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Perceptions of Female High School Students on Engineering

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Abstract
There is overwhelming evidence that females are underrepresented in engineering worldwide, and Kenya is not an exception. Recent study at School of Engineering (SOE), Moi University (MU) established that engineering parity ration was found to be 1.68 %, meaning that for every 59 students admitted to MU there was only one student admitted to SOE. Engineering female parity index was found to be 0.0038, meaning that, on average, for 260 female students admitted to MU, only 1(one) female student was admitted to SOE. Humankind depends on engineers to create new technologies, to find solutions to practical problems and to shape the world that people live in and the future they rely on. Yet young people have little or no perception of engineering and the understanding they do have is all too often confused with other careers, such as science. The perception of engineering as "masculine" and "too hard" is a contributing factor for the female minority in engineering. On the other hand there are very few studies on what high school students think about engineering. In view of the above, this paper will try to fill this gap of information, by exploring teenage girls' perceptions of engineering as a subject for study and as a potential career choice. Furthermore, it will attempt to raise awareness about and improve the image of engineering, by providing fused notion of engineering to the potential broad audience of this paper. The study is significant and essential for deeper comprehension on the subject matter, and for proposing and designing effective strategies to increase females' representation in engineering. Quantitative and qualitative methods have been used in this study. The researchers designed, administered and analyzed a 21-question questionnaire addressed to 100 female students at secondary school in Eldoret, Kenya (at their Form Four-final year of study). Qualitative Data Coding Techniques were applied to interpret the collected data. In addition, "Draw an Engineer Test" (DAET) was included as one of the questions in the questionnaire. The purpose of the test is to have students describe their perception about engineers via drawn responses. Each picture was analyzed for the images and artifacts contained in the drawings. The study established that majority of female pupils have a fairly good idea of what engineering is and they generally have a positive attitude towards it. The rest of the students, however, perceived engineering as largely dirty and noisy manual-work. To help changing that misconception, this study proposed several recommendations. The most important ones are: In order to attract much more females into engineering, both stereotypes (Engineering and Gender) should be challenged and, in the long run, changed; To make engineering a core-subject, differentiated from science, in the Secondary Schools educational curriculum; To offer students freedom of choice of future career, providing exposure to various career alternatives; and finally, students should choose a career that matches one's personality.
Keywords: gender, engineering, engineer, stereotype, perception.

1. Introduction

1.1. Universal significance of engineering

Our world today faces a multitude of increasingly interlinked-challenges, such as: the need to reduce poverty, promote sustainable social and economic development and address the other UN Millennium Development Goals; globalization; and the need to bridge the digital and broader technological and knowledge divides. Specific emerging issues and challenges include: climate change mitigation and adaptation and the urgent need to move to a low-carbon future; the recent financial and economic crisis and recession – the worst since the 1930s; and calls for increased investment in infrastructure, engineering capacity and associated research and development (UNESCO, 2010).

In this context, the technical know-how and capability to uncover new solutions to overcome these challenges requires advanced skills in Science, Technology, Engineering and Mathematics (STEM). The need for a large and diverse pool of skilled engineers remains as high as ever, as unrelenting growth in a national productivity requires a continuous supply of engineers, who are highly competent in mathematics and science, and who are adaptable to the needs of a rapidly changing profession.

At the same time, many countries are concerned about the apparent decline in interest and enrolment of young people, especially young women, in engineering, science and technology (UNESCO, 2010).

1.2. Gender gap in engineering

Engineering as a human endeavor is also facing numerous additional challenges of its own, including attracting and retaining broader cross-sections of our youth, particularly women.

Diversity is essential for creativity and innovation, which are at the heart of engineering. Thus

engineering can benefit from the richness and varied perspectives and expertise which individuals from different ethnicity, culture and gender can bring to problem-solving. Furthermore, promoting diversity in the workforce provides greater access to talent by increasing the pool of qualified and skilled professionals.

Many studies investigated the gender gap in STEM fields. A primary factor is stereotypes that are subconsciously perpetuated by educators, parents, and society (Moss-Racusin, 2012). Girls may be taught by teachers and parents that they are inherently less capable than boys in math, which can lead to negative attitudes about the subject (Gunderson, 2012). Perhaps as a result of this influence, women who contemplated entering STEM fields underestimated their ability to perform in those fields (Forssen, 2011). Society also typically views STEM jobs as male jobs (Crettaz von Roten, 2011; Platz, 2012). When girls are presented with predominantly male scientists and engineers rather than a diverse set of mentors, they are less likely to believe that they could be successful in STEM careers (Cheryan, 2011).

The metaphor of the "leaky pipeline" (Capobianco, 2006) has been used for many years to describe the progressive loss of women on the career ladder. The phenomenon is clearly visible in the higher education sector with women accounting for 20% of engineering graduates but 6% of professors in engineering and technology (European Commission, 2006). The leaky pipeline actually starts with High Schools, where pre-university career choices are made.

There is, indeed, an overwhelming evidence that females are under-represented in engineering worldwide (Vest, 2005; Excel, 2011). Concerns about the underrepresentation of girls in the fields of science, engineering and technology in Kenya have been raised and expressed by the government and various organizations for a long time. The major factors which contribute to this underrepresentation have been identified to include; lack of relevant policies, inadequate curriculum content and delivery, biased teaching materials, lack of role models and negative socio-cultural attitudes and practices (MoHEST, 2010).

In the local context, according to recent study by Starovoytova & Cherotich (2016), Moi University (MU) and School of Engineering (SOE) female admission rates for the period (2003-2014) was found to be 45.4% and 13.9% respectively(they both skewed in favor of male). The comparison of female admission trends at SOE with other schools of MU revealed that the persistent underrepresentation of females in engineering is perplexing, particularly when female representation in other programs of MU has enjoyed superior improvement over time. Total retention rate, SOE was found to be 0.9 (10% drop-outs). Engineering parity ration was found to be 1.68 %, meaning that for every 59 students admitted to MU there was only one student admitted to SOE. Engineering female parity index was found to be 0.0038, meaning that on average for 260 female students admitted to MU only 1(one) female student was admitted to SOE. The situation in SOE is more distinct as the admission ratio of F/M is 0.143, meaning that for every 7 male students admitted to SOE there was only one female student. These trends suggest that females' participation in engineering professions is likely to be affected.

Engineering is vital to a country's economy and the everyday life of society. Humankind depends on engineers to create new technologies, to find solutions to practical problems and to shape the world that people live in and the future they rely on. Yet, young people have little or no perception of engineering and the understanding they do have is all too often confused with other careers, such as science, or even carrier of a mechanic or a repairman. To investigate the reasons why a small number of young women are choosing careers in engineering and to propose action to alter the situation; it is logical to investigate the root-causes of the phenomenon.

1.3. Widespread misconceptions about engineering (problem statement and justification of the study)

Current engineering messages in the society largely portray engineering as challenging, demanding and stressful. The existing image of engineering is masculine - indeed, engineering has a huge image problem (Tietjen, 2004). The perception of engineering as manly is, according to Phipps (2002) a contributing factor for the female minority in engineering.

Many people understand an 'engineer' to be someone who does manual work, probably with machinery. This misleading 'grease behind your fingernails' image can discourage pupils, especially girls, and promotes an image which does not accurately reflect a profession that has changed radically over the last 20 years.

High School students, including females, and the people who influence them—teachers, school counselors, parents, peers, and the media—largely do not understand what a career in engineering looks like and therefore don't consider it as a career option. Undeniably, misconceptions regarding exactly what engineering is about constitute a real barrier to understanding the profession – both in terms of public awareness and the recruitment of young engineers (NAE, 1998).

Another common misconception about studying engineering is that, engineering is only for the intellectual elite, or that, it's only for students getting A's in maths and science in high school. Engineering is a way to make life better. Many problems are solved by applying math principles, but math is just one tool in the engineer's toolbox. Inspiration, experimentation, vision, analytical ability, creativity, curiosity, imagination,

energy, passion and communication skills are also extremely important (Bainye, 2015).

