THE NIEW JOURNAL

THE VOICE OF THE NAM WOMAN

VOLUME 7 / 2015

Women in Science, Technology, Engineering and Mathematics

KPWKM
Kementerian Pembangunan Wanita, Keluarga dan Masyarakat

NIEW
NAM INSTITUTE FOR THE EMPOWERMENT OF WOMEN
MALAYSIA

THE NIEW JOURNAL

THE VOICE OF THE NAM WOMAN

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FOREWORD

YB Dato' Sri Rohani Abdul Karim
Minister of Women, Family and Community Development Malaysia

Congratulations to NIEW for successfully coming up with the 7th edition of The NIEW Journal – The Voice of the NAM Woman! I think the theme on "Women in Science, Technology, Engineering and Mathematics" is an excellent choice in view of the fact that these fields are the driving force in the development of the NAM nations in this digital age. Everywhere we go, we often hear that there is a great need for more and more people in the science, technology, engineering and mathematics or STEM fields, which undeniably, is the way forward for all countries in the future. Sadly enough, today it is a world's phenomenon that the number of women involved in the STEM fields are still very small, and in some countries, negligible. More measures must be taken to lure many more talented girls and young women into these fields. For example, mothers must encourage and promote the fields of STEM to their young daughters in instilling the love for science and mathematics. Young girls should play with building blocks to make buildings, lego toys to design tall structures and robotic toys to trigger their inquisitive minds about engineering and technology. Parents should take their children to science fairs and expositions, science camps, or visits to the science centers and laboratories to expose their young children to science and research.

If science and mathematics subjects are taught in an exciting and interactive manner using digital teaching aid and 3-D illustrations, boys and girls would be more excited to learn and excel better in those subjects. We need to erase the typical and stereotype mindset that science and mathematics are only for the boys, and that the challenging careers in STEM are not meant for the women. Women are equally competent and capable as the men in these fields and women would perform very well if only the working environment in both the labs and fields are women-friendly, the misconceptions and stereotyping among the people is changed, the office policies in particular about balancing children and job responsibilities, to name a few, would be addressed and rectified. Most countries in the world face these common challenges that their women who enter the science and engineering fields often leave prematurely, and even if they stay, many do not advance in their careers as quickly as their male counterparts. We need to ensure that women not just enter the STEM fields, but more importantly, they remain, compete and truly excel in the scientific and engineering careers. Retaining talented women in just one organisation alone would benefit the

industry, what more with many organisations. Sustaining the pipeline of female talent in STEM will not be resolved by the Chairman, CEOs and MDs acting alone. The solution lies in companies, communities, employees and their representatives, policy makers, regulators, individual male and female to play a bigger role in collaborating together in making change happen.

The world cannot function without innovation and technology as it transforms the ways and process of work, the way we live our lives together, the way we connect with people worldwide, the way we travel from one point to another, the way we indulge ourselves in sports, recreational activities and entertainment and many more. All these are connected to us very closely in our daily lives and humans are simply handicapped without all these technology that makes our lives so much more fulfilling and meaningful. We all owe these miracles of life from the people who are committed, dedicated and passionate about inventing new technologies, creating new things, making prototypes, innovating new models and simplifying processes so that people can have a more advanced lifestyle.

Imagine how our lives have been transformed without scientific research and new discoveries in Quantum theory, for example, lasers would not have been invented. Further examples include among others, hospitals would not have precision surgeries, the entertainment industry would not have top-notch and state-of-the-art digitalized music and films, road users would not enjoy fast paying system at toll plazas on the highways, customers would not have speedy check-out counters at hypermarkets without the bar codes and laser readers. We would not have all these convenience in life at all.

I hope that more women will be inspired and have a change of heart about venturing into science and technology after they have read this journal because we have so many talented young girls and women out there who need to be assured that careers in STEM is very lucrative and fulfilling.

Thank you.

Dato' Sri Rohani Abdul Karim

FOREWORD

YBhg Dato' Sabariah Hassan
Secretary-General, Ministry of Women,
Family and Community Development
Malaysia

I would like to express my heartiest congratulations to NIEW for another successful edition of The NIEW Journal – The Voice of the NAM Woman on the theme *"Women in Science, Technology, Engineering and Mathematics".* This theme is in tandem with the federal government's goal to increase its focus on science, technology, engineering and mathematics (STEM) fields, in particular in the education of these subjects, in realizing our vision 2020 to be a developed nation. It is our vision to see Malaysia achieve a target of 60 percent of all secondary school leavers to specialize in STEM subjects by 2020 from the 40 percent in 2013. In line with this, we need to harness skills and knowledge in STEM among women in Malaysia across all sectors to remain on the growth trajectory towards economic and societal gains. In recent years, our economy had been transformed from an agriculture-based to a resource and manufacturing-based, where science, technology, and research are the driving force behind the strong development. In this 21st century where globalization is conquering every aspect of business, trade, finance, education, and research, Malaysia cannot ignore the growing importance of STEM subjects and the need to increase its human capital in these fields. Skills like critical and inventive thinking, communication, collaboration, cross-cultural and information skills must also complement the sound knowledge in STEM.

Although we have come a long way where we can now see more women scientists and engineers in our own country, the women's participation and involvement is still not being felt. As in most Asian cultures, patriarchal institutions strongly exist in Malaysia. In many areas, we are still living in a male-dominated setting society. Women generally are still trapped in their stereotyped roles. The data from our Ministry of Education shows that although more women are studying science in university, fewer of them go past undergraduate levels. As shown by the research work featured in this publication, the main barriers for women to enter the STEM fields are the lack of role models, gender stereotyping, lack of targeted educational policies towards girls and women in STEM fields, as well as limited gender-responsive career counseling. It is, therefore, my hope that the policy makers, educationists, researchers, practitioners and individuals involved in enhancing STEM education in Malaysia would review more successful initiatives, draw up more relevant experiences, establish more feasible strategies, lobby in a more effective manner, restructure and remodel more exciting teaching modules and tools, so as to enhance the promotion of STEM subjects among our Malaysian girls at schools and tertiary education.

The government will continue to support and complement programmes that promote and foster advancement of women in the science field such as our initiatives through the implementation of the Economic Transformation Programme (ETP) and the education blueprints (Malaysia Education Blueprint 2013-2025 and the Malaysian Higher Education Blueprint 2015-2025). In the 11th Malaysia Plan 2016-2020, we are focusing on anchoring the nation's growth on people where women's role will not be limited to building happy families but they will also contribute to socio-economic development and hope to achieve an increase in their workforce participation from 54 percent in 2014 to 59 percent by 2020.

Once again, I would like to congratulate NIEW for this unique compendium of research work highlighting analyses, insights and recommendations addressing the many concerns of women in STEM that evidently are very common among the developing countries and energy economies. This compilation of extensive research work will be a useful guide and reference for all to formulate more meaningful initiatives in attracting and retaining more women in STEM fields. I wish all the women who are in the STEM fields in NAM nation success in their education and career and looking forward to see more women from NAM to win those prestigious international STEM awards.

Thank you.

YBhg Dato' Sabariah Hassan

FOREWORD

Normalia Ibrahim
Director
NAM Institute for the Empowerment of Women (NIEW)
Ministry of Women, Family and Community Development Malaysia

Greetings to all our readers. It gives me great pleasure to write a foreword message to you in the 7th edition of our The NIEW Journal – The Voice of the NAM Woman. This year, we are focusing on a theme of *"Women in Science, Technology, Engineering and Mathematics"* or STEM fields as we realize that in this world, we are facing enormous challenges on global change, health epidemic, increased income inequality, rising socioeconomic issues, among others, all requiring new solutions to sustainable and inclusive economic growth for all mankind in the world. This means we need more STEM professionals and for that we need to get more women involved. Many reports made by UN, UNESCO, World Bank, and others say that globally women make up 30% of researches in science, technology and innovation, but only two women out of two hundred, Marie Curie for her work on radiation research which led her to discover polonium and radium and the development of X-rays, and Maria Goeppert-Mayer for her discovery on nuclear shell model for the structure of atomic nuclei, have won the Nobel laureate awards in physics to-date since 1901. Although women make up half of the world population, this shows that there are so much talent being untapped and women are still very much unrepresented in STEM fields around the world.

