Direct and Critical. Direct realism is where our senses portray the world as it is and we perceive objects as they are. "Through the use of appropriate methods, reality can be understood" [61]. Critical realism goes one step deeper and argues that the researcher's conceptualization of reality is just a way of knowing that reality, that there is a distinction between the object and the terms used to describe and understand that object. Here, social conditioning impacts on the researcher's approach to data collection which contrasts with the positivist approach where the researcher is independent in the role of data collection.

3.2.2 Interpretivism

Interpretivism is the term used to describe the alternative view to positivism. It respects the differences between people as social actors and social objects and requires the researcher to understand the subjective meaning of social action [61]. The researcher needs to understand and see the world from the point of view of the research subject and not to generalise and predict the causes and effects. It contrasts with positivism because the data collected are not value free since the researcher interacts with the human subjects of the research and these changes the perceptions of both parties [63].The interpretivist researcher believes that many realities exist due to the many different and ever-changing perspectives of their subjects.

3.2.3 Pragmatism

Pragmatism suggests that the approach the researcher takes is determined by the research question and that a mixed methods approach can be used to address different questions. A mixed methods approach is the term used when both qualitative and quantitative data collection and analysis techniques are used [60]. Quantitative methods are concerned with the numeric representation of data. These provide answers to questions of incidence and measurement [64]

Qualitative research usually refers to the written or spoken word rather than numbers and can be a product of all research strategies [60] extending to visual methods such as reports, photographs, video etc. [61]. The mixed methods approach has been deemed appropriate by many [65] [66] since, in most cases, a simple quantitative-qualitative divide cannot always address the complex nature of the research question. Qualitative analysis provides rich detail and addresses the context, while quantitative analysis can answer the 'how much' and 'how many' questions [64]. Pragmatic researchers recognise this and understand that every method has its advantages and limitations and that the different approaches can be complementary. The aim of using mixed methods is to maximise the strengths and minimise the weaknesses of each method. For example, the researcher may use face-to-face interviews to gather rich qualitative data and then use the results to develop an in-depth quantitative survey upon which statistical analysis can be undertaken.

A knowledge and understanding of all the research philosophies helps researchers decide on a research strategy. However, it is important to note that no one research philosophy is the best as they all have different qualities and merits. The key is to choose the best research

philosophy to answer a particular research question. Moreover, this research philosophy fits the research question at hand.

3.3 Research Strategy

A pragmatic research approach was adopted for this research to allow both quantitative and qualitative data collection to achieve the first objective. Adopting an exclusively quantitative or qualitative method was deemed impractical in addressing the research questions.

The following research strategy was used:

1. Semi-structured interviews with deans, head of department and lecturers to understand the current situation whether the universities are using any mentorship program in Computer Science female at undergraduate to maintain the number of female students.

3.4 Sample Population

The research aim to develop a system that would optimise student peer assisted mentoring of computer science female student at undergraduate. The research took the qualitative approach, sample size of 135 from the population of 500 students in computer science. The ideal sampling frame for this research would have been all universities registered with the Ministry of Higher Education in 2018-2019 period, using probability-based sampling, whereby all universities would have had an equal chance of being selected from the sampling frame. Unfortunately, due to time constraints and financial limitations, it was not possible to use this sampling method. Instead, a more convenient sampling method was used, where relationships already existed with universities, to maximise the response rate and meet the research deadline.

3.5 Interviews

To explore this theme, a semi-structured interview checklist was designed to gather qualitative data to review the mentorship program that the universities are running for the female undergraduate and how many female students get to second year in Computer Science as a course of study. According to Miller and Crabtree [67], semi structured interviews are open-ended but focused and guided events that are co-created by the interviewer and the interviewee. These types of interview gives the researcher some flexibility to adapt the

questions to the situation e.g. omit questions, change the ordering or to adapt to information initiated by the interviewee [60]

3.5.1 Interview Execution

The nature of the research was explained to each interviewee at the start of the interview. All participants were advised that they were not obliged to respond to any question they did not want to answer and could withdraw from the interview at any time. They were informed that interviews would be completely anonymous and were offered the opportunity to ask questions before and after the interview. Researcher contact details were also provided in accordance with the ethical procedures. Information sheets and informed consent forms were provided to each participant. Each interviewee indicated that they accepted the terms listed in the informed consent form by signing the declaration. Permission was also received from each participant to allow the interview to be recorded using an audio device. Copies of the information sheet, informed consent form and interview questions can be found in Appendices.