There are very few studies on what pupils think about engineering. One study reported on the development of a drawing test for students in grades 3–5, 6–8 and 9–12 in the USA (Knight& Cunningham, 2004). They found that engineering was mostly associated with designing and associated with words such as 'overalls', 'men', 'machinery', 'dirty', and 'noisy'. Karatas, Mickos&Bodner performed a study among grade six students in the USA and found that, for that age level, the students' images of engineering were 'fragile, or unstable'(Karatas et al., 2010). Evidently, not much is known yet about what senior secondary school children think about engineering.

In view of the above, this paper will try to fill this gap of information, by exploring teenage girls' perceptions of engineering as a subject for study and as a potential career choice. It will also judge high school girls' level of interest in and awareness of careers in the engineering field, assess general career motivators and barriers towards the engineering field, and explore messaging opportunities for increasing enrolment in the engineering field. Furthermore, it will attempt to raise awareness about and improve the image of engineering, by providing fused concept of engineering to the potential broad audience of this paper. The research focused on two main factors affecting young women's choice of engineering as a future career; knowledge about engineering at the high school level and awareness of potential careers in engineering. The study is significant and essential for deeper comprehension on the subject matter, and for proposing and designing effective strategies to increase females' representation in engineering.

2. Materials and methods

Quantitative and qualitative methods have been applied in this study. The qualitative part for the study also was used as a basis for the quantitative instrument (the questionnaire). Document analysis, another secondary method of data collection, was a necessary aspect of the study. The methods chosen are unique to this particular study. Researchers in qualitative studies look for patterns, themes, and categories for use in other settings, but do not focus on replication.

In-depth study of the phenomena (the concept of engineering) was conducted, where secondary sources of reputable information were critically reviewed. In addition, the expert-opinion of seasoned-engineers was utilized to add value and some flavor to the concept.

In this article, however, the main focus is on the quantitative analysis of data (the questionnaire). The researchers designed, administered and analysed a 21-question questionnaire addressed to Form Four female pupils at Moi Girls High School Eldoret, Kenya. The questions were based on the review of existing literature and researchers' interest, and in particular were aimed to collect the views of young female students about engineering as a subject, career choice and a discipline. The focal point sample was chosen at random, and was limited to 100 female students (about 40% of the population) of Form Four-the final year of study. Qualitative Data Coding Techniques were applied to interpret the collected data; where, in particular, systematic approach was utilized to creating codes such as the research questions that guided the study; then the organized data was summarized. Next step was to analyze the data for ―pattern-able regularities that can aid in generalization. This followed by inductive interpretation of the findings, and finally synthesization of the information. The survey on demographic information was used strictly for statistical purposes such as averages of age among other information. All participants were to read an introductory paragraph of the questionnaire, which guaranteed that their names would not be mentioned anywhere in the study.

General public has an incomplete understanding of engineers and engineering as a profession; many still reference the "conventional" stereotype of engineers as train operators (Davis, 2002; Frehill, 1998). In order to make sense of their everyday experiences humans create images, which are a powerful form of communication. Thus exploring and understanding images has important theoretical and practical implications (Finson, 2002). Images shape the way individuals view the world, thus, understanding the image students have of engineers and engineering is extremely important. In this regard, one of the questions in the questionnaire was focused on "draw an engineer test" (DAET), which was initially modified from the "Draw a Scientist Test" (DAST) that has been widely used to assess students' attitudes about scientists (Finson, 2002; Margolis et. al., 2001; Fung, 2002). In this study a modified from Knight& Cunningham (2004) "Draw an Engineer Test" (DAET) was applied. The purpose of the test is to have students describe their perception about engineers via drawn responses. Each picture was analyzed for the images and artefacts contained in the pictures.

The subjects of the study were drawn from Moi Girls High School, Eldoret, Kenya. The School has a long history dating back to 1928. It was first established then as a European Primary School to cater for the children of the white settlers. The primary school was later re-named Highlands Primary School. After attainment of independence and self-rule in 1963 and 1964 respectively, the school experienced dramatic decline in number of students, as settlers began relocating to other countries. So, in 1965, the first African students were admitted to the school through the government policy of integration. Mr. Moi, D.T. was elected as the first African board chairman of the school. In 1978, the school was renamed, in honor of the long serving board

chairman, who had become the second president of the republic of Kenya the same year. Currently Moi Girls High School is one of the largest National Girls boarding school of Kenya educating over 1000 in-residence female students per year; the school is also ranked as 72 out of Top 100 National Schools of Kenya. It provides secondary cycle of the 8-4-4 system of education (MGHS official website).

3. Results

3.1. Engineering: Definitions, an essence, achievements, and a profession.

The following digest is a reflection of extensive and critical review of secondary sources of information, supplemented with a number of expert-opinions. The findings recorded below do not claim to be fully comprehensive account of every order associated with engineering, but they do give a fairly good picture of the fundamental nature of engineering, array of magnitude of activities and achievements, and, probably, include the most significant ones identified, for which information was available at the time this study was carried out.

3.1.1. The definitions and the essence of engineering

The term '*engineering*' originate from the word '*engineer*' used in the 1300s for a person who operated a military engine or machine – such as a catapult or, later, a cannon. The word '*engine*' in turn derives from the Latin '*ingenium'* for ingenuity or cleverness and invention. The word "engineer" literally means 'one who practices ingenuity'. The term also relates to the Greek '*technikos'* relating to art, craft, skill and practical knowledge (Jackson, 2010).

The other definition of engineering in the Free Dictionary states: ''Engineering is the application of scientific and mathematical principles to practical ends such as the design, manufacture, and operation of efficient and economical structures, machines, processes, and systems''.

Engineering is also defined as "discipline, art, skill and profession of acquiring and applying scientific, mathematical, economic, social, and practical knowledge, in order to design and build structures, machines, devices, systems, materials and processes that safely realize improvements to the lives of people"(Andrew& Clark, 2012).

The American Engineers' Council for Professional Development (ECPD) has defined "engineering" as: " The creative application of scientific principles to design or develop structures, machines, apparatus, or manufacturing processes, or works utilizing them singly or in combination; or to construct or operate the same with full cognizance of their design; or to forecast their behavior under specific operating conditions; all as respects an intended function, economics of operation or safety to life and property"(Doyle, 2012).

Despite the variety of definitions, the concept of engineering is not easy to identify clearly. Jamison (2009) also explained that "one of the main difficulties in discussing the context of engineering is that engineering, like science, art, and other forms of human creativity, has a range of different meanings and functions: commercial, economic, social, professional, cultural, and human ". Figueiredo (2008) discussed four major dimensions of engineering:

1. *Engineer as Scientist*. This dimension is "inspired by the basic sciences views of engineering as the application of the natural and exact sciences, stressing the values of logics and rigor, and seeing knowledge as produced through analysis and experimentation. In this dimension research is preferred… and seen as the activity leading to higher recognition"
2. *Engineer as Sociologist.* Engineers are seen as "social experts, in their ability to recognize the eminently social nature of the world they act upon and the social complexity of the teams they belong to. The creation of social and economic value and the belief in the satisfaction of end users emerge as central values"
3. *Engineer as Designer.* In this dimension, engineering is "the art of design… it includes exploring alternatives and compromising. In this dimension, which resorts frequently to non-scientific forms of thinking, the key decisions are often based on incomplete knowledge and intuition, as well as on personal and collective experiences"
4. *Engineer as Maker/Doer.* Engineering is "the art of getting things done"

In every dimension, an engineer requires to have a specific type of knowledge. Sheppard (2008) stated that "the knowledge that engineers must bring to bear in their work includes knowing how to perform tasks, knowing facts, and knowing when and how to bring appropriate skills and facts to bear on a particular problem". According to Sheppard (2008), engineering knowledge can be divided into three major categories:

1. Knowing that (declarative knowledge) - it is important for the dimension when the engineer is recognized as scientist;
2. Knowing how (procedural knowledge)- the engineer performs as technologist;
3. Knowing why (strategic knowledge) - needed when the engineer is problem-solver and decision-maker, including social, economic, and ethical aspects.