This publication portrays vignettes that explore the various aspects of women in STEM fields in the hope that it will enlighten readers with regard to this pertinent issue. You will realise that there is much to be done to inspire girls to be interested in science in schools, so that they will choose STEM fields to study in universities and a career in STEM when they graduate. However, we also realise that the far greater challenge is not to get the girls to be interested in science from school, but how to retain them in the workforce, especially after they get married and are faced with motherhood challenges. Most of the articles featured here looked into the real issues on *"where are the women in STEM fields?"* and *"where are they in the workforce?"* and *"why are they dropping out of their careers?"*. The findings are alarming as traditionally girls have been taught that science is a boy's game and is still is in many parts of the world. However, findings also show that over the years the numbers of girls studying in STEM fields have increased tremendously in the higher institutions earning them degrees, masters and PhDs. If we look at the figures in the workforce, women are scarce in filling up the positions, even more so at the higher levels. The leakage is happening everywhere, in both developed, developing and under-developed countries.

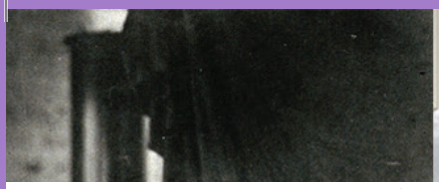
In this publication, you will be able to get insights from ten scholars who have explored and deliberated in depth about the challenges faced by women in STEM fields from all over the world. Many enlightening recommendations have been made to share with readers on addressing the multiple challenges faced by women in STEM. Indeed these are timely suggestions as many parts of the world, in particular the NAM nations, are looking for pragmatic recovery measures from the global economic crisis so as to build a more resilient and sustainable economic order for trade and business in their countries.

The contributors and editors need to be congratulated for successfully bringing out this edition. I would like to take this opportunity to congratulate the Editorial team who have worked relentlessly and tirelessly for this valuable publication. I would also like to express my profound gratitude and appreciation to all the eminent scholars and researchers for sharing with the readers their valuable insights and findings.

May I wish you Happy Reading!

Thank you.

Normalia Ibrahim



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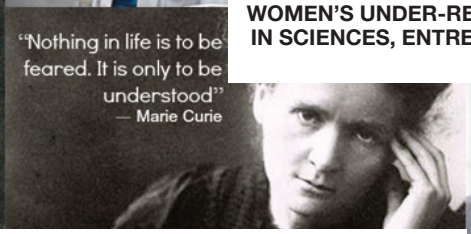

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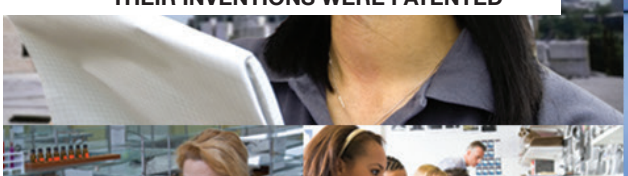

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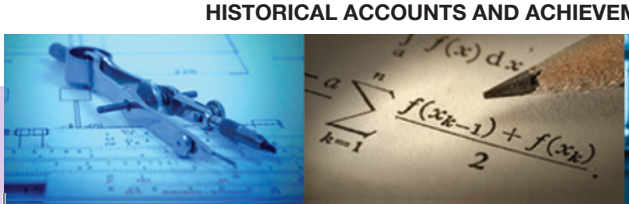

THE LIFE OF MARIE CURIE "MOTHER OF MODERN PHYSICS" (1867 – 1934)

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"Nothing in life is to be feared, it is only to be understood. Now is the time to understand more so that we may fear less." – Marie Curie

INTRODUCTION

Marie Sklodowska Curie discovered the mysterious radioactive elements radium and polonium and is remembered for her huge contribution to the fight against cancer. It opened the door to deep changes in the way scientists and the public understand and think about matter and energy. Her work has not only influenced the development of fundamental science but also ushered in a new era in medical knowledge and research as well as the treatment of diseases. Madam Curie a.k.a "Mother of Modern Physics" was the first woman to win a Nobel Prize and also the only woman till today who has been honored twice with the Nobel Prize in two different fields namely Physics and Chemistry. In 1903, she won her first Nobel Prize for rendering extraordinary services in Physics wherein she had carried forward the research work of Henri Becquerel, a French physicist who had discovered the unique property of element uranium which could emit rays. Later in 1911, she was awarded a second Nobel Prize for her extraordinary services in the field of Chemistry where she discovered radioactive elements like radium and polonium. Marie Curie is one of the most famous scientists that ever lived. Her contributions such as the discovery of radium, polonium and other key elements have helped doctors in modern medicine till today. In addition, Marie Curie was also an active humanitarian supporter. During the World War 1, she set up mobile radiography units known as petite Curies or "Little Curies" to help doctors treat the soldiers and victims of wars. She continued to promote the use of radium for therapy throughout her life. She was also the Director of the Red

Cross Radiology Service and initiated France's first military radiology centre operated in late 1914. Her determination, relentless efforts, total commitment and undivided dedication to science and humanity were extraordinary. Marie Curie has definitely inspired generations of women scientists and engineers.

HER EARLY LIFE 1867 - 1891

Manya, as she was called by family and friends, was born as Maria Salomea Sklodowski, or better known as Marie Curie, in Warsaw in modern-day Poland on November 7, 1867. She was the youngest of five children, three older sisters named Zosia, Bronya and Hela and a brother named Józef. Both of her parents were educators who believed deeply in the importance of education and insisted that their girls be educated as well as their son. Her mother was Bronislawa Boguska, a pianist, singer, and teacher. Her father was Wladyslaw Sklodowski, a professor of mathematics and physics. Since childhood, she was remarkable for her prodigious memory, and at the age of 16 she won a gold medal on completion of her secondary education at the Russian lycée.

Maria's parents raised their children to be patriots of a nation that no longer existed. By 1815, through wars and treaties, the countries around Poland had divided up the country. Warsaw was in the part of Poland controlled by the Czar of Russia who hoped to stamp out Polish nationalism by keeping the people ignorant of their culture and language. But Polish patriots were determined to regain control of their nation. As educators, Maria's parents did their best to overcome restrictions placed on them by their Russian supervisors. The Sklodowskis and other patriots were determined to preserve Polish culture at all costs.

The birth of Maria had led her mother to resign from her position as head of a school, where the family had resided until then. To help make ends meet, they had to take in student boarders. Maria was only eight when her oldest sister, Zosia, caught typhus from a boarder and died. That death was followed less than three years later by the death of her mother, Madame Bronislawa Sklodowska, who lost a five-year battle with tuberculosis at the age of 42. The surviving family members, Professor Sklodowski, his son Józef, and three daughters Bronya, Hela, and Maria drew closer to one another. On Saturday nights, he read classics of literature to Maria and her siblings. He also exposed them to the scientific apparatus he had once used in teaching physics but now kept at home, since the Russian authorities had eliminated laboratory instruction from the Polish curriculum.

As a child, Maria took after her father and had her first lessons in physics and chemistry from him. She had a brilliant aptitude for study and a great thirst for knowledge; however, advanced study was not possible for women in Poland. Because her father had lost his savings through bad investment, she had to work as a teacher and, at the same time, took part clandestinely in the nationalist "free university," reading in Polish

to women workers. Maria graduated from high school first in her class at the age of 15. In spite of being a top student in her secondary school, she could not attend the men-only University of Warsaw. She and Bronya instead continued their education in Warsaw's "floating university," a set of underground, informal classes held in secret. This illegal night school got its name because its classes met in changing locations to evade the watchful eyes of the czarist authorities. However, her brother Józef was able to enroll himself in the medical school at the University of Warsaw.

Bronya and Maria were both interested in scientific research; but to get the education they desired they would have to leave the country. Both Curie and her sister Bronya dreamed of going abroad to earn an official degree, but they lacked the financial resources to pay for more schooling. Undeterred, Curie worked out a deal with her sister. She would work to support Bronya while she was in school and Bronya would return the favor after she completed her studies. At the age of 17, Maria became a governess to help pay for Bronya to attend medical school in Paris. Maria continued to study on her own, looking forward to joining her sister and getting her own degree. For roughly five years, Curie worked as a tutor and a governess. She used her spare time to study, reading about physics, chemistry and mathematics. In 1891, when Curie was 24, she finally made her way to Paris where she enrolled at the Sorbonne in Paris to study mathematics and physics. Bronya was now married to a doctor of Polish origin, and it was at Bronya's urgent invitation to come and live with them that Marie took the step of leaving for Paris. By then she had been away from her studies for six years, nor had she had any training in understanding rapidly spoken French.

When Maria registered at the Sorbonne, she quickly realized that neither her high school education and self-study in mathematics or science nor her ability in technical French had prepared her for Sorbonne or equaled that of her fellow students. Refusing to let go of her goals, she was determined to overcome these drawbacks through hard work.