3.6 Ethics Approval

It is important that ethical concerns be considered at each stage of the research process. Ethical considerations are needed to ensure the safety and well-being of the participants.

An application was submitted to the Research Ethics Committee on the 13th September 2019 for ethics approval to carry out the research. Ethics Committee required that: participants to be eighteen years or older; give informed consent to participating in the research; their participation was voluntary and they could opt out at any point; all questions were optional and all answers would be anonymous.

CHAPTER FOUR

RESULTS

4.0 Introduction

This chapter reports the results of the literature reviewed and semi-structured interviews with deans and Heads of Department. It presents an analysis of the qualitative and quantitative results.

Result of the first objective, after reviewing literature and conducting interviews the results showed that mentorship program is 100 percent non-existence in the Zambian universities, that meant that data collection would be a challenge, since the system is not used in Zambian universities. However, informal type of mentorship was used by 35 percent of individual lecturers without being aware of its application, since mentorship has not been clearly defined and so many educators are not sure of it.

Results of the second objective, based on the literature reviewed found that the mentorship program is lacking in the following areas: differing in structure and methods, focus and theoretical orientation. Hence the proposed model as shown below;
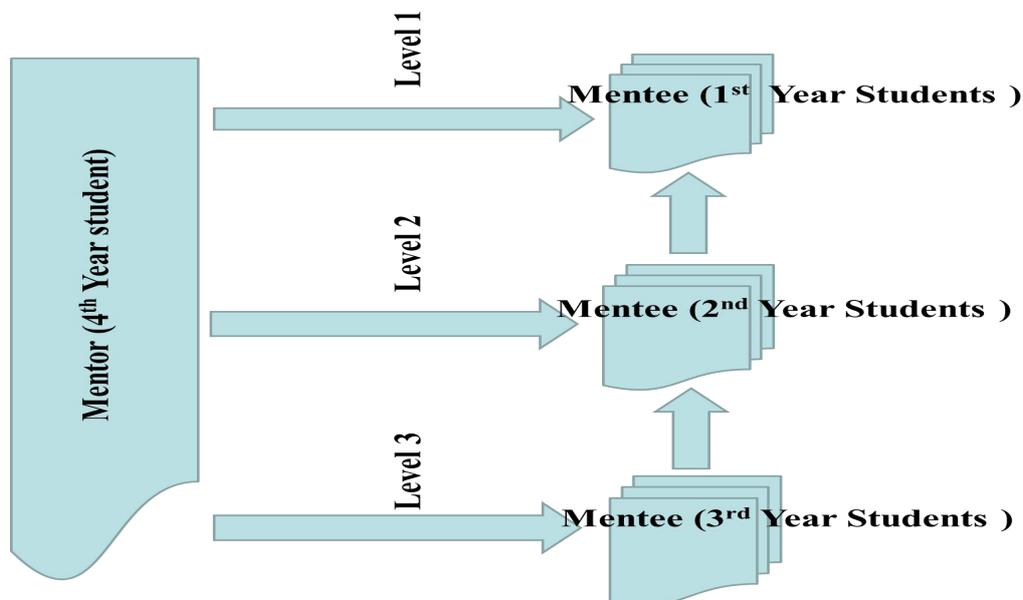
Figure 4.0 Model of developed integrated multi –level student peer assisted mentoring framework for a 4-year female computer science program. (MSPAM)

4.1 Integrated Multi-level Student peer Assisted Mentoring framework for a 4-year Female Computer science Program (MSPAM)

As shown on Fig 4.0 and Fig 4.1, the multi-level student peer assisted mentoring (MSPAM) activity for a 4-year female computer science program shows the model of activities of a 4-year program. In the first year, the students are advised on the best course to study, that's career advising by either the fellow students who are in second year or fourth year student in computer science with experience. The major activity in the second year since by this time they belong to school of natural science under the department of computer science. At this stage recruitment and training of student leaders for the mentorship program starts, these students who will be mentors are recommended by the course tutor. The objectives of the mentorship program and variable dates and times for group meetings are set at that particular time.

In the third year, the following are the activities proposed to take place; production of meeting modules, Plan regular program activities (e.g., monthly gathering, mentor recognition, closure event) Fixed pre-scheduled meeting dates and times for mentee group based on student test schedules.