The concept of engineering is drawn from the very beginning of human evolution, as our ancestors developed and designed tools that were vital for their survival. Undeniably, human-beings are defined by their

tool-making and the milestones (eras) of human development is associated and correspond to specific materials from which their tools were made, such as: stone, copper, bronze, gold, silver, iron, steel, polymers, diamonds, composites, and silicon among others. Although based on trial and error, tool-making activity is similar to the modern idea of engineering where trial and error is still an important part of innovation.

In our time almost everything you touch has been influenced or designed by an engineer directly or indirectly. Through the work of engineers, we are able to have iPhones, camera phones, wireless computers, High Definition video, satellite TV, airplanes, wind farms, electric cars, high-speed trains, digital music, underwater robots, air-conditioning, cosmetics, and titanium knee and hip replacements among others. The list goes on and on. Engineers have enabled us to explore the galaxy, break the sound barrier in a car, replace broken body parts, and instantly connect with family and friends all over the world and so much, much more (Chubin, 2005).

3.1.2. Brief account of engineering achievements

The ancient history of engineering encompasses the following well-known accomplishments: The Pharos of Alexandria, the pyramids in Egypt, the Hanging Gardens of Babylon, the Acropolis and the Parthenon in Greece, the Roman aqueducts, Via Appia and the Colosseum, Teotihuacán and the cities and pyramids of the Mayan, Inca and Aztec Empires, the Great Wall of China, the Brihadeeswarar Temple of Thanjavur and tombs of India, among many others, stand as a testament to the ingenuity and skill of the ancient civil and military engineers (web article 1).

Due to epigrammatic nature of this narrative, we have to jump directly to 20th Century. In 2003, the National Academy of Engineering in the United States published *A Century of Innovation: Twenty Engineering Achievements that Transformed our Lives* (NAP, 2010). This work detailed historical information on the following list of what the authors consider to be the top twenty engineering achievements of the 20th century or those achievements which had the greatest impact upon life during and following this period. The list was published as follows: (NAE, 2010): Electrification, Automobile, Airplane, Water Supply and Distribution, Electronics, Radio and Television, Agricultural Mechanization, Computers, Telephone, Air Conditioning and Refrigeration, Highways, Spacecraft, Internet, Imaging, Household Appliances, Health Technologies, Petroleum and Petrochemical Technologies, Laser and Fiber Optics, Nuclear Technologies, and High-performance Materials.

3.1.3. Engineering profession

Engineering is one of the oldest professions, along with theology, medicine and law. Almost every area of human interest, activity and endeavor has a branch of engineering associated with it. There is a common misconception that engineers are applied scientists. This is a further distortion of reality, as engineering is distinct from, but related to, science, and, in fact, predates science in the use of the scientific method, as engineers were the first scientists.

Lewis (2005) also explains different roles of engineers and scientists: “unlike scientists who proceed within the framework of scientific laws, engineers employ heuristic laws to arrive at design solutions. Heuristics do not guarantee solutions, but they reduce the search time in solving a problem”. The other difference between engineering and science is that engineering problems are usually ill-defined (Jonassen, 2003). A few “right” decisions for one task can co-exist together depending on the resources required for performing the task. Creating an appropriate mathematical model of a problem allows engineers to analyze it (sometimes definitively), and to test potential solutions. Usually multiple reasonable solutions exist, so engineers must evaluate the different design choices on their merits and choose the solution that best meets their requirements. Genrich Altshuller, brilliant Russian engineer-inventor, after gathering statistics on over 40,000 patents, suggested that compromises are at the heart of "low-level" engineering designs, while at a higher level the best design is one which eliminates the core contradiction causing the problem (for detailed information see Starovoytova et.al., 2015b).

Engineers use both scientific knowledge and mathematics on the one hand to create technologies and infrastructure to address human, social and economic issues, and challenges on the other. Engineers connect social needs with innovation and commercial applications. The relationship among science, technology and engineering can be generally portrayed as shown in the Figure 1.

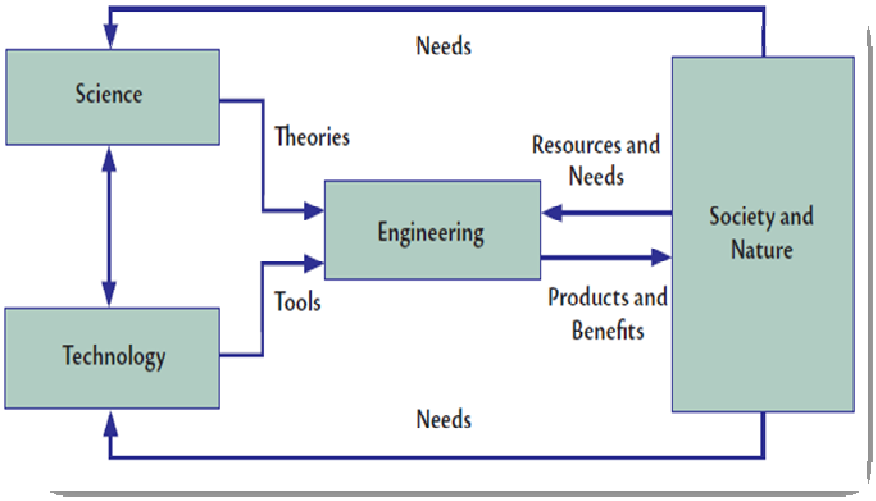

Figure 1: Engineering associations (UNESCO, 2010).

Engineering includes some of the most versatile and crucial careers in the contemporary world. The technical areas of work include design, product management, software manufacture, production planning, material resource planning, logistics, manufacturing, quality control, assembly, commissioning, maintenance, health and safety, recycling and waste management, water resources, supply and sanitation, patents, standards and so on. Engineering is the backbone of public utilities, transport systems, buildings, computers and the Internet, food production, diamond rings and sports cars among others.

Most new developments that are making our world a better place are from the contributions of engineering fields. Engineering is concerned with the application of scientific and mathematical principles towards practical ends. It seeks to create cost-effective solutions to practical problems by applying scientific knowledge to building "things" or systems. Engineering is all about solving problems using a systematic approach, subject to economic, environmental, social and other constraints. It deals with real problems – whether it is concerned with building a railway or designing an artificial limb – whose solutions matter to ordinary people. Thus, engineering lies at the interface between science on the one hand and society on the other.

Many engineers develop new products. During the process, they consider several factors. For example, in developing an industrial robot, engineers specify the functional requirements precisely; design and test the robot's components; integrate the components to produce the final design; and evaluate the design's overall effectiveness, cost, reliability, and safety. In addition to their involvement in design and development, many engineers work in testing, production, or maintenance. These engineers supervise production in factories, determine the causes of a component's failure, and test manufactured products to maintain quality. They also estimate the time and cost required to complete projects. Supervisory engineers are responsible for major components or entire projects.

Engineers use computers extensively to produce and analyze designs; to simulate and test how a machine, structure, or system operates; to generate specifications for parts; to monitor the quality of products; and to control the efficiency of processes. Nanotechnology, which involves the creation of high performance materials and components by integrating atoms and molecules, also is introducing entirely new principles to the design process.

Most engineers specialize. Engineering encompasses a vast diversity of areas of specialization (over 36 major branches and more than 200 sub-fields and areas of expertise). Conventional fields of engineering, such as, for example, Civil engineering alone comprises of 25 sub-areas, such as: architectural engineering, earthquake engineering, environmental engineering, highway engineering, transportation engineering, and hydraulic engineering, just to mention a few. Some examples of the novel fields of engineering are: aerospace engineering, geo-engineering, marine engineering, nuclear engineering, genetic engineering, planetary engineering, systems engineering, and sports engineering among many others (web article 2).