As a compensation to her hardship, Marie had total freedom to be able to devote herself wholly to her studies. "It was like a new world opened to me, the world of science, which I was at last permitted to know in all liberty," she wrote. She was able to go to hear lectures by France's leading mathematicians and physicists, people with names we now encounter in the history of science: Marcel Brillouin, Paul Painlevé, Gabriel Lippman, Edmund Bouty and Paul Appell at the Sorbonne. There she met physicists who were already well known like Jean Perrin, Charles Maurain, and Aimé Cotton. After two years, Marie finished first in her master's degree in physics course in the summer of July 1893. She began to work in Lippmann's research laboratory. Having little money that stood in the way of her mathematics degree, senior French scientists recognized her abilities and helped her by awarding a scholarship. Women's education advocates then gave her a scholarship to stay and take a second degree in mathematics. In the following year, she came second in a degree in mathematics in her class. After three years, she had brilliantly passed

examinations in physics and mathematics. Before completing the mathematics degree she was also commissioned by the Society for the Encouragement of National Industry to do a study on different types of steel and their magnetic properties of different steels to their chemical composition. Marie needed a lab to work in and a colleague introduced her to a French physicist named Pierre Curie where they had met in Spring 1894.

LOVE AND MARRIAGE WITH PIERRE CURIE

Pierre was a brilliant researcher himself and had invented several instruments for measuring magnetic fields and electricity. He arranged a tiny space for Marie at the Municipal School of Industrial Physics and Chemistry where he worked. A romance developed between the brilliant pair and they became a dynamic scientific duo. Pierre and Marie were married in Summer of July 1895 and that marked the beginning of a historic partnership that was soon to achieve results of world significance, in particular the discovery of polonium as coined out by Marie in honour of Poland in the summer of 1898, and that of radium (Italian for “rays”) a few months later.

Marie had been intrigued by the reports of Wilhelm Roentgen’s discovery of X-rays and by Henri Becquerel’s report of similar “rays” emitted from uranium ores in 1896. She decided to use Pierre’s instruments to measure the faint electrical currents she detected in the air that had been bombarded with uranium rays. Her studies showed that the effects of the rays were constant even when the uranium ore was treated in different ways. She confirmed Becquerel’s observation that greater amounts of uranium in an ore resulted in more intense rays. Then she stated a revolutionary hypothesis: Marie believed that the emission of these rays was an atomic property of uranium. If true, this would mean that the accepted view of the atom as the smallest possible fragment of matter was false. Pierre and Marie was the first to coin out the word “radioactivity”. Maria who was then looking for a subject for a thesis, decided to find out if the property discovered in uranium was to be found in other matter. She discovered that this was true for thorium at the same time as G.C. Schmidt did. Marie was determined not only to get her own doctorate but to see to it that Pierre received one as well. Although Pierre had done important scientific research in more than one field over the past 15 years, he had never completed a doctorate (in France the process consumed even more time than it did in the U.S. or U.K.). Marie insisted that he wrote his research on magnetism. In March 1895, he was awarded the degree. At the Municipal School, Pierre was promoted to a professorship. The honor and the higher salary were offset by increased teaching duties without any improvement in lab space.

Turning to minerals, her attention was drawn to pitchblende, a mineral whose activity, superior to that of pure uranium, could only be explained by the presence in the ore

of small quantities of an unknown substance of very high activity. Pierre then joined her in the work that she had undertaken to resolve this problem and that led to the discovery of the new elements, polonium and radium. While Pierre devoted himself chiefly to the physical study of the new radiations, Marie struggled to obtain pure radium in the metallic state, achieved with the help of a chemist A. Debierne, one of Pierre Curie's pupils. On the results of this research, Marie Curie received her doctorate of science in June 1903 making her as the first woman in Europe to earn a doctorate in Physics. And together with Pierre, they were both awarded the Davy Medal of the Royal Society. Also in 1903, they shared with Becquerel the Nobel Prize for Physics for the discovery of radioactivity.

THE DISCOVERY OF X-RAYS AND URANIUM RAYS

Marie Curie's choice of a thesis topic was influenced by two recent discoveries by other scientists. In December 1895, about six months after the Curies married, German physicist Wilhelm Roentgen discovered a kind of ray that could travel through solid wood or flesh and yield photographs of living people's bones. Roentgen dubbed these mysterious rays X-rays, with X standing for unknown. In recognition of his discovery, Roentgen became the first Nobel laureate in physics in 1901. In early 1896, only a few months after Roentgen's discovery, French physicist Henri Becquerel reported to the French Academy of Sciences that uranium compounds, even if they were kept in the dark, emitted rays that would fog a photographic plate. He had come upon this discovery accidentally. Despite Becquerel's intriguing finding, the scientific community continued to focus its attention on Roentgen's X-rays, neglecting the much weaker Becquerel rays or uranium rays.

With the aid of a new kind of electrometer which is a device for measuring extremely low electrical currents that was invented by Pierre and his older brother, Jacques, Marie used the Curie electrometer to measure the faint currents that could pass through air that has been bombarded with uranium rays. The moist air in the storeroom tended to dissipate the electric charge, but she managed to make reproducible measurements. With numerous experiments Marie confirmed Becquerel's observations that the electrical effects of uranium rays are constant, regardless of whether the uranium was solid or pulverized, pure or in a compound, wet or dry, or whether exposed to light or heat. Likewise, her study of the rays emitted by different uranium compounds validated Becquerel's conclusion that the minerals with a higher proportion of uranium emitted the most intense rays. She went beyond Becquerel's work, however, in forming a crucial hypothesis: the emission of rays by uranium compounds could be an atomic property of the element uranium which is something built into the very structure of its atoms.

Marie tested all the known elements in order to determine if other elements or minerals would make air conduct electricity better, or if uranium alone could do this. In this

task, she was assisted by a number of chemists who donated a variety of mineral samples, including some containing very rare elements. In April 1898, her research revealed that thorium compounds, like those of uranium, emit Becqueral rays. Again the emission appeared to be an atomic property. To describe the behaviour of uranium and thorium she invented the word “radioactivity” in 1898 (based on the Latin word for ray). Pierre was so interested in her research that he put his own work aside to help her. Together, they found that two ores, chalcolite and pitchblende, were much more radioactive than pure uranium. Marie suspected that these ores might contain as yet undiscovered radioactive elements.

Little by little, various components of the ore were tested. The Curies found that two of the chemical components, one containing mostly bismuth and another containing mostly barium, were strongly radioactive. In July 1898, the Curies published their conclusion: the bismuth compound contained a previously undiscovered radioactive element that they named polonium, named after Marie’s native country, Poland. By the end of that year they had isolated a second radioactive element they called radium, from *radius*, the Latin word for rays. In 1902, they announced success in extracting purified radium. The Curies published in detail all the processes they used to isolate radium, without patenting any of them. Radium was tightly linked with the Curies. Pierre’s pioneering work on the effects of radium on living organisms showed it could damage tissue, and this discovery was put to use against cancer and other diseases.

The birth of her two daughters, Irene and Eve, in 1897 and 1904 did not interrupt Marie’s intensive scientific work. She was appointed lecturer in physics at the École Normale Supérieure for girls in Sévres in 1900 and introduced a method of teaching based on experimental demonstrations. In December 1904, she was appointed chief assistant in the laboratory directed by Pierre Curie.

PIERRE’S UNTIMELY DEATH

A few days before his death, Pierre was cautiously optimistic about the progress he and Marie were making in their attempt to make precise measurements of the radioactive gas that radium emitted. He also thought of returning to the studies of crystal symmetries he had set aside when their joint work began. Unfortunately, Pierre was killed when he was run over by a horse-drawn wagon with a load of military uniforms while hurrying to cross the street in a heavy rain.

The sudden death of Pierre Curie was a bitter blow to Marie Curie, but it was also a decisive turning point in her career. She had to devote all her energy to complete alone the scientific work that she and Pierre had undertaken. On May 13, 1906, Marie received an unexpected offer from the Sorbonne University inviting her to take up Pierre’s academic post. Although skeptical at first, she accepted the offer and was

appointed to the professorship that had been left vacant after her husband's death; thus making her as the first woman to teach in the Sorbonne. By doing so, she hoped she could one day establish as a tribute to Pierre's memory, a state-of-the-art lab such as he had never had. It was not enough to be a teacher and researcher. She would have to learn how to create a scientific institution. In 1908, she became titular professor and in 1910 her fundamental treatise on radioactivity was published. In 1911, she was awarded the Nobel Prize for Chemistry for the isolation of pure radium. In 1914, she saw the completion of the building of the laboratories of the Radium Institute (Institut du Radium) at the University of Paris.