In the final or fourth year among the many activities are, meeting with a member of the course team on a monthly basis to report back on how course content is being received at all levels, for instance, reports on how second year students are progressing and what material course they find difficult to understand. Since it is a proposed multi-level student peer assisted mentoring of female computer science students at undergraduate, the mentorship can be done at any level of study.

Result of the third objective, the proposed Integrated Multi-level Student Mentoring Activity for 4 year female computer science students.

Career advising (female Computer Science) Program

- Produce meeting modules
- Plan regular program activities (e.g., monthly gathering, mentor recognition, closure event)
- Fixed pre-scheduled meeting dates and times for mentee group based on student test schedules.

| 1st Year | 2nd Year | 3rd Year | 4th Year |

- Recruit and train student leaders for the mentorship program, recommended by Course Tutor.
- Peer Mentor Group Leader (Lecturer or HOD starts the matching and agree on the goals and objectives of mentorship program.
- Variable dates and times for group meetings with suggested topics.
- Conduct Interviews with the prosperous mentor. See **APPENDIX E**.

- Expectation of faculty advising sessions per semester
- Organise monthly career social Hours with the second/third years.
- Meet with a member of the course team on a monthly basis, to report back on how course content is being received, how second year students are progressing and what they are finding difficult to understand.

Figure 4.1 developed integrated Multi-level Student Peer Assisted Mentoring activity for a 4-year computer science female students program.

4.2 Role Models

The shortage of female role models in the Computer Science industry were cited as a reason why there are so few females choosing to study computer science at undergraduate. Female role models can inspire more females to choose Computer Science as a career. However, if these female role models display stereotypical traits, the impact may be opposite.

Female students often make decisions relating to their careers by being able to see themselves in the role through having direct access to a woman already in that role. However, recurring findings from the literature show that there is a severe lack of positive female role models in Computer Science careers.

A girl needs to see confidence, leadership and accomplishment in other women in order to envision herself with those qualities. A programme designed to empower girls must provide powerful, positive role models. As programme directors, it is helpful to expose girls to a diverse set of role models as consistently as possible. [56].

Precisely, 83 per cent of respondents think role models are important. When asked, why this was the case, it is apparent that female students are already aware of what a role model is and what their purpose would be in influencing their career choice. Respondents mentioned keywords to describe the role model as, *'aspire', 'encourage', 'inspire', 'influence' 'motivate', 'positive impact'*.
A large number of respondents, particularly females, commented on the fact that role models can inspire people to follow them in their chosen career path.

Some of the comments from female respondents were -

> *'Good role-models who are happy with their job encourage young people to consider joining career'*
>
> *'Encourages people to want to work in that profession and industry'*
>
> *'To influence people into choosing it as a career'*
>
> *'They help to motivate and inspire people to work in that certain area. They show off what is needed for that certain profession as well'*
>
> *'They would encourage you to be more like them as they would leave a positive impact on you'*
>
> *'Because it's someone for you to look up too when making your own career choice'*
>
> *'A positive role model will encourage a person to go far in the career'*

These comments stress the point that role modelling and peer mentoring are the same at some point when it comes to inspiring a student in doing a particular task. Girls particularly look for role models that will encourage and inspire them in their career area of choice.

According to the interviews conducted participants responded to the question whether they know anyone in the computer science field /industry the answer was mainly men who held this Computer Science related jobs were alternating from uncle, brother to father.

Two respondents referred to a female working in the computer science /IT industry with the rest being non-gender specific: friends, relatives and neighbours, which clearly shows that there are no female role model to look at.
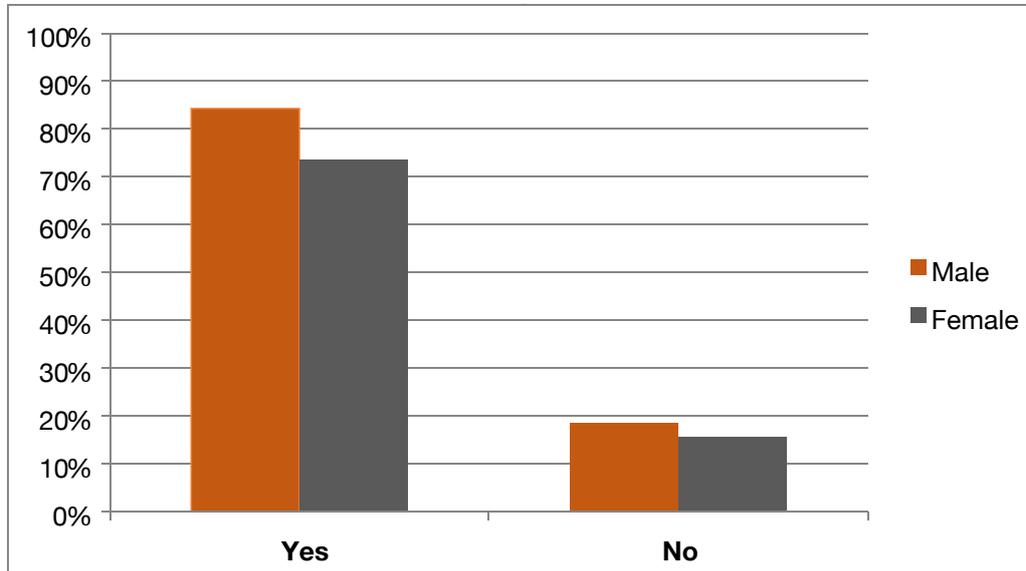
*Figure 4.2 – Participates who responded to **Yes** or **No** need for positive Role Model*