It also includes a diversity of types and echelons of engineers– from engineers in universities more concerned with teaching, research and publication, what is sometimes described as the 'engineering sciences'(rather than engineering practice), to practicing professional, consulting engineers, and to engineering technologists and technicians. These are dynamic concepts; as engineering changes, so does the idea and definition of what it means to be an engineer.

The authors, in synopsis of this brief opening on fundamental nature of engineering, endorse the legendary and eloquent expression: "The ideal engineer is a composite ... He is not a scientist, he is not a mathematician, he is not a sociologist or a writer; but he may use the knowledge and techniques of any or all of

these disciplines in solving engineering problems "(Dougherty, 1955).

3.2. Results and analysis of the questionnaire' evaluation

All the 100 administered questionnaires were returned to the researches after completion (giving 100% response). While general response- rate for most questions was 100%, few questions proved to give various complications, probably due to varied interpretation and therefore these particular questions were left blank. The questions and corresponding responses (%) are: Q1-85, Q18-95, and Q19-93.

Due to the large number of questions, for ease of reference and avoidance of repetitions and disorientation, the results, in this section, are followed directly by their analysis. The questionnaire was evaluated question by question. Questions appear exactly the way they are stated in the original questionnaire.

Q 1: Rank the academies listed based on your interest. Number 1-6 (1- is the most interested and 6-is the least interested). The academies are: Arts and Communication, Business, Engineering, Health science, Human resource Management, and Social science.

The engineering had the highest number- 44 students (51.76%) ranking it as their first interest of the academies out of the total students who responded to the question. Students generally show an interest in engineering. This is similar to what was found in studies by de Vries (2005). Subsequent to engineering were: Health Science- 28 students (32.94%), Business-7 students (8.23%), Art &Communication-3 students (3.53%), Human Resource-2 students (2.35%), and Social Sciences-1student (1.18%). In addition, engineering scored high-79 students (92.94%) in total choose it as their 1st or 2nd or 3rd preference.

Possibly, the contributing factors as why the surprisingly high number of students prefers engineering were: (1) the students may have been slightly intimidated by the presence of the research- team (waiting for the completion of 2-hour exercise) and (2) every student read the introductory part of the questionnaire, where researchers introduce themselves as engineering faculty. In addition, the purpose of the survey was stated clearly; in particular, that level of awareness and interest in engineering are to be assessed.

In addition, students' reflection on the exercise with their teachers revealed that some students were very excited and just wanted to impress the surveyors with the high level of their interest in engineering, which was, most likely, overstated. The interpretation of this question could be, therefore, that the high number of respondents giving preference to engineering, is, probably, not reflecting the extent of the real situation.

Q 2: Do you have an idea of what engineering and technology entails, if yes where did you get the idea?

Only 11 students (11%) confessed that they had no idea about Engineering and Technology. The table 1 below, shows where the other 89 (89%) surveyed students heard about the Engineering and Technology. Note that the students were listing the *main* source where they acquired information.

Table 1: The source of the idea about engineering

Source	**Frequency**	**Percentage**
Parents	27	30.34%
Teachers	19	21.35%
Guidance counselor	7	7.86%
Guest speaker	11	12.36%
Brochures	6	6.74%
Others	19	21.35%
Total	**89**	**100%**

From the table, it is clear that parents are the prevailing source of information about engineering, followed by teachers.

Q 3: Are there people who influence you in career choice? If yes who are they?

19 (19%) students said their careers choices are not influenced by other people, while 81 (81%) said their career choices were influenced by other people. The table 2 shows who influenced the careers of the 81% of students.

Table 1: Table showing who influences career choices of students

Influencer	**Frequency**	**Percentage**
Parents	41	50.61%
Other relatives	10	12.35%
Family friend	10	12.35%
Teacher	7	8.64%
Others	13	16.05%
Total	**81**	**100%**

It was evident that much careers and subject choice advice came from parents, family and friends: teachers did not feature prominently.

Q4: Have you developed a career path that you strive/attain in life? If yes what is your career choice?

92 (92%) agreed that they had developed career path, while 8 (8%) said they had not developed career path to

strive to achieve. The table 3 shows the number of students that have chosen career to strive in respective fields.
Table 2: Table showing the career path that students strive to achieve

Table 3: The career path that students strive to achieve

Career	Frequency	Percentage
Doctor /physician/dentist	35	38.04%
Accountant /banker	9	9.78%
Social scientist	3	3.26%
Lawyer	17	18.48%
Teaching	1	1.09%
Engineering	27	29.35%
Total	**92**	**100%**

Out of those students who have chosen a career, 35students (38.04%) choose to be either medical doctor or physician or dentist. A career in medicine is perceived as a 'normal' or desirable choice for women, because it is seen as a caring or nurturing profession consistent with prevailing stereo-typical attitudes about women (ASPIRES, 2013). Engineering is the second favorite with 27(29.35%) students; It's a good show that at high school the students have an aim of doing engineering but the problem comes when only a few of them end up to engineering. What happens to others?

Q 5: Have you received encouragement during school to pursue engineering as a profession? If yes from who did you receive?

82 (82%) of students agreed that they had received encouragement during high school to pursue engineering while 18(18%) students said they have not received any encouragement to pursue engineering. Teachers proof to be the main source of encouragement, others specify the main source of encouragement being former students of the school who were invited to come to talk to them. In the written additions, to our surprise, it was also indicated that careers advisers had even tried to discourage pupils from studying engineering, saying plainly that STEM subjects are inherently "too tough for females", and "there is no need to stress yourself", and that these careers are for boys.

Table 4: Source of encouragement

Source	Frequency	Percentage
Parents	9	10.98%
Teachers	30	36.58%
Guidance counselor	16	19.51%
Others	27	32.93%
Total	**82**	**100%**

Q 6: Have you ever interacted with any engineer or scientist as part of any classroom activities here at Moi Girls' High School or anywhere in Eldoret town? If yes how do you describe this experience?

53 (53 %) of the students said that they had not interacted with a scientist and 47 students (47%) had experienced this opportunity in the classroom. The students who said they had interacted with either scientist or engineer described experience as interesting, inspiring, and motivating to do engineering, eye-opener for those who had already chosen their career leading to engineering.

Q 7: Have anyone talked to you about the importance of:

a. Taking subjects that will prepare you for future career

92 students (92%) had been informed about the importance of taking subjects that will prepare them for future career, while 8 students (8%) had no idea of the importance of taking subjects that would prepare them for their future careers. This survey question is important so as to know whether the students are prepared even from the time they are in high school to take the subjects that will enable them to pursue the careers of their choice.

b. Math and science to your future career

87 students (87%) said that they have been told the importance of math and science to their future career, while 13students (13%) have never been told the importance of math and science in their future career. This survey question was important since to pursue engineering one ought to have taken science and mathematics. The survey question seeks to look into how many students knew the importance of taking the subjects for the sake of their future career.

Q 8: Does gender influence your choice of your future career? If yes how does it influence you?

93 students (93%) responded that their gender did not influence the choice of their future career, while 7 students (7%) said their gender influenced the choice of their future career. They felt that their gender influenced them when it comes to career choices since there are some fields which are only meant for males, one gave an example of engineering being male-dominated field.

For each of the following statements please circle one of the following:

Strongly Agree (SA), Agree (A), Neutral (N), Disagree (D), Strongly Disagree (SD)

Q 9: Do you feel that you are good at math?
Q 10: Do you feel you are good in science?
Q 11: Engineering is for students who are good in science and math
Q 12: Technical classes are for students who are good at working with their hands.