THE WAR AND HELP FOR THE WOUNDED – RADIUM CAMPAIGNS (1914-1934)

The Curie's research was crucial in the development of X-rays in surgery. In 1914, when Marie was in the process of beginning to lead one of the departments in the Radium Institute established jointly by the University of Paris and the Pasteur Institute, the First World War broke out. In August 1914, Germany invaded France. Nearly all of Curie's staff at the Radium Institute enlisted in the war effort. Scientific research had to halt during the World War and Curie looked for ways where her science could help. She worked as an "X-ray technician" and taught radiological technology and equipped vehicles with portable X-ray equipment which she herself drove to the front lines. She knew that doctors could use X-rays to save the lives of wounded soldiers by revealing bullets, shrapnel, and broken bones. The problem was to get the X-ray machines to the doctors near the front lines. Curie talked the wealthy people into donating their cars and assembled a fleet of 20 mobile X-ray stations as well as 200 stationary stations. Throughout the war, she was engaged intensively in equipping more than 20 vans that acted as mobile field hospitals and about 200 fixed installations with X-ray apparatus. Those medical vehicles earned the nickname "Little Curies". The International Red Cross made her head of its radiological service and she held training courses on the new techniques for medical orderlies and doctors. Meanwhile Marie thought of another way for radioactivity to help save soldiers' lives. At the Radium Institute, she prepared tiny glass tubes containing a radioactive gas (radon) that comes from minerals containing radium. Hospital doctors inserted the tiny tubes into patients at spots where the radiation would destroy diseased tissue.

Irène, aged 18, became involved, and in the primitive conditions both of them were exposed to large doses of radiation. Heedless of the dangers of over-exposure to X-rays, mother and daughter were inadequately shielded from the radiation that helped save countless soldiers' lives. After the war, the French government recognized Irène's hospital work and awarded her with a military medal but not to Marie Curie. Throughout the World War I, Marie with the help of Irène, devoted herself to the development of the use of X-radiography. In 1918, she was made the Head of the

Paris Institute of Radium which then became a universal centre for nuclear physics and chemistry and also helped founded the Curie Institute. It became France's most internationally celebrated research institute during the inter-war years. Even then, the French state did not do much in supporting her. She worked hard to raise money for her Radium Institute, including two trips to the United States in 1921 and 1929 to raise funds to buy radium and to establish a radium research institute in Warsaw. In 1921, Marie made a triumphant journey to the United States, where President Warren G. Harding presented her with a gram of radium bought from a collection among the American women. She returned with a gram of radium - only a speck, but so fiercely radioactive that it could fuel thousands of experiments - as well as expensive equipment and cash for the Radium Institute.

Marie Curie, now at the highest point of her fame, and, from 1922, as a member of the Academy of Medicine, devoted her researches to the study of the chemistry of radioactive substances and the medical applications of these substances. She was made a member of the International Commission on Intellectual Co-operation by the Council of the League of Nations. In addition, she had the satisfaction of seeing the Curie Foundation in Paris developed and the inauguration of the Radium Institute in Warsaw in 1932, of which her sister Bronya became the director. In 1934, she was delighted when her daughter Irène and husband, Frédéric Joliot-Curie, discovered artificial radioactivity at the Radium Institute. The Curies received another honor in 1944 with the discovery of the 96th element on the Periodic Table of the Elements, which was named curium.

> *"The use of the X-rays during the war saved the lives of many wounded men; it also saved many from long suffering and lasting infirmity." -- Marie Curie*

FINAL DAYS AND LEGACY

All of her years of working with radioactive materials took a toll on Curie's health. Her life was totally flooded in ionizing radiation. She was known to carry bottles of the polonium and radium in the pockets of her coat and even stored them in the drawer of her desk. By 1920, she was suffering from medical problems, likely due to her exposure to radioactive materials. In 1934, Curie went to the Sancellemoz Sanatorium in Passy, France, to try to rest and regain her strength. On July 4, 1934, at the age of 67, Maria Sklodowska-Curie died of aplastic anemia, a blood disease which can be caused by prolonged exposure to radiation.

She was buried next to Pierre. In 1995, the remains of Pierre and Marie Curie were transferred to the majestic Pantheon in Paris, a mausoleum where they now lie alongside France's greatest citizens such as philosophers Rousseau and Voltaire. Marie Curie became the first and only woman to be laid to rest there. The president

of France, Ferdinand Miterrand declared that the transfer demonstrated the nation's respect for all those, like the Curies, "who dedicate themselves to science."

Today, several educational and research institutions as well as medical centers bear the Curie name, including the Institute Curie and the Pierre and Marie Curie University, both in Paris. Marie had opened up a completely new field of research: radioactivity. Various aspects of it were being studied all over the world. In Uppsala, Daniel Strömholm, a professor of chemistry, and Svedberg, then associate professor, investigated the chemistry of the radioactive elements. In 1909, they were close to the discovery of isotopes. However it was the British physicist Frederick Soddy who in the following year, finally clarified the concept of isotopes. Marie's laboratory became the Mecca for radium research. At the 1st Solvay Congress in Physics, Curie was joined by other famous and brilliant scientists, Albert Einstein and Max Planck where together they had discussed the many groundbreaking discoveries in their fields.

Marie had led an exciting life receiving 15 gold medal awards, 19 degrees, and many other honors. She has opened a lot of doors for the young women today. Marie's granddaughter, Hélène Langevin-Joliot is a nuclear physicist and has made a close study of Marie and Pierre Curie's notebooks so as to obtain a picture of how their collaboration functioned. Curie's personal belongings are considered as national and scientific treasures; till today her laboratory note books have been preserved in special lead-lined boxes at France's Bibliotheque National in Paris. Marie and Pierre were not aware of the dangerous effects of radioactive elements and thus all the while during their research they were constantly being exposed to radiations. All of Curie's belongings are believed to be contaminated with 'radium 226' which will continue to be radioactive for another 1,500 years. Curie's body, too, is considered to be radioactive and hence it has been placed in a coffin which is coated with an inch of lead.

Presently physicists and scientists have a better understanding of these radioactive elements and find its applications in medicine as well as nuclear power. Curie also passed down her love for science to the next generation. Her daughter Irène Joliot-Curie followed her mother's footsteps, winning the Nobel Prize in Chemistry in 1935. Irène shared the honor with her husband Frédéric Joliot for their work on the synthesis of new radioactive elements. In the last ten years of her life, Marie had the joy of seeing Irène and Frédéric did successful research in the laboratory. She lived to see their discovery of the artificial radioactivity but sadly did not live to see Irène and Frédéric received the 1935 Nobel Prize in Chemistry for their discovery. She is a great inspiration to both men and women scientists as she is the "Mother of Modern Physics" and had introduced modern medicine to mankind.

Perhaps the most famous of all women scientists, Maria Sklodowska-Curie is notable for her many firsts:

She was the first to use the term radioactivity for this phenomenon.

She was the first woman in Europe to receive her doctorate of science.

In 1903, she became the first woman to win a Nobel Prize for Physics. The award, jointly awarded to Curie, her husband Pierre, and Henri Becquerel, was for the discovery of radioactivity.

She was also the first female lecturer, professor and head of Laboratory at the Sorbonne University in Paris (1906).

In 1911, she won an unprecedented second Nobel Prize (this time in chemistry) for her discovery and isolation of pure radium and radium components.

She was the first person ever to receive two Nobel Prizes.

She was the first mother-Nobel Prize Laureate of daughter-Nobel Prize Laureate. Her oldest daughter Irene Joliot-Curie also won a Nobel Prize for Chemistry (1935).

She was the first woman which has been laid to rest under the famous dome of the Pantheon in Paris for her own merits.

She received 15 gold medals, 19 degrees, and other honors.

Maria Sklodowska-Curie became the first Pole to receive a Nobel Prize.