4.3 Female Career Influences

135 Participants were asked who influences their career choices. 55 participates (41 percent) stated that their family were one of their main information sources. The parents were next with 25 number of mentions (18 percent) as an information source. Teachers, Internet and friends were the other main influences (Table 4.3).

Influence	%	Number of mentions
Family	41	55
Parents	18	25
1st Year to 2nd Year Results determination	12	15
Subject Teachers	9	12
Internet (Facebook, LinkedIn, Google)	7	9
Friends	5	7
University Perspective	3	5
Professional in Computer Science	2	3
Former Students	0.74	1
Neighbour	0.74	1
Television (ZNBC)	0.74	1
School Career Guidance Teacher	0.74	1

4.4 Computer Science as a Career Choice

Participates were asked if they had applied to study a Computer Science course, 20 per cent of participants responded positively: 21 (42 percent) male respondents and 9 (13 percent) female respondents (Figure 4.4). Of the twelve female respondents, only one mentioned that she had inert interest in computers science. Three stated that they would like to have a Computer Science subject revised to a softer course, while one commented that she was convinced to study it by her parent who was in the same professional:

> *'I was convinced by my Dad that this is the only area worth pursuing in terms of job aspects'* (Female Respondent).

Career influencers listed by the female participants who were interested in Computer Science were: *'boyfriend', 'friends'* and *'using a computer games at a young age'*. The remaining female participants mentioned influences such as *'friends', 'family' 'IT professional'*.

For male respondents positive influences varied widely, from family and friends to good job prospects and the global economy.
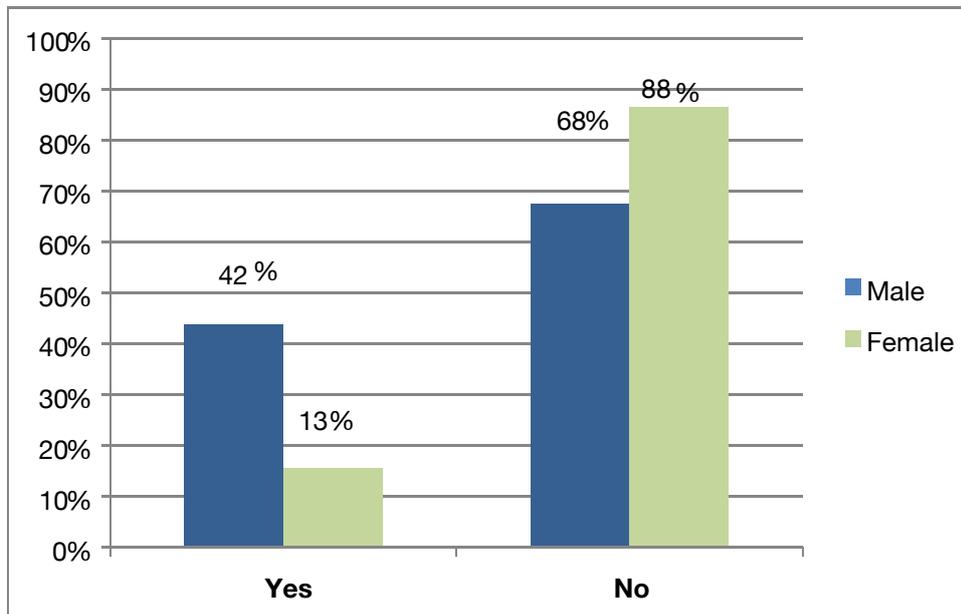
Figure 4.4 Respondents Planning to Study Computer Science

 The majority of female respondents (88%) are not planning to study Computer Science. Just over half of them cited *'no interest in computers'* in their open ended responses. Another common reason was their awareness that Computer Science is heavily related to Mathematics: '*Maths is my night mare subject', 'not good enough in Maths', 'I don't like programming'*, indicating that poor mathematical skills limit the number of female students choosing to study Computer Science.