The survey results showed that the students feel overly strong in math and science, as Table 5 shows. A good number of students only agreed and others strongly agreed that they were strong in math and science, 47 students (47%) strongly agrees while 39 students (39%) agree. The majority 61students (61%) strongly agrees and 29students (29%) agree that they are good in science. 40 students (40%) strongly agree, and 49 students (49%) agree that technical classes are for students who are good in math and science.39 students (39%) agree while 25 students (25%) strongly agree that technical classes are for students who are good at working with their hands. The lack of confidence in these areas is a sign that self-efficacy could be a cause of low numbers, along with lack of knowledge and exposure.

Table 5: The ratings about different feelings on some aspects

	Strongly Agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
Do you feel that you are good at math?	47	38	15	0	0
Do you feel that you are good at science?	61	29	10	0	0
Technical classes are for students who are good in math and science.	40	49	4	4	3
Technical classes are for students who are good at working with their hands.	25	39	14	9	13

Q 13: Have you ever participate in science fairs or other educational competitions or clubs?
77 students (77%) had been involved in these types of events, while 23 students (23%) had never been involved in such activities. Those who had been involved in such activity listed the activities including science congress, mathematics contests and joining different clubs like science clubs, and math's club.

Q 14: Below is list of activities; please check the ones you enjoy most
Note: Respondents was checking more than one activity depending on the interest. This question helped us to analyze whether the students enjoy most activities that are related to engineering field or not, most of the activities, for example, exploring new ides is liked by 91students (91%), questioning on how things work- (85%) and inventing- (65%), showing substantial interest in activities directly related to engineering. The rest of the activities received lower score, and in particular: Building new things-50%, Taking things apart-45%, sports &athletics-40%, and arts&crafts-20%.

Q15: What do you plan to do when you graduate from high school?
From the survey reports it shows that the highest number (88%) of students wants to join either college or university, this is important since one can only practice engineering when she is in either college or university. 7% indicated that they plan to get a job, while 5% had other plans, which they did not reveal.

Q 16: The table below shows statement about attributes of work that may influence you as you think about your future career. For each sentence below check the appropriate box to tell us how what level of importance you place on each attribute.
The students had a strong opinion about the attributes that may influence them as they think about their future career. The following table 6 shows how the students rated different attributes concerning what they think about their future job.

The majority of the students wanted a job that makes them think, and that is fun to do, and is satisfying to them, work that allows them to help community and society, the highest numbers (93%) shows that they want work that allows them to help society and work that is satisfying to them. The results have also shown that students want a career and want to have time for family. We do not really know if these feelings are a reason that female students are not choosing Engineering. We therefore recommend a further research to be done when it comes to how such feelings affect career choices.

Table 6: The importance of different things to career

How important is it to you	Not important	Somewhat important	Very important
Works that makes you think	11	5	84
Work that allows me to make lots of money	7	38	55
Work that allows you to use computer, math, engineering skills and science	14	32	54
Work that allows me to tell people what I do	21	38	41
Work that allows me to help solve problems and create new solutions	17	15	68
Work that is fun to me	5	11	84
Work that allows me to help my community and society	0	7	93
Work that allows me to have time with my family	4	11	85
Work that makes me think highly of me	7	19	74
Work which is satisfying to me	0	7	93

Q 17: What do engineers do?

71 students (71%) agree that mainly, engineers work on computers, 84 students (84%) agree that engineers work with people to solve problems, while 87 students (87%) disagreed that engineers work on things that have nothing to do with me. In total the number of students with "I don't know" and no answer is 38 (38%) meaning there is indeed lack of information of what engineers do. The table 7 below shows how well the students know some facts about an engineer.

Table **7**: Perception on what engineers do

Engineers:	Agree	Disagree	Don't know	No answer
Mainly work on machines and computers	71	23	6	0
Mainly work with other people to solve problems	84	14	2	0
Work on things that help the world	87	9	14	0
Work on things that have nothing to do with me	5	84	9	2
I don't know what engineers do	9	84	2	5

Q 18: Please write few sentences to complete the following statements: My favourite subjects are …and why

Note: students were choosing more than one subject as their favorite subjects.

The level of favorability is as follows: Mathematics-62%, Physics-62%, Chemistry-44%, Biology-39%, Georgaphy-15%, Business studies-21%, English-12%, Kiswahili-6%, History and government-9%, Christian, Religious Education-3%, Computer studies-3%, French-2%, Art and Design-1%, and Agriculture-1%.

From the reports we realize, that the highest number, 62 students (62%) love both mathematics and physics. This is a good sign of their capability to join engineering and enjoy the career. The second highest number (44%) love chemistry, this gives them a good combination, together with mathematics and physics, to join any engineering discipline. Some of the reasons they gave why these were their favourite subjects are: interesting learning them, contribute to their future career, they are real and easy to learn them and the interest for various subjects. It was also realized that, currently in Kenya, no subjects directly related to engineering, such as Introduction to Engineering or Introduction to Engineering Design, etc. are offered at High School level.

Some of the things I like about engineering are

From survey reports, students had many things they liked about engineering, these include: innovation and invention that is involved in it; brings about providing technical solutions to problems; most of their work are done out of offices which is fascinating; respect and money that someone earns by being an engineer; one has to be a critical thinker; and also the fact that engineering is enjoyable when it comes to learning.

Apart from the many positive things they mentioned about engineering, those with negative opinion said they did not know anything about engineering. Some said it was not of interest to them, since that was not their career they wanted to pursue.

Q19. What is your perception in taking engineering as your profession?

The girls' views on Engineering as a career choice varied. 48 students (50.53%) had positive perception concerning engineering. They said: taking engineering is interesting; dream come true; gives great experience; will be an eye-opener to many things; and many other descriptions that showed that they were going to take engineering for they had passion and interest for it.

33 students (34.74%) had a rather negative perception towards engineering. They gave reasons like: engineering needs a lot of commitment; there are many engineers already, so I don't want to end up jobless as engineering is not marketable in Kenya; Others gave a reason that, engineering was never their first option, so they will take it only if they miss their careers of choice. Some of the careers they mentioned as their first choice include medicine and law. 5 students (5.26%) said that they are not sure or they have never even thought of

engineering, while 9 students (9.47%) said that engineering is good but only for those people who have total passion for it and not just meant for anyone. One female student clearly viewed engineering as being purely a 'masculine' career and "categorically, not for me, please", "but I will not mind if my husband will be an engineer". Some said that engineering is not as important in life, as medicine, for example.

The study clearly established a massive information gap or even ignorance on the side of the students and possibly their advisors-teachers and counsellors. The students stated that:" there are many engineers already, so they don't want to end up jobless as engineering is not marketable in Kenya." The truth of the matter, however, is that, currently according to Starovoytova (2015) Kenya has a huge deficit of engineers (-238%).

Q 20: Please draw a picture of an engineer (the way you see or visualize it in your mind)

30 students (32.26%) had a visualization of an engineer as a male-gender, 43 students (46.24%) visualize an engineer as a female, while 20 students (21.5%) did not give a clear visualization as to whether an engineer is of either gender. We can therefore conclude that the students had strong confidence that female can also become an engineer.

From the questionnaires, 92 drawings of the respondents showed that engineers do the manual work, which by authors' opinion could discourage them from undertaking engineering.

From the drawings, the students also used different features in their drawings to show that they are engineers and not just ordinary people. Students used more than one feature to draw an engineer as they visualize. Out of the total students who responded, 48 students (51.61%) drew an engineer with helmets, this is a clear indication that most of the students have seen an engineer. 25 students (26.88%) drew persons holding some tool or instruments in their hands. The tools ranged from screw drivers, drawing instruments, spanner, welding machines, bulbs, spades, a plan drawing in a paper, tool box and even laptops. This is a clear sign that some of these students understand what the field of engineering entails. 22 students (23.66%) drew a picture of an engineer at different workstation that ranged from road construction site, computer work station, mechanical workstation, aeronautical workstation, transformers and even boosters. This showed that some students understood clearly what engineering work entailed.10 students (10.75%) represented an engineer with different kinds of protective gears ranging from dustcoats, protective glasses to protective shoes among others.