A truly remarkable figure in the history of science

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WOMEN'S UNDER-REPRESENTATION AND THEIR FEATS IN SCIENCES, ENTREPRENEURSHIP, ENGINEERING AND TECHNOLOGY IN NIGERIA

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Abstract

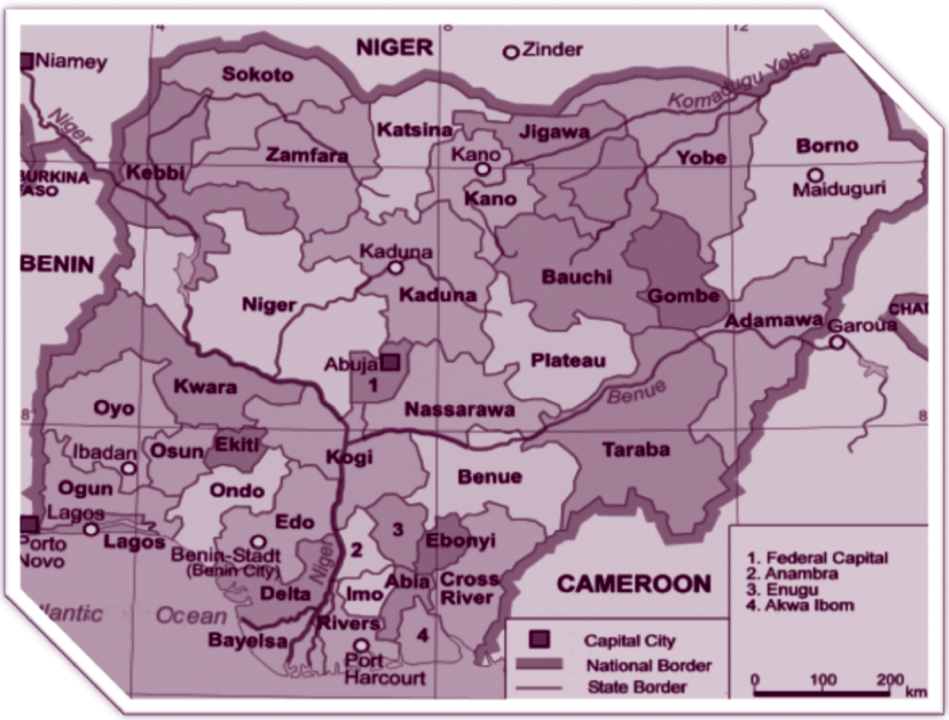
The purpose of this paper is to explain with more clarity the factors responsible for women's under-representation in the fields of sciences, entrepreneurship, engineering and technology (SEET), celebrates women's feats and consequently enhance their representation in these vital fields. To achieve this, the authors employ a critical discourse analysis reviewing previous scholarly works on the subject, synchronizing various opinions and arguments on women's under-representation. The paper found that women are indeed under-represented in the fields of SEET because of social-cultural and institutional factors which tend to view women as economic liabilities rather than assets, but despite this weakness they have contributed immensely to scientific development in Nigeria. The paper concludes to enhance women's representation there more institutional support is needed from the policymakers and stakeholders in the education sector for sustainable development.

Keywords: *Women, Economic Development, Engineering, Entrepreneurship, Nigeria. Science*

INTRODUCTION

The name Nigeria was a merger of two words, Niger and Area; a feat attributed to a woman called Lady Flora Shaw Lugard (Omoruyi, 2002; Helly and Callaway, 2004).

At present, Nigeria has thirty-six (36) states and a federal capital territory which housed a population of 174.5 million (CIA Factbook, 2013). Nigeria is strategically located in West Africa on the Gulf of Guinea with a total area of 923,768 km^2. It shares 4,047 kilometre border with Benin (773 km to the West), Chad (87 km to the East), Cameroon (1690 km to the East), Niger (1497 km to the North), and maintains a coastline of at least 853 km on the Gulf of Guinea on the Atlantic Ocean (Central Intelligence Agency Factbook, 2011). With regards to economic growth indices, Nigeria has a nominal GDP of $272.6 billion and per capita income of $2,700, which positions it as 176th among over 228 countries rated (CIA Factbook, 2013).



Source: Raimi (2015:23)

Figure 1: Map of the Federal Republic of Nigeria

Nigeria is historically a patriarchal society, because practically its political, educational, economic and social landscapes are male dominated, which unintentionally leads to gender inequality and women exclusion (Bolaji, 2007). In most parts of Nigeria, women are subjugated by powerful male chauvinistic tendencies and forces like poverty illiteracy, religion and cultural prejudices. The media especially the film industry has assisted in sustaining this negative image through portrayal of women

in bad light as weak and marginalized social groups (Okunna, 1996). The imbalance between both sexes (gender imbalance or inequality) has tilted investment in human development in favour of men. The continued marginalization of women despite their numerical strength (as evidenced in Table 1) engendered unrepresentative policies, feminization of poverty and lack of ownership and acceptability of policies on women (Bolaji, 2007). Gender imbalance finds relevance in the transitional African economies, where women work tirelessly to support their families, and are largely responsible for creation of small businesses that provide self-employment as well as employment for several other women; they also facilitate production of local goods and services thereby increasing the wealth of their local communities and national economies (Alekhuogie, 2014). In the realm of education, Nigerian women are under-represented in the fields of sciences and technology because a woman is perceived as an economic waste and a kitchen manager (Akinsowon and Osisanwo, 2014). Real world experiences have however shown that when women are given better economic opportunity and educational access, they would contribute productively to nation-building and emerge as competent future mothers (British Council, Nigeria, 2012).

Table 1: Nigeria Population History

Year	Population	Male Population	Female Population
2015	182,201,962	92,788,950	89,413,012
2010	159,424,742	81,050,685	78,374,057
2005	139,611,303	70,831,776	68,779,527
2000	122,876,723	62,209,582	60,667,141
1995	108,424,821	54,793,044	53,631,778
1990	95,617,345	48,276,221	47,341,124
1985	83,901,570	42,309,982	41,591,588
1980	73,698,095	37,166,337	36,531,759
1975	63,565,598	31,925,201	31,640,397
1970	56,131,844	28,144,091	27,987,753
1965	50,238,569	25,153,951	25,084,618
1960	45,211,614	22,604,000	22,607,614
1955	41,122,333	20,534,345	20,587,988
1950	37,859,745	18,886,350	18,973,395

Source: World Population Review (2015)

Moreover, the phenomenon of under-representation of women in science and technology is a continental phenomenon. However, these countries are redressing the gender inequality through effective policies for increasing visibility of women in

fields such as science, engineering, technology, construction, and the trades. One of such policy by the UK government is the establishment of the Technical and Vocational Education Initiative and the Resource Centre for Women in Science and Educational Technology (Phipps, 2008). Although the presence of women in science and engineering is some countries is relatively encouraging, but when compared with men at the upper echelon in these professions, the women are still under-represented, as they struggle to gain relevance relative to men in the scientific community (Etzkowitz, Kemelgor & Uzzi, 2000).

At the elementary, middle, and high school, both male and female are equally represented in science classes. However, at the tertiary level the gap becomes obvious as women are less represented in science, technology, engineering and mathematics (STEM). Therefore the social and environmental factors largely contributed to the poor representation of women in science and engineering (Hill, Corbett & Rose, 2010).

In the field of entrepreneurship, Sagagi (2005) noted that although Nigerian women have carved out a niche for themselves in places such as Kano, Zamfara and Sokoto (Northern Nigeria), but the type of businesses they focused on are sale of food items, household materials and textiles. For the South-Eastern part of Nigeria such as Enugu, Rivers and Anambra, the focus of women in businesses is relatively wider relative to the Northern part. Other identified challenges stifling exploits of women entrepreneurs include inadequate access to market information, poor technology, constraint of finance/funding, poor linkages with business support services and unfriendly policy and regulatory environment (Kitching and Woldie, 2004).

In view of the strength of women in entrepreneurship and their weaknesses in sciences, engineering and technology, the women seek to redress the challenge of under-representation in the scientific community through formation of women-based associations (Henwood, 1996). At present there are associations such as: Women into Science and Engineering (WISE); Nigerian Association of Women Scientist (NAWS); Nigerian Association of Women in Science, Technology and Mathematics (NAWSTEM); Forum of African Women Educationist (FAWE) Nigeria chapter and Women in Technical Education and Development (WITED).

WITED is a project of the Commonwealth Association of Polytechnics in Africa (CAPA). It was formed in 1988 for the purpose of identifying and demystifying the factors which impede female participation in technical education, training and employment. The associated seeks to increase women's participation in science and technical education across commonwealth nations (Mombasa Technical Training Institute, 2015). The Women into Science and Engineering (WISE) came to prominence in 1984. It was formed purposely to bring to the policy circle the issue of gender and sexuality in career choice in science and technology with a view to seeking equal opportunities for women in science and technology, having a major influence on both policy and practice (Henwood, 1996).

Having observed the wide gap between men and women, the Beijing Conference of 1995 recommended the implementation of the affirmative action which give women 30% of the appointive positions of leadership at ward, state and national levels, ensure that the concerns of women, like those of, men occupy the center stage of agenda for democratic change; demand for 30% representation of women, and ensure that 10% of the annual budget should be devoted to programmes on empowerment of women (Makinde and Oladipo, 1999).

In view of the foregoing, the purpose of this paper is to bring more clarity to the discourse on women's under-representation in SEET within the Nigerian context, celebrates women's feats and consequently enhance their representation in these vital fields. This objective could be reframed into two research questions, namely: What are the factors responsible for women's under-representation in the fields of SEET in Nigeria? What are the feats of Nigerian women in these fields? Apart from the introduction above, the paper is divided into three Sections. Section 1 focuses on the factors responsible for under-representation from empirical and theoretical viewpoints. Section 2 discusses the feats of Nigerian women in SEET. Section 3 concludes with research implication and recommendations.