A number of female respondents also commented on the fact that they wanted to work in careers that makes them interact with many people in order to help them. They felt that a career in Computer Science would not allow for this*: 'I feel like I would be stuck in a job in front of the computer for the rest of my life', 'I prefer to work with people, not stuck indoors working on software by myself'*.

 A number of female students felt they had very limited knowledge about Computer Science because from grade one they had no component of computer science and some felt there were few opportunities with it upon leaving university.

> *'I have never taken a subject like computer science related while at primary or secondary level and don't know what it takes in this course'* (Female Respondent).

'If there are so many job opportunities in this field, why is it not being introduced in all courses and at the secondary school as a subject to prepare the students?' (Female Respondent).

4.6 Awareness of Computer Science as career through mentors

When asked about whether the first year female students are aware of careers in computer science, the consensus was that 30 percent of students are aware about the computer science career. Of the two universities conducted research on, the students seemed to be more aware of computer science as a career. In these universities, the Dean/HOD appeared to be very knowledgeable on the subject and very active in promoting it, while the other lecturer actively promotes it as one of the careers where there are a lot of job opportunities because it's a field which is not yet flooded with people.

4.7 Addressing the Gender disparity in Computer Science

Interviewees were asked from their professional perspective whether anything could be done, to address the gender disparity in computer science. Some of the main ideas and suggestions emerged included: introduction of mentorship programs in universities where female students (mentor) mentors their fellow female student (mentee) on how to go about difficult courses in computer science. Inviting speakers from computer science/IT industries to give talks on the courses and inviting former students who had studied Computer Science and gone on to work in the industry back to the university to talk to the students about how marketable the course was as a female student.

One interviewee felt that inviting female professionals from the industry to talk to the students might work, as long as the speaker was approachable and somebody whom students could relate to to enable them to ask questions that bother them about the course contents,this is a form of mentorship. This method would introduce female students to a positive role model in the industry and showcase women working in IT and how they have built successful careers.

CHAPTER FIVE

DISCUSSION AND CONCLUSIONS

5.0 Introduction

The aim of this research was to develop a structured peer mentoring (MSPAM) program enhancing the performance of undergraduate computer science female students that can be integrated in the 4-year computer science at undergraduate. This chapter looks at the conclusions of the research undertaken in this study and makes recommendation to address these. It describes the limitations of the research and assesses the need for further studies into this field of research.

5.1 Conclusions

Multi-level Student Peer Assisted Mentoring (MSPAM) is not only of the knowledge and skills gained but also students can learn from peer mentors and professionals. Mentoring provides professional socialization and personal support to facilitate success at undergraduate school and beyond postgraduate.

The shortage of female role models in the Computer Science industry was cited as a reason why there are so few women choosing to study computer science. Female role models can inspire more females to choose Computer Science as a career. However, if these female role models display stereotypical traits, the impact may be opposite.

Despite increases in female's representation in careers such as Law, Engineering and Medicine in Zambia, their participation in computer science/IT careers is well below that of the mentioned careers. The literature review identified the potential reasons for this, however, no studies were identified that focused on females in Computer Science in Zambia and due to the extensive growth of the computer science industry in recent years, the issue of gender disparity in computer science based jobs is becoming an ever increasing concern to both educators and experts/Professionals.

Throughout the literature on gender and Computer Science, there are widespread findings that suggest females are less confident than men in their technical abilities and have inaccurately low self-efficacy in stereotypically male dominated careers. Echoing these findings, this study also indicates that lack of confidence and poor self-efficacy are one of the main reasons why females are not choosing to study Computer Science at undergraduate in

Zambian universities. Even though there was no difference in how proficient male and female students rated themselves, female students doubted themselves much more than male students with regard to their ability to study Computer Science. Hence, multi-level student peer mentoring program would help to instil confidence and remove the doubt in the female students if they see their fellow female students managing the course.