It was interesting to note that more students identified that engineers work in a variety of places and professions rather than simply in factories and garages. They associated engineering with, for example, gas and photocopier engineers and with repairing and upgrading the rail and road networks.

Few pictures (4%) also included evidence of engineers in the process of designing. Often, these pictures included a person seated at a desk holding a pen or pencil, or a person in front of a computer. Finally, images of trains, train tracks and train engineers appeared about 17 times in the sample, indicating that a few students still associate engineers with trains. Images of laboratory work such as test tubes and beakers appeared only 2 times in the sample.

Q21. What are the first (two or three) words coming into your mind when you think about "an engineer"?

The words mentioned are: huge factories, large machines, noisy and dirty, ever-busy, not for me, manly and unfriendly, gifted people only, not for "sissies", math and science, smart, really smart, problem-solving, design, building, hard, complex, men, cars, engines, don't know, trains, bridges, math, too difficult, science, machines, boring, too complex, and boys among similar others.

4. Discussion

4.1. Analysis of perception about engineering

It was predicted that the female pupils involved in this survey would have at least a basic understanding of engineering; however, this would be mainly through TV and family exposure. To an extent this is true, however, the results of this study suggest that the majority of female pupils have a fairly good idea of what engineering is and they generally have a positive attitude towards it. Actually in some cases the students' perception and broad awareness about the subject matter were beyond the expectations of the researchers. These findings largely challenge a "stereotypical view" identified in the Science Council Report (2008) suggesting that many young people simply fail to understand exactly what an engineer is and what engineering is about. The findings also differ from what was found in previous studies of Dakers& deVries (2009).

In several occasions, however, an obstructive perception of engineering careers, among both girls and probably their families, as 'masculine' or 'brainy' was evident from the in-depth analysis of the responses. This perception is prompted by a social fabric that pervades our society, represented not only within our educational systems but also in homes, within families, and in popular culture, which, by and large, stereotypes engineering as particularly inappropriate for girls and women. Part of the problem with this perception of engineering as 'male' and 'too hard' is wider ignorance about engineering careers and the 'engineering pathway' among school-children and their key influencers – parents, teachers and career advisers. This finding concurs with study of Tietjen (2004): "Not only do students have a poor understanding of engineering careers, but many families and teachers do not have enough knowledge about science careers in general".

Family knowledge and encouragement of engineering and engineering careers is important in shaping science aspirations. More specifically, how much science capital a family possesses has measurable impact on their children's aspirations from as early as the age of 14 (and sometimes even earlier). 'Science capital' refers to a family's science-related qualifications, understanding, knowledge (about science and 'how it works'), interest and social contacts (for example, knowing someone who works in a science-related job) (Mujtaba& Reiss, 2012).

Parents and peers play a crucial role in framing subject preferences and job/career preferences. Changing the attitudes of parents and peers is as crucial for challenging gender stereotypes as is changing the attitudes of teachers. Parents are powerful players in the gender game; they can and do reinforce gender stereotypical expectations. A number of studies have shown that teachers' and parents' gender-stereotyped behavior and expectations can undermine girls' confidence in their mathematical abilities and eventually discourage them from choosing mathematics-related courses in secondary school (Eccles & Wigfield, 2002; Turner et al., 2004).

Adolescence is a key period of identity formation, and identifying with certain subjects in school and disconnecting with others is a way of developing an identity as a person. Because some subjects are seen as masculine and others as feminine, subject choices are not simply driven by academic interests or even by capabilities. They are driven in some part by the desire to present oneself as particular kind of (attractive) masculine or feminine person (Hannover& Kessels, 2004). Peers tend to reinforce gender stereotypical behavior and punish non-conformity; this impacts on subject choices (Kessels, 2005).

Gender identity and femininity, however, is a multi-faced conception. Traditional, compliant (polite, feminine), transgressive ("girl power") and dissociative (tom-boys) femininities interact side by side (Reay, 2001). Gendered femininities are monitored and restrained by the peer group and staff who are active in maintaining traditional gender roles and restraining transgressive attitudes and behaviors on the part of girls (Gordon, 2006). The role of teachers in the maintenance or challenging of gender stereotypes is highly influential; as they are the ones who interact with students in and out of classroom environment. In addition the teachers' opinion is known to be very valuable and influential in the eyes of their pupils from their yearly years of schooling. Many of us, who are parents, probably remember how some of our children were very concrete when our opinion (as parents) was not coincided with the of their teacher's opinion, saying:"but my teacher said...!"

Student's images and stereotypes about engineers and engineering are important, since perceptions of careers are closely linked to whether students feel they can pursue those careers. Therefore, joint action must be taken to challenge popular perceptions of engineering careers among females and their families. There must be a massive hit on stereotypes to discredit myths surrounding women in engineering and perceptions about STEM careers in general and engineering careers in particular. This will require detailed planning and consolidated effort from all stakeholders, such as the industry, professional bodies, expert educators& administrators from secondary and tertiary institutions, and Governmental representatives.

Many studies have already stipulated varied recommendations on how to confront the gender stereotype and how to attract more females to engineering.

4.2. Prior recommendations made on how to attract more females to engineering

Selected previous recommendations made by international and local authors to attract more female students to engineering are as follows:

Showing that engineering, innovation and technology are part of the solution to global issues, their attention and interest are raised and they are attracted to engineering (UN, 2010). The World's Women, 2010 report sheds new light on the need to:

- Develop public and policy awareness and understanding of engineering, affirming the role of engineering as the driver of innovation, social and economic development;
- Develop information on engineering, highlighting the urgent need for better statistics and indicators on engineering (such as how many and what types of engineers a country has and needs – which was beyond the scope of this Report);
- Transform engineering education, curricula and teaching methods to emphasize relevance and a problem-solving approach to engineering;
- More effectively innovate and apply engineering and technology to global issues and challenges such as poverty reduction, sustainable development and climate change – and urgently develop greener engineering and lower carbon technology.

To attract more females to engineering, the Extraordinary Women Engineering Project (EWEP) coalition recommends the following actions:

- Facilitate a dialogue within the engineering community on the need to redefine engineering as a desirable career option for academically prepared high school girls.
- Develop and test messages that illustrate engineering as a career that complements and supports

community interests, family interests, and self-interests.

- Create materials using these tested messages to promote engineering to high school girls
- Create training opportunities and resources engineers can use to promote engineering education and careers to girls, their parents, and educators.
- Create training opportunities and resources school counselors and teachers can use to promote engineering education and careers to girls and their parents.

Additional suggestions include the following: getting students to join math and science clubs; exploring technology hobbies among school children; helping them to participate in science fairs; basic computing and internet browsing; including them in Internet forums and social networking; providing them with books and magazines on science and mathematics; motivating them to pursue science and engineering careers (Stout et. al., 2011). Examples of such materials can be found in the "Engineering – Go For It!" publication and website produced by the American Society of Engineering Education (ASEE, 2009).

Another instance is at the University of Nevada, a course in Science and Technology for High School Teachers is being run to encourage teachers to include engineering content and problem solving skills in the curricula. In the case of the University of Alabama in Huntsville, a similar program targets pupils with an aptitude for science and mathematics, but not necessarily considering engineering as a career choice.

ATTRACT project, funded in 2009 under the EU flagship program "Lifelong Learning", is a follow up initiative of a Swedish national project ("UngIngenjör/Young Engineer coordinated by KTH) which had the main objective of investigating the attractiveness of engineering studies for young students (ATTRACT, 2012).

Pennsylvania State University also exploited a computer aided bridge design competition to outreach high school students. Several other initiatives have also been reported, aiming to achieve enhanced awareness for engineering (Bunyi, 2003; National Academy of Engineering, 2008; Lewis et.al., 2007; Mills et al., 2008; Norden, 2008; Gosink, 2001; Clutterbuck, 2001; Engineer Your Career, 2009).