FACTORS RESPONSIBLE FOR WOMEN'S UNDER-REPRESENTATION IN SEET

Women's under-repsentation is a major discourse under sexism. Sexism, otherwise called gender inequality is a nuance flagged by women activists locally and internationally to campaign against gender inequality and demands for equitable representation of women in workplaces, professions, politics etc., where it is perceived that women's interests are not well represented or defended. According to Foster (2011), the problem of sexism leading to inequality affects both men and women, but proponents discuss gender discrimination/inequality/underrepresentation as largely an onslaught against the women. In practical terms, sexism becomes real and measurable when its consequences appropriate privileges to the male over the female, thereby engendering gender inequality and imbalance (Johnson, 2000).

In the Nigerian educational system, there is no sexism or inequality as the National policy on Education (2013) promotes gender equity and makes no discrimination between boys and girls (men and women) with regards to access to sciences and technology-based subjects. The nation's Education policy emphasizes EFA or Education for All irrespective of gender and socio-economic status. Also, the policy is so comprehensive that it prescribes admission ratio of 60:40 percent for science and liberal arts respectively (Imhanlahimi & Eloebhose, 2006).

Why has the thrust of the National Policy on Education with regards to equal representation of both sexes not realizable? There are a number of theoretical and empirical answers to the above question.

First and foremost, Nigerian women have poor visibility in sciences and technology-based subjects because of socio-economic and cultural environments which relegate women to the background, as they are saddled with a number of family responsibilities such as custody of children, routine home maintenance and food preparation three times a day as well as the task of enhancing family health (Oniye, 2008). This could be described as societal expectations of women.

Secondly, women are under-represented in the fields of SEET because they play multiple and overlapping roles as a wife, a mother and a dutiful home keeper, as well as contributing to the national development (Oniye, 2008). Confirming the view about above, Okeke (1997) found low participation of women in science and technology relative to men.

Thirdly, women are under-represented in the SEET because of negative perceptions by the parents, teachers and other stakeholders. Spear's (1985) field survey elicited the opinions of science teachers on the importance of science to boys and girls. It was found that science teachers noted that science education is suitable and of immense importance to boys than girls. The implication of the finding is that teachers of science subjects with such mind-set cannot motivate girls to take up sciences at both lower and higher levels of education. Similarly, Ogunjuyigbe, Ojofeitimi & Akinlo (2006) investigated the perception of Nigerians about female involvement in science, mathematics and technology (SMT), and found that about 57% of fathers, 45.6% of mothers and 57.6% of the children opined that both boys and girls have equal access to SMT education; social forces play an important role in determining people's attitude to SMT; and that the perceptions of parents and stakeholders about girls' participation in certain fields is changing, but socio-cultural and economic factors has serious influence on the sex in SMT.

Besides, women's under-representation in science, technology, engineering and mathematics (STEM) was linked to the very nature of the STEM itself, when viewed in terms of the rigour and profundity or what has been styled "the scientific culture". The fact is that the nature of science acts as a barrier which removes women from the top echelon of the profession (Bebbington, 2002; Blickenstaff, 2005). In other words, it is a widely held presumption that sciences especially mathematics, chemistry and physics are abstract, difficult and unsuitable for daily routine of girls and women. In other words, they are viewed as male-oriented or masculine subjects, while liberal arts and humanities are female-oriented or feminine subjects (Imhanlahimi & Eloebhose, 2006).

Furthermore, women are under-represented because of poor self-motivation relative to men. Zeldin, Britner & Pajares (2008) provided answers to what motivated men and women to take up career in the fields of science, technology, engineering and mathematics (STEM); and why women are poorly represented in (STEM). They found that mastery experience was the primary source of the men's self-efficacy beliefs,

while for women, social persuasions and vicarious experiences were the primary sources of self-efficacy beliefs. The implication of both finding is that different factors shape and enhance the self-efficacy of men and women with regards to preference for career in the fields of STEM.

Another important factor identified as a cause of women poor representation is sex role and expectations as defined by the society. African society assign role to both gender. Boys are assigned training in the areas of farming, blacksmithing and other masculine-oriented socio-economic and cultural activities, while girls are mentored to be like their mothers keeping the home, preparing food, washing utensils and offering course like home economics and biology that could enable them to become successful housewives. In schools, boys are trained to engage in brain storming activities which have relevance with mathematics, physics and chemistry, while girls are encouraged to offer biology and home economics that could enable them to become successful housewives. In other words, girls as a result of marriage, child bearing and rearing opt out of science and technology careers (Imhanlahimi & Eloebhose, 2006).

FEATS OF NIGERIAN WOMEN IN SEET

In spite of the under-representation of women in the field of SEET, there are hundreds of distinguished Nigerian women in SEET. For the scope of this paper some outstanding women are presented hereunder. Odili (2015) and Uba and Onwuachumba (2013) identified the following Nigerian women as role models in the SEET fields.

1. **Funke Opeke:** Funke is a seasoned telecommunications professional and founder of the Main Street Technologies. She obtained a degree in Electronics & Electrical Engineering from Obafemi Awolowo University, Ile Ife in 1981. Her growing thirst for knowledge took her to New York where she bagged a Master's degree at Columbia University. She had carved a reputation for herself in previous employments as Chief Technical Officer in MTN Nigeria; Adviser to Transcorp; and Chief Operating Officer of NITEL. She launched her Main Street Technologies in 2007. An important feat was mobilization of over $240 million to build the pioneer private submarine cable system in West Africa. The 7,000km cable extends from Portugal to Accra, Ghana and Lagos, Nigeria. In recognition of her achievements, she was presented with a Goodwill Ambassadorship award in 2014 by the Lagos Chamber of Commerce and Industry.
2. **Linda Ikeji:** She is an accomplished blogger in Nigeria. Her blog is one of the most celebrated blogs in Africa with massive traffic. Her blog is also and the one stop portal for information, entertainment and education with over 365,541 visitors daily. On account of hard work, innovation and creativity, Linda turned what commenced as a gossip column, emerged as a popular online medium

for breaking news, exclusive interview and personality profiling. What really assisted her was the deployment of technology into blogging. At the moments, she has mentored and inspired several young Nigerian entrepreneurs.

3. **Dr. Omobola Johnson:** She is an accomplished technocrat in the private sector where she served as the Country manager at Accenture Nigeria. Her wealth of experience made her the pioneer Minister of Communication Technology sequel to her appointment to midwife the transformation Agenda of the former administration. She deployed professionalism within twenty four months when she held the position. Her hard work, role modelling and technological pedigree earned her public commendations for launching the nation's NigComSat-IR Satellite, which has complemented Nigeria's capability at fibre connectivity and access to greater bandwidth.

4. **Evangeline Wiles:** This enviable woman is the Managing Director of notable online marketplace called Kaymu. She was born in the United States with a degree and an MBA from Wharton Business School. After working for six years in the financial sector in the US, she relocated to Nigeria to contribute her own quota to technological and ICT development through E-commerce. Before starting her own company, she had acquired impeccable work experience as a strategy consultant at Bain & Company, South Africa. Since she assumed the present status at Kaymu, she has been a champion of SME/entrepreneurship initiatives for Nigerian youth. This beautiful initiative earned her the appellation of an ambassador conferred on her by the Lagos Chamber of Commerce and Industry (LCCI) as an award for fostering technological entrepreneurship in Nigeria.

5. **Juliet Ehimuan:** She is a Fellow of the Cambridge Commonwealth Society. On account of hardwork and competence, she is the current Country Manager for Google since 2011. Initially, she worked for Shell Petroleum Development Company as Performance Monitoring and Quality Assurance Supervisor. Later, she worked for Microsoft UK for six years as a Program Manager. She had also occupied the position of Business Process Manager at MSN Global Sales and Marketing Organization.

6. **Lola Mahsha:** She is the current Country Manager of OLX effective from 2014. She is an engineer with a PhD in Engineering from the University of California, Berkeley. While in school, she was an activist and the president, representing over 10,000 graduate students in the student government on campus. After sojourning for 10 years in USA, she returned to Nigeria to take a job with BankPHB as Head of Corporate Strategy.