Three quarters of female students in this study cited that they have no interest in Computer Science or that it is 'Difficult' and 'challenging', yet they also state that they have no background and foundation from secondary level. Computer Science is not offered as a compulsory subject at secondary level in Zambia, which has resulted in a lack of awareness and knowledge regarding the subject for students. Ministry of general education have avoided introducing Computer Science or programming as a compulsory subject in the curriculum because of many factors from lack of computers in schools to shortage of computer science teachers. Ultimately, this is affecting negatively on the numbers of students choosing to study Computer Science at undergraduate. For Zambia to succeed it needs to improve and encourage females to join the ICT sector.

Female students acknowledged that role models are important to them. Female students in particular feel that a good role model can positively impact on career choices and encourage them to go into that industry. Female students often make decisions relating to their careers by being able to see themselves in the role through having direct access to a woman already in that role. However, a recurring finding from the literature shows that there is a severe lack of positive female role models in Computer Science careers. With a lack of positive female role models, the scarcity of women in Computer Science is self-perpetuating. If female students do not see women in computing careers they are less likely to feel it is a possible career option for themselves as there is no indication that they could succeed in that career. Under such conditions, female students may self-select themselves towards careers in which they do observe women having successful careers.

CHAPTER SIX

RECOMMENDATIONS

6.1 Introduction

The relevant stakeholders including private and public universities among others adopt the multi-level student peer assisted mentoring (MSPAM) as a means to close up the existing gender disparity at undergraduate in computer science and also increase and maintain the female graduates in the field of computer science.

6.1.0 Secondary School Curriculum

The Zambian secondary school curriculum should be reviewed to make it more relevant to the current needs of Zambia's ICT economy. With so many real jobs available in the ICT sector and that Zambia is developing in terms of ICT infrastructure, this is where the focus needs to be for second year students choosing computer science. The lack of education in ICT from primary school age has a detrimental effect on the numbers choosing it as a career option. This is particularly affecting females who tend to shy away from subject areas they know least about like computer studies.

The introduction of Computer Studies as a compulsory subject at junior and senior level would create an awareness of the subject and would ensure that girls get an opportunity to try it out in a classroom situation where there is less risk involved. This should also improve confidence levels in female students and start to break-down the stereotype that is associated with people who study Computer Science at undergraduate. Guidance and counselling office can be introduced if it is in existence be strengthen in secondary schools so that through their office mentorship programs can be coordinated.

6.1.1 Mentoring and Partnership Program

Research shows that the negative stereotype of females' suitability for male dominated careers is harmful. To help eliminate the stereotype, girls need to be exposed to Computer Science in real world situations from an early age.

Partnerships should be formed between industry and Universities to showcase that Computer Science is a great career option for females.

A partnership/mentorship program would lead to:

- Increased exposure for female students to female role models in Computer Science careers

- Mentors to hold workshops that bring secondary school students to their campus for a day to experience what studying Computer Science at university level is really like.

- To increase the student's Computer Science work experience with the mentor and mentee to practice in real technology companies with a lot of exposure

6.1.2 Promotion of Computer Science

Results from this research show that students are not receiving enough information regarding Computer Science and the resulting career opportunities available. Through the multi-level student peer assisted mentorship program female students (mentors) are able to inform their fellow students (mentees) on the career opportunities in computer science.

Multi-level student peer assisted mentorship program coordinator and Student leaders to hold special information day on Computer Science for parents of female students to help educate them on the options available for their children when it comes to career choice of computer science. Through the mentorship program Female representatives from IT industry, who are passionate about their work, could also come out to universities to give talks/workshops to promote Computer Science. This would also encourage university students, particularly females, to have a mind shift and adopt a neutral attitude to Computer Science.

6.2 Limitations of Research

Due to time, resource and financial constraints, a number of limitations were encountered during this research.

A convenience sampling technique and sample size were used to gather opinions from students of Universities in Zambia, which can be prone to bias and influence which is out of the control of the researcher. Further studies should use a probability sampling method to ensure that results can be generalised to the entire population of both private and public Universities of Zambia.

This study was limited to the university level.

Despite these limitations, the results further our understanding of why female students are not choosing to study Computer Science at second year in university.

6.3 Future Research Opportunities

Information from students surveyed in this research suggests that lack of exposure to Computer Science is one of the main reasons why particularly second year female students are not pursuing it as a career option. Parents, Students and computer science lecturers support the introduction of a Computer Science course into secondary level curriculum and find a way of making it softer or two steams of computer science for weak and strong students.