These recommendations for action attempt to challenge misconceptions and ignorance about the reality of STEM careers. The key is to change girls' and young women's self-concept, and to widen their aspirations so that they at least consider an STEM career. Keeping more women in the engineering talent pipeline will require many interventions: there is not a single silver-bullet solution for addressing the lack of female engineers, and only pursuing one single intervention is unlikely to have any meaningful impact.

4.3. Areas of concern and potentials identified by the study

As much as the authors concur with most of the above recommendations, practices and activities; the current study identified some new, or renewed, avenues to address the subject matter. Brief discussion below will provide some specifics on the avenues.

4.3.1. Enhancement of curricular

Findings of this study indicates that many students (more than 70%) do not consider going into a career in engineering because they do not have clear understanding of the field, a contention that is supported by the literature (Frehill, 1998). The study also identified that: (1) 11% of pupils had no idea about Engineering and Technology, (2) 38% of female students lacked information and comprehension of what engineering is and what engineers do, (3) 34.74% of students had a negative perception toward engineering, (4) currently in Kenya no subjects directly related to engineering, such as: Introduction to Engineering or Introduction to Engineering Design, etc. are offered at High School level.

As a consequence, raising awareness of the fundamental principles of engineering as a profession needs to be a high priority.

Engineering needs to be presented to girls as a potential, exciting and viable career option throughout their time at Secondary/High School. Therefore, there is a strong case to suggest that Government of Kenya (GoK) needs to be persuaded to make engineering a core-subject, differentiated from science, in the educational curriculum.

Secondary School Curriculum needs to be broadened so as to ignite children's *Engineering Imaginations* from an early-age. For children to consider Engineering as a potential and viable career option, the subject first needs to become embedded within their everyday life, daily language and learning right from the start of their School Careers. On the other hand, a failure to choose the right subjects at the age of 16 effectively closes the door to professional engineering and science careers. Therefore the authors suggest a radical shift-starting Careers Introduction from primary schools.

4.3.2. Career Counseling at school

The current study identified that: (1) only 7.86% of female pupils received an idea of what engineering and technology entails from their Guidance counsellor/Career advisers, (2) only 19.51% of students received encouragement from their Guidance counsellor/ Career advisers during school to pursue engineering as a profession, and (3) Career advisers had even tried to discourage pupils from studying engineering, saying plainly that STEM subjects are inherently "too tough" for females, and "there is no need to stress yourself", and also that

these careers are for boys.

This statistics shows clearly that Career advisers did not feature prominently. The findings also suggest that the current careers-advice-arrangements give students too little information on engineering, which sometimes is very inadequate, largely misleading and even discouraging. This is ironic, as proper career advice & counseling, is what is expected from them in the first place (by their job description).

Secondly, Career advisers should not give any preferential treatment (favoritism or discrimination) to any of the careers they are introducing. They should hold a neutral stand and be very objective. For example, in case of engineering, they should honestly acknowledge that engineering careers require significant investments and hard work during preparation. However, students who do commit themselves from the very beginning of the secondary school, and succeed in sciences and mathematics can succeed in the engineering path in their future studies. Moreover, qualities and skills such as: curiosity, the ability to think logically and creatively in problem-solving, communication skills and the ability to work in teams are all required to succeed in engineering careers.

It also appears that better and more informed careers guidance at key stages would help steer more female students towards mathematics and physics, and would also help to break down some misconceptions about what an engineer does and who can become an engineer. In this regard, Career advisers will need to have access to a wider range of resources that can enable them to clearly demonstrate connections between what they are teaching and engineering, be they in the form of "what engineers do" or "the impact of engineering" on our world. Such resources might include, but not limited to the following: study trips, guest speakers, special supplies and equipment for projects, audio-visual aids, subscriptions to professional publications, children's and young adults' books about engineering and engineers; attendance at conferences, faculty-engineer exchanges and so forth.

The message from all the above is straightforward: 'provide better training and resources for Career advisers'. To achieve this, the government should provide more investment in supporting teachers and counselors preparation programs that provide strong content and pedagogical knowledge in STEM subjects.

Better careers-advice would help to de-mystify career options in science. Again, this should start as early as possible, and be implemented in the primary school curriculum. Because aspirations are, in part, shaped by family and other key influencers, it is also important to work with families to boost science capital. Increasing science capital would mean that more students and families know that pursuing science keeps doors open instead of shutting them down, and would mean that more young females will consider engineering as a rewarding and fruitful career option.

A good example to this end is STEM Subject Choice and Careers (2010), which report illustrates how schools have raised STEM careers awareness by means of a range of successful interventions, together with some review of the impact of those interventions.

4.3.3. Outreach programs to schools

This study identified that 92% of drawings of the respondents showed that engineers do manual work, which by authors' opinion could discourage pupils from undertaking engineering. The students' view is out-dated, if not primitive, as modern engineering hardly involves any manual jobs; the work is largely intellectual. In addition, present-day engineering is more sophisticated than ever before, and now encompasses complicated computers, complex mathematical models, printed circuit boards, and electronics - all of which help to dismiss the 'dirty & noisy' myth when used in schools' information and careers literature.

Informing those students that engineering is not just "fixing cars" may cause more students to consider engineering as an option. Taking these conceptions into account, intervention and outreach programs can directly address these ideas, and engage the students in discussion in order to form more accurate understandings of the role of an engineer.

The ground-breaking research of the National Academy of Engineering's "Changing the Conversation" project has led to new best practices (Rockland et.al, 2002). This research showed high school students related more to messages of vision, such as "engineers are creative problem solvers." High school girls related best to the messages, "Engineers make a world of a difference," and "Engineering is essential to our health, happiness and safety" (Hermanussen & Booy, 2002).

In addition, efforts to recruit more women into engineering must avoid appealing to gender stereotypes, which associate men and masculinity with 'things technical', and women and femininity with 'things social'. Rather, recruitment campaigns should 'speak to' the enthusiasm about maths, science and technology and the desire to be practical, which all would-be engineers – women and men – share. And at the same time, they should strive to reach the diverse 'types' of people which engineering needs (RAEng, 2007).

Outreach programs are considered 'recruitment' and their success is measured in terms of number of participants who eventually enroll in science and engineering (Cuny& Aspray, 2000; Lane, 1999; Roberts et.al., 2002; Grose, 2006). However, numbers are secondary. The paramount importance of the whole exercise is that an outreach program should teach students how science and engineering can make the world a better place. There is also a need to develop and promote an attractive and inspirational message about the STEM disciplines

and the role they play in addressing global challenges. Outreach programs should aim to reach young women and provide them with an understanding of engineering as a career so that they can make an informed choice rather than being influenced by stereotypes.

The following program has been proven successful in introducing young females to engineering. The Discover Engineering Summer Camp was established in 1991 by Ryerson's Women in Engineering (WIE) Committee. The primary objective of the program was to introduce young women in high school to the challenges and rewards of engineering through a variety of fun, hands-on activities and discussions led by women engineers, scientists and students.

4.3.3.1. Role-models and their influence

This study determined that 53 % of the students said that they had never interacted with an engineer. Moreover, it was found that 25% of students were showing lack of self-confidence by holding neutral position when asked if they feel that they are good at math and science. The study also found that vast majority of students perceived engineering as "masculine" and "too hard", "not for me" among other negative misconceptions.

To change the students' perceptions about some careers, there is need for more role models in the careers that are perceived to be either male or female-dominated (Stout, et. al., 2011).

Role-models can help to improve students' understanding of engineering careers and the engineering pathway. Teachers' contact with role models or ambassadors from industry could be used to contextualize learning and improve teachers' and students' careers knowledge. Role models (STEM professionals visiting schools) could also be supported by STEMnet to develop longer-term relationships with teachers, act as their link with industry, and give them up-to-date information about STEM workplaces and careers. ScienceGrrl, for example, suggests that teachers and ambassadors could talk via alternative communication channels such as Skype and Google Hangouts (Zecharia et al., 2014).