7. **Professor Francisca Okeke:** She is a Professor of Physics; the first female Head of Department and the Dean in the faculty of Physical Sciences (2008 – 2010) at University of Nigeria Nsukka. She received the 2013 L'Oreal-UNESCO for Women in Science Award valued at $100,000 for her valuable contribution to

the understanding of daily variations of the ion currents in the upper atmosphere which has immensely enriched the world's understanding of the climate change phenomenon. As a scientist, she has been a role model to several women in the field of sciences. She made her mark in a male-dominated field of sciences because of self-encouragement and self-motivation. For women to be visible in the sciences, she advised against forcing brilliant girls into early marriage. The award offered her opportunity to mentor young girls and women to actively take-up the field of science and technology by offering core sciences courses in schools and universities.

8. **Dr. Eucharia Nwaichi:** She is an environmental bio-chemistry lecturer at the University of Port Harcourt, Nigeria. Her area of interest is environmental sustainability specially cleaning polluted soil in the Niger Delta area using two local plant species. On account of her excellent performance and research works, she received the 2013 L'Oreal-UNESCO for Women in Science Award valued at $100,000 for her valuable contribution to the understanding of daily variations of the ion currents in the upper atmosphere which has immensely enriched the world's understanding of the climate change phenomenon.

CONCLUSIONS/ RECOMMENDATIONS

This paper adds to the growing body of literature seeking to explore the factors responsible for women under-representation in the fields of SEET. The authors set out to explain with more clarity the factors responsible for women's under-representation in the fields of SEET, celebrates women's feats and consequently enhance their representation in these vital fields. At the end of the analysis, the paper found that women are indeed under-represented in the fields of SEET because of social-cultural and institutional factors which tend to view women as economic liabilities rather than assets. However, despite this weakness, they have contributed immensely to scientific development in Nigeria. Some policy prescriptions required to increase women's representation in the field of SEET include renewed effort by parents to imbibe the love of sciences, enforcement of affirmative action such as Beijing's recommendations, training of girls and young women, inducement with award like the Intel Prize Winners and creation of special intervention funding for building women's capacity and building of a directory of resources for women in science and technology programs (Thom, 2001). Another way of reducing women's poor representation and boosting their visibility is the use of information and communications technologies (ICTs) especially the use of blogs to attract women to sciences and technology and as well helping them to boost their self-worth (Somolu, 2007).

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EMPOWERING YOUNG WOMEN AND GIRLS IN ICT CAREERS

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Abstract

Information and Communications Technology (ICTs) shape our world. But even though ICTs touch almost every aspect of modern life, girls are steering clear of careers in science and technology at a time when their talent and perspectives might serve as a foundation for IT innovation and improved quality of life potentially for billions of people. This paper takes a look at a crisis that is brewing worldwide as reported by many bodies and offers a number of recommendations for getting girls and young women to be interested in STEM.

Keywords: *ICT, girls, young women, careers, IT innovation, STEM*

INTRODUCTION

Information and Communications Technology (ICT) has become a potent force in transforming social, economic and political life globally. Without its incorporation into the information age, there is little chance for countries or regions to develop. More and more concern is being shown about the impact of those left on the other side of the digital divide – the division between the information "haves" and "have nots". Most women within developing countries are in the deepest part of the divide – the further removed from the information age than the men. It is imperative to ensure that women in developing countries understand the significance of these technologies and use them. If not, they will become further marginalized from the mainstream of their countries and of the world (Arabi 2006).

According to the 2015 Reports by United Nations Educational, Scientific, and Cultural Organization and the United Nations Entity for Gender Equality and Empowerment of Women evidence from around the world suggests that female predominance in undergraduate enrolments notwithstanding (59% in Australia, 55% in America, and greater than 50% in many European Union countries), girls are reluctant to pursue ICT study at tertiary level (Rees, 2001) accounting for 10% to 30% of students in ICT courses and under 20% of employees in ICT-based careers. The underrepresentation of females in ICT studies and careers results not only in a massive loss of talent for ICT companies and economies, but also in a technology divide that perpetuates disadvantage among women in general and women of low socio-economic status in particular. Initial approaches to reverse this trend centered upon notions of equality and affirmative action since the lack of significant numbers of females in the discipline was seen as inequitable. To alleviate the problem, intervention programs aimed at women have promoted information on technology-related careers, provided experience of computing work, and highlighted female role models. Other initiatives focused on helping women to develop skills, attitudes, or background knowledge that they were thought to lack.

This article discusses the key ingredients of such an environment drawing on lessons learned from a variety of initiatives aimed at attracting ICT female students in general and female students from educationally disadvantaged backgrounds in particular. The article also describes a small number of programs aimed at attracting adult women to ICT.

LITERATURE REVIEW

According to the 2015 Reports by United Nations Educational, Scientific, and Cultural Organization and the United Nations Entity for Gender Equality and Empowerment of Women, ICT helps to drive economies, reduces labour burdens, supports human rights, and serves as stepping-stones out of poverty. ICT, in fact, touches almost every facet of our lives – from health care to employment and from the use of natural resources to social connections. But in both developed and developing nations, women face difficult challenges regarding ICTs. In some regions, they must battle myths that deem ICT careers as taboo for women. They lack access to ICTs. They even lack the time to use them. In addition, the number of young women majoring in computer science in college is dwindling, and women and girls are underrepresented in science and technology. In the United States, young women earned 37% of computer science degrees in 1985; today the number has plummeted to 18%. Some 22% of software engineers at technology companies are women. Also, only 6% of the CEOs of top 100 technology companies are women, showing the underrepresentation of women in ICT decision-making and leadership. This underutilization of talent and perspectives only serves to dampen ICT innovation, slow economic development and contribute to women's economic and social marginalization. By focusing on four

areas, we can foster the growth of women and girls in science and technology: ICT access and skills, relevance to their lives, empowerment, and combating stereotypes about women and girls in science.

In another report, which is the 2015 Global Information Technology Report launched by World Economic Forum and CISCO it highlighted the importance of closing the gender gap in ICT to ensure everybody benefits from ICTs. According to the report these are some of the sobering statistics:

- Teenaged girls are 5 times less likely to consider a technology-related career compared to boys of the same age, even though the way in which each gender uses computers and the Internet is nearly identical.
- Only 18% of undergraduate computer science degrees were awarded to women in the United States between 2008 and 2011.
- In OECD countries, women account for less than a fifth of ICT-related specialists.

An enormous gap exists between the size of the ICT workforce demanded and the current global supply. Employers around the world are struggling to fill hundreds of thousands of ICT jobs, and part of the problem is the lack of women trained in these fields. In 2015, the shortage of skilled IP networking professionals was estimated at least 1.2 million. In some countries, such as Costa Rica, the UAE and Saudi Arabia, there may be over a 45% gap. Even where countries have a relatively low shortage like for example Australia and Korea, the gap ranges between 10 to 20%. And in all countries, the networking skills gap is growing – due in large part because of positive developments such as increasing connectivity, the Internet of Everything, rising digitization of all business activity, globalization of trade and travel, and economic growth. While a wide range of economic and cultural influences drive these gaps, one resounding reality is clear: empowering women and girls to pursue careers in ICT, helping close the IP skills gap, is no longer simply a good thing to do—it has become essential.

In another Report by the *2015 International Telecommunication Union (ITU),* it says that there is a bright future in ICT opportunities for a new generation of women. The report highlighted that the most important determinant of a country's competitiveness is its human capital and talent — the skills, education and productivity of its workforce. According to the ITU Report as women account for one-half of the potential talent base throughout the world, closing the male-female employment gap would be good for economic growth of the country. Research indicates that narrowing this gap has been an important drive of Europe's economic growth over the past decade. The costs of not doing so are huge. In Asia and the Pacific, for example, restricting job opportunities for women is costing the region between USD 42 and USD 46 billion a year. World Bank findings demonstrate that similar restrictions have imposed massive costs throughout the Arab States region where the gender gap in economic opportunity remains the widest in the world today. The World Economic Forum reveals that regardless of their income level, countries that divide resources equitably between women and men fare better than those that do not.

The ITU 2015 Report also mentioned that in most countries, the ICT sector is still perceived as a male industry. Men hold most of the top jobs, while women are overrepresented in the lower level of the ICT occupations. This is true in both developed and developing countries. On average, women account for 30% of information technology (IT) technicians, a mere 15% of ICT managers, and only 11% of IT strategy and planning professionals. Few women hold leadership positions at board and senior management levels. In another report entitled "Digital gender divide or technologically empowered women in developing countries? A typical case of lies, damned lies, and statistics" published in the Women' Studies International Forum suggested that the discussion about women's access to and use of digital Information and Communication Technologies (ICT) in developing countries has been inconclusive so far. Some claim that women are rather technophobic and that men are much better users of digital tools, while others argue that women enthusiastically embrace digital communication. The report was based on an empirical study analyzing data sets from 12 Latin American and 13 African countries from 2005-08. This was believed to be the most extensive empirical study in this field so far. The results were surprisingly consistent and revealing: the reason why fewer women access and use ICT was a direct result of their unfavorable conditions with respect to employment, education and income. When these variables are controlled, women turn out to be more active users of digital tools than men. This turned the alleged digital gender divide into an opportunity: given women's affinity for ICT, and given that digital technologies are tools that can improve living conditions, ICT represent a concrete and tangible opportunity to tackle longstanding challenges of gender inequalities in developing countries, including access to employment, income, education and health services.