Non-progression, crossovers and dropout rates from Computer Science courses are one of the highest of all courses offered at undergraduate. In the academic year 2014/15, the non-progression rate for Computer Science was 35 per cent and 25 per cent in the academic year 2016. As this figure was inclusive of both males and females, due to limitation in my research, research could be carried out to investigate if female students who enter to study Computer Science are progressing to graduation and if not, what are the barriers to this?

6.4 Chapter Summary

The objective of this research was to review the structure of student peer mentoring programs. Secondly, propose an integrated student peer assisted mentoring framework for a 4-year computer science program.

Student peer assisted mentoring in higher education has been regarded as an effective intervention to ensure the success and maintenance of students. Many universities and colleges have therefore implemented some form of mentoring program as part of their student support services. In agreement to the researcher, the Zambian universities can as well use the multi-level student peer assisted mentoring program by integrating it in the 4 year computer science program; the multi-level student peer assisted mentoring can help retain and maintain the number of female computer science students at undergraduate.

Peer mentoring programs have been widely adopted by universities outside Zambia and colleges as important components of their strategies to enhance the experience of first year students to assist them in making the transition from secondary school to university.

Academic achievement is, however, just one indicator of the success of a peer-mentoring program and is not necessarily applicable to all such programs.

This research has further demonstrated that there are a number of barriers that have contributed to the number of female students stopping to study or altogether choosing Computer Science at undergraduate such as poor self-efficacy, curricula, a lack of role models and negative stereotypes.

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APPENDICES

APPENDIX A: Ethics Approval

THE UNIVERSITY OF ZAMBIA
P.O. Box 32379, LUSAKA - ZAMBIA

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APPENDIX B: Interview Information Sheet

THE UNIVERSITY OF ZAMBIA

INFORMATION SHEET FOR INTERVIEW PARTICIPANTS

BACKGROUND OF RESEARCH

This research seeks information on multi-level student peer assisted mentoring of female computer science at undergraduate.

Your participation in this research will make a contribution to our understanding of the current situation and will help us identify what invested stakeholders need to do to maintain the number of female computer science students and to address the gender disparity in the computing workforce.

THE INTERVIEW PROCESS

The following points should be noted about the interview:

- Your participation is voluntary and anonymous

- You have the right to withdraw from the interview at any time during the process without penalty.

- You may refuse to answer a question without penalty

- The interview process should take approximately 30 minutes to 60 minutes.

- In order to accurately record the answers to the interview questions, I will ask for your permission to audio record the interview, however, if this is not agreeable with you, I will take written notes, which you will be asked to append the initial and date on completion of the interview.

THE RESULTS

Once the interviews have been completed, the answers will be analysed and interpreted. No source, individual or university will be identified in my findings. If you wish, you may receive an electronic copy of the research dissertation by contacting me at chalwe.musonda@cs.unza.zm, after the 1st February 2020**.**

OTHER INFORMATION

- This information is being gathered for the completion of a dissertation as part of the M.Sc. in Computer Science

- I have no conflict of interest to the research topic and with any of the participants.

APPENDIX C: Interview Consent Form

THE UNIVERSITY OF ZAMBIA

INFORMATION CONSENT FORM FOR INTERVIEW PARTICIPANTS

Background of Research:

The percentage of female students majoring in computer science is much smaller than that of male students. Studies show that computer science has one of the lowest shares of women degree recipients among the broader field of science and engineering, with reports of only nineteen percent of the computer science degrees in 2016 been awarded to women at University of Zambia. As such, fewer women than men enter the computing profession, leading to a gender disparity in the computing workforce.

This research proposes Multi-level Student Peer Assisted Mentoring (MSPAM), an approach to optimise peer mentoring by organising mentors into levels. Hence, increase the performance and maintain the female student in the field. The act of mentoring/mentorship, describes an experienced person (mentor) guiding a less experienced person (mentee). When women are under-represented in this field of computer science, they miss out, novel solutions that diversity brings in addressing real world problems such as climate change, renewable energy, and universal access to education and health services.

This study seeks information on multi-level student peer assisted mentoring as a solution to maintain female students in Computer Science at undergraduate.

Methodology:

This research will be based on interviews conducted with Deans, Head of Department – Computer Science and Computer Science Lecturers in universities and literature reviewed.