Girls respond with particular success to the influence of role models and mentors. Lively and successful women Engineers, technologists and scientists have a very real impact (Platz, 2012).The current study suggests that seeing other successful women in engineering promises to free young women in the present generation from a societal constrained view of their abilities. These cultural stereotypes are deeply-rooted and reinforced by the continued scarcity of women within engineering, and also by the fact that gender disparity has been not decreasing in engineering. The study advocates that increasing the visibility of a critical mass of scientists, engineers, and mathematicians, and providing for young females opportunities to have personal contact with them, has a profound positive effect on young women's self-perceptions in science, math, and engineering.

How people view themselves in relation to science is important in determining students' future career choices. As such, strategies to increase female engineers need to address young women's self-concepts and self-confidence. The study proposes equality and inclusion training for teachers, and access to diverse role-models and mentors for pupils in primary school onwards.

4.3.3.2. Hands-on activities for schools.

Hands-on activities/experiences should be introduced and incorporated as a vital part of marketing campaigns and outreach programs.

A popular solution takes the form of outreach programs towards high school girls, giving them a more hands-on experience of science and engineering (Sullivan et.al., 2003; Moskal, 2000; Muller& Pavone, 1997; Cohoon, 2002; Anderson& Northwood, 2002).

This approach, proven to be very successful in the project: "Engineering for a Day", developed at UCS - Bento Gonçalves campus, has the objective to raise the interest to the Engineering. The activities of this project, performed in sequenced stages, culminated in the "creation" of a remote- controlled toy-car. The pupils joined in, in the whole process in a dynamic and joyful way, interacting and experiencing the academic environment. Moreover, they could establish a bond between the practical life situations and school content in approximately three hours of work (Parmegiani et.al, 2014).

4.3.4. Freedom of choice and selecting a career that matches one's personality.

Outreach activities inform and inspire; however, young people often attend these with a misunderstanding of the fundamental nature of university and its disciplines (e.g. engineering). This misunderstanding is not restricted to young people, but held widely within society by teachers and even some careers staff (Marshall et al., 2007).

Although this paper's main purpose was to investigate the female pupils' perception on engineering, as a possible cause of female underrepresentation in engineering education, the authors, by no means, are trying to force female pupils to engineering.

First, it is very important to choose a career that matches one's personality. Students should find out as much about themselves as possible by taking personality assessments at career guidance centers and talking to friends, family, guidance counselors, and your math and science teachers. Another helpful resource is the Felder's Index of Learning Styles (available online for free self-assessment). In Felder-Silverman learning style model (FSLSM) each learner is characterized by a specific preference for each of the following dimensions: Active learners, Reflective learners, Sensing Learners, Intuitive Learners, Visual Learners, Verbal Learners,

Sequential Learners, and Global Learners. The Index of Learning Styles (ILS), developed by Felder& Soloman, is a 44-item questionnaire for identifying the learning styles according to FSLSM. These preferences are expressed with values between +11 to -11 per dimension, with steps +/-2. This range comes from the 11 questions that are posed for each dimension. Studies seem to support the argument that ILS is reliable, valid and suitable. Open issues arose, such as dependencies between some learning styles and the existence of some latent dimensions which need further investigations (e.g., Viola et. al., 2007). If engineering is of interest, however, additional skills such as critical thinking, analytical abilities, creativity, a practical aptitude, and an awareness of global social context should be assessed (for more details see "Engineer of 2020" Study, NAE, 2003).

This study suggests creating an exciting target-oriented marketing campaign for Engineering at MU that stimulates potential students to think about the technical fields in a new way that is attractive and inclusive.

Finally, the authors would like to clearly emphasize and stress, that increasing female enrolment numbers in engineering is not supposed to be an ultimate goal, as it might appear. Freedom of choice of future careers is, however, paramount. The authors concur with the eloquent example given by Bouville (2007), which states:" ...take three girls. Tell the first one how rewarding science is and show her that she can be a successful scientist. Do the same with the other two girls in respective to medicine and law. What will happen? The first girl will graduate in science, the second in medicine, and the third in law. Does the outcome correlate with what the girls want? Not at all! It correlates with the viewpoint that they have heard. *We* are the ones making a decision by choosing what information we give them". In this regard, the study proposes that, various careers alternatives (science, engineering, art, business, journalism, law, medicine, teaching, etc.) should be presented to pupils, providing unbiased, comprehensive, user-friendly, up-to-date, and consistent-format information about the opportunities and rewards for each of the careers.

5. Conclusion and Recommendations

5.1. Conclusion

In the first part of this paper the authors strived indeed to provide compact and yet enlightening information on engineering, by outlining its essence, providing its brief account and explaining what a profession entails. The second, larger part, was dealing with assessment of the views of female students on engineering as a career. This concise study has only started to scratch the surface of the subject matter; however, it illustrates an interesting phenomenon, which could be one of the major contributing factors to female underrepresentation in engineering education. This phenomenon happens when redundant stereotypical perception about Engineering and very persistent out-dated Gender stereotype meet head-to-head. Logically, in order to attract much more females into engineering, both stereotypes (Engineering and Gender) should be challenged and, in the long run, changed. As Lie (2003) has mentioned, the discourse on gender and engineering tends to appear as a very tight knot that is difficult to untie. Our aim was to loosen it up by throwing a different light on gender-engineering relations.

Because stereotypes are imbedded in us: in our families, in our believes, in our culture, in our media, and in society at large; they are extremely slow and reluctant to change. However, the war against stereotypes should start, and it should start from us-all, the stakeholders. The change should be initiated and achieved in a consistent and targeted manner, supported by sufficient resources and by practical policies. Engineering educators need to take steps to place "engineering" at the heart of public debate, raising public-awareness whilst addressing many deep-rooted misconceptions.

If the role of Engineering is more visible and better understood, more young people (both females and males) would be attracted to it as a career. Therefore, the time for action is NOW!

5.2. Recommendations

Previously mentioned, in this paper, recommendations are summarized below, as follows:

1. In general, in order to attract much more females into engineering, both stereotypes (Engineering and Gender) should be challenged and, in the long-run, changed.
2. To make engineering a core-subject; differentiated from science, in the educational curriculum. Secondary School Curriculum needs to be broadened so as to ignite children's *Engineering Imaginations* from an early-age.
3. To provide better training and resources for Secondary Schools Career advisers. To achieve this Ministry of Education, Science and Technology should provide more allocation and investment in supporting teachers and cancellers preparation programs that provide strong content and pedagogical knowledge in STEM subjects.
4. Outreach programs should be developed to teach pupils how science and engineering can make the world a better place. There is also a need to develop and promote an attractive and inspirational message about the STEM disciplines and the role they play in addressing global challenges. Hand-on activities/experiences should be introduced and incorporated as a vital part of marketing campaigns and outreach programs.

5. To create an exciting target-oriented marketing campaign for Engineering (for example at MU) that stimulates potential students to think about the technical fields in a new way that is attractive and inclusive.
6. To increase the visibility of a critical mass of both women and men scientists, engineers, and mathematicians, and providing pupils and students opportunities to have personal contact with them (role-models).
7. To provide students with freedom of choice of future career, various career alternatives (science, engineering, art, business, journalism, law, medicine, teaching, etc.) should be presented to pupils, providing unbiased, comprehensive, user-friendly, up-to-date, and consistent-format information about the opportunities and rewards for each of the careers.
8. Students should choose a career that matches one's personality.

Moreover, the study had several important limitations that hamper its generalability. The dataset for the study came from one institution. In addition, the students in the dataset are from the final year of a High School. In this regard, the study recommends broadening and enriching the scope of future studies by including in the assessment, for example, different types of schools (girls-only, boys-only, and mixed, also boarding and day-schools). Another prospect is to include students at different level of their school experience, starting as early as Form One.

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