The interviews will take approximately 30 minutes to complete and will be recorded. Each question is optional and you can withdraw or refuse to answer a question at any stage. The analysed and interpreted data will be completely anonymous and the identity of any participant or their school will not be recorded or revealed in any way.

Publication:

These data will be used in the completion of a dissertation as part of MSc in Computer Science, The University of Zambia. Recordings will be transferred to a computer and kept in a password-protected folder for the duration of the research project. Once the research is published, the data collected will be encrypted and stored on a DVD, which will be held in The University of Zambia in the School of Natural Science under the department of Computer Science for a minimum of 10 years.

Declaration

- I am 18 years or older and am competent to provide consent.

- I have read, or had read to me, a document providing information about this research and this consent form. I have had the opportunity to ask questions and all my questions have been answered to my satisfaction and understand the description of the research that is being provided to me.

- I agree that my data is used for scientific purposes and I have no objection that my data is published in scientific publications in a way that does not reveal my identity.

- I understand that if I make illicit activities known, these will be reported to appropriate authorities.

- I understand that, subject to the constraints above, no recordings will be replayed in any public forum or made available to any audience other than the current researchers/research team.

- I freely and voluntarily agree to be part of this research study, though without prejudice to my legal and ethical rights.

- I understand that I may refuse to answer any question and that I may withdraw at any time without penalty.

- I understand that my participation is fully anonymous and that no personal details about me will be recorded.

- I have received a copy of this agreement.

Please tick box

- I agree to the interview being audio recorded   **Yes**   **No**

- I agree to the use of anonymised quotes in publication   **Yes**   **No**

PARTICIPANT'S NAME: (PRINTED)

_____

PARTICIPANT'S SIGNATURE:

_____

Date: _____/_____/_____

Statement of investigator's responsibility: I have explained the nature and purpose of this research study, the procedures to be undertaken and any risks that may be involved. I have offered to answer any questions and fully answered such questions. I believe that the participant understands my explanation and has freely given informed consent.

RESEARCHERS CONTACT DETAILS:

Chalwe Musonda

Email: chalwe.musonda@cs.unza.zm

Phone: +260 0966 424 976

INVESTIGATOR'S SIGNATURE:

_____

Date: ____/____/____

APPENDIX D: Interview Questions

Semi Structured Interviews Questions with Dean, Head of Department, Lecturer – Computer science

1. Have you ever heard of the student peer assisted mentoring? If so, do you have any form of mentorship program at your school/university?

2. What type of school do you teach in and approximately what percentage of your students' progress to second year? What is the Gender mix of students that go on to second year in computer Science?

3. In your experience from 2015, what has being the ratios of female and male students in Computer science department?

4. In your department or school/University, is there some courses more suitable for male than female and vice versa? Can you give examples?

5. If so, can anything be done to change this?

6. Do you promote informal education experience for both male and female students? If so, how?

7. Are your students in first year aware of computer science before they get to second year?

8. Do you think female students have pre-conceived stereotypes of the type of people who work in Computer Science/ IT related Industry?

9. Do you ever hold any talks with your students specifically on Computer Science?

10. If so, do you ever have past female student who, now work in the Computer Science /IT industry, back to give a talk?

11. Do you think some aspects of Computing as a compulsory subject should be introduced into the secondary school curriculum?

12. What more could be done from a Career Guidance perspective to address the gender disparity in Computer Science/IT?

Thanks for taking the interviews

APPENDIX E: Interview Questions

Semi Structured interview questions for the prospectus mentor

1. Why do you want to become a mentor?

2. Do you have any previous experience volunteering or working with youth? If so, please specify.

3. What qualities, skills, or other attributes do you feel you have that would benefit a youth? Please explain in details.

4. Can you commit to participate in the Mentoring Program for a minimum of one year from the time you are matched with a fellow student?

5. Are you available to meet with a fellow student a minimum of one hour per week and have contact at least once per week? Please explain any particular scheduling issues.

6. How would you describe yourself as a person?

7. Are you willing to communicate regularly and openly with program staff, provide monthly information regarding your mentoring activities, and receive feedback regarding any difficulties during your participation in the mentoring program?

8. Are you willing to attend an initial training session and one in-service training sessions per year after being matched?

_____ _____

Name: ……………………………………………. Year of Study: ………………………

Signature: …………………………………………

Date:...

Thanks for your interest in mentoring a student! Please return this form to the computer science department.