A study in the United States found that today's generation of college-bound females appear to be less interested in computing than their male counterparts. Girls tend to associate computing with "typing, mathematics and boredom", while boys are more likely to think of computing in terms of "video games, design, electronics, solving problems and interesting". The same study found that girls were more interested in the computing field when they were given the message that with computing, they will be able to connect technology to their community and make a world of difference — reducing energy consumption, improving health care, enhancing security, reducing pollution and advancing learning and education.

FINDINGS AND DISCUSSIONS

From the many research found they mostly indicate that the success in growing the numbers of women and girls in science and technology depends on progress in the following areas: (1) Access & Skills, (2) Relevance, (3) Empowerment, and (4) Combatting Stereotypes. Each of these factors presents unique challenges. They are covered below, along with possible solutions.

(1) ***Access & Skills***

With the world's population at 7 billion people, one person in three uses the Internet, and 45% of Internet users are under the age of 25, according to a 2011 International Telecommunications Union (ITU) report. Also according to media metrix worldwide, globally women are in the minority of Web users, with nearly 46% of the Web-using population, aged 18 or older. Regionally, 42% of Internet users in Asia-Pacific countries are girls or women, 47% in Europe, 50% in North America, and 48% in Latin America. There are no regional statistics for women and girls' Internet use in Africa. In fact, reliable statistics on their Internet use are difficult to obtain because standard indicators are not disaggregated by gender.

But the story of access to information technology isn't just a "numbers story," or a simple matter of women's ability to log onto the Web. Women's access is much more complicated than whether there's a computer at hand; it is measured by two other factors:

- Whether women understand the significance and transformative power of ICTs, and
- Whether they know how to use ICTs, not just for meeting basic needs, but also as a tool for improving their quality of life, participation in all aspects of society, or giving them access to quality education, formal or non-formal, technical or vocational.

Moreover, it is also about women's ability to actively participate in the production and direction of ICTs (e.g. content, applications, devices, etc.). So, while to a degree the above factors may be met through increased digital and information literacy initiatives, women's increased and active participation as producers of ICTs is also a critical component. Access and relevance of ICTs also depends on priorities and investments within government and the private sector, and this is where women are notably absent. We get women into these positions through proper development of ICT skills, including via improved approaches to the studies of science, technology, engineering and mathematics (STEM).

Certainly, a tech education that is firmly grounded in mathematics, programming languages, systems and theory is a must in order to work as a computer scientist, engineer, or designer. But today, women are underrepresented in ICT. Worldwide, they comprise less than 30% of the ICT workforce. This belies a rich tradition of women in computers. Women have been deeply, if not widely, involved in computers since English mathematician Charles Babbage proposed the analytical engine, a mechanical general-purpose computer first described in 1837 and Ada Lovelace (1815-1852), the daughter of Lord Byron, is regarded as the mother of computer programming.

Obstacles to Access & Participation on the ICT Sector

- Lack of literacy and numeracy. Such skills provide a foundation for reading and writing electronic messages, executing software commands, navigating the Internet, and writing programming code. But for a majority of women and girls in developing countries, education is simply out of reach.
- The language barrier. This is the top barrier to Internet use by women in Latin America, the Middle East and Francophone Africa. The language of ICTs is predominantly English. This serves to exclude a majority of the world's population who do not speak this language.
- Social and cultural norms. The geographic location of ICT facilities can pose an obstacle to training or regular use of ICTs, resulting in a gender gap in access. In many developing countries, women do not have the same freedom to move about the community as men, due to social or religious customs. In some countries in the Middle East, women are not allowed to travel without a male companion.
- Costs are prohibitive. In developing countries, yearly Internet dial-up fees can be even higher than the annual per capita income, putting access out of reach for most women. According to the ITU, fixed broadband penetration is below 1% in many of the world's poorest countries, while access costs can be more than 100% of monthly average incomes. (In contrast, in the world's most developed economies, around 30% of people have access to broadband at a cost of less than 1% of their income.)
- Limited infrastructure. Internet connectivity is frequently limited to capital cities in developing countries, even though the majority of the population lives in rural areas. This urban bias impedes women's progress in ICT education and deprives them of their ability to communicate via the Internet.

Potential Solutions

- Develop women-centered ICT policies. Government policies, regulations and investments should be responsive to women's specific needs and seen through a gender lens.
- Shift perspective. ICTs must be regarded as essential tools for the masses and for daily life, rather than as a vehicle reserved mainly for elites' leisurely pursuits.
- Develop specialized training. This is considered essential if girls and young women are to develop their ICT skills that commensurates with their needs as full-fledged participants in knowledge-based societies. Some nations take advantage of digital literacy initiatives such as summer camps for girls and adolescents in mathematics, science and technology that are operated by public-private partnerships.
- Build community empowerment centers in areas where there's a high demand for ICTs among girls and women. Rural areas where girls and women are the majority of the population often need resources and infrastructure for ICT education and business development. In addition, cities globally must do more

to ensure the safety and security of women and girls as they make use of ICTs at such empowerment centers.

- Use gender-sensitive teaching methods. Adopt best practices to promote an environment in science, engineering and technology education that encourages females to take up STEM occupations and prevent job pipeline leakages during the transition from education to career. This includes sensitizing teachers to girls' needs, increasing the number of women teachers, and revising curricula and educational materials to make STEM more relatable and interesting to girls.

(2) ***Relevance***

Government ministers, NGO officials, academics and others contend that women in developing countries have a more pressing need for safe water, adequate food, improved health, and better education than for information technology. But in the drive to empower women and girls, information technology is crucial because it can end the isolation felt by rural women and girls, while stimulating economic development, bringing improved health services, and throwing open a window to the outside world, among other benefits. A report from IDS also cited the exposure of women to new ideas and knowledge as a critical pathway to empowerment. Yet there is a disconnection between the myriad of opportunities from ICTs to improve women and girls' lives, the development of relevant applications and the interest and opportunities for girls and young women to pursue these by going into STEM. What prevents STEM from being relevant in women's lives?

Obstacles to Increased Enrollment in STEM

- Gender discrimination. Girls and women's enrollment rates in science and technology trail that of men globally due to a lack of ICT access, but also due to negative attitudes toward girls once they are enrolled in college, especially as students of mathematics, science or technology. Female professors themselves were found to be just as biased against women students as male professors, according to a study by Yale University researchers, who found that science professors at American universities regarded female undergraduates as less competent than male students with the same skills. They also found that male and female professors were equally likely to exhibit bias against female students. This bias, which researchers characterized as pervasive, perhaps reflects subconscious cultural influences rather than overt discrimination, but the effects nonetheless can be devastating; and left to accumulate over the course of a career, bias can sap a woman's confidence and undercut efforts to rise to the top.
- Irrelevancy. Girls themselves fail to see how these fields are relevant to their daily lives, and often view technology jobs as unattractive because they do not consider them as being applicable to their lives.
- Misconceptions. Many girls don't really understand what engineers actually do, and think of engineering as a dirty, manual occupation.

Potential Solutions

- Resonate with students. Teachers must relate to girls and young women by talking about science and technology in ways that resonate and relate to their lives and aspirations. Girls are more likely to be attracted to technology education if STEM curricula and ICT projects are tied to the real world beyond school and domestic contexts, researchers have found.
- Increase relevancy by developing gender-specific content. The Web contains massive amounts of information, but little of it appears useful or especially relevant to girls and women in developing countries. More must be done to address their specific needs, interests and priorities regarding ICTs and STEM.
- Adapt ICT training. Improvements in curricula and training materials can produce benefits. A Belgium program has been developed to sensitize teachers about girls in science tracks, and in Zambia, science camps and bursaries have been established for women entering the science field. Both programs have been successful. Also, university courses renamed to appeal to non-geeky students have seen a rise in popularity among young women.
- Take it to the airways. The power of television can be used to attract girls to ICTs and STEM. The Argentine government has created a public television station dedicated to science and technology, and is commissioning programming on girls and ICTs.

(3) ***Empowerment***

Technology and science are reshaping our world and how we interact, and increasingly STEM and ICT innovations are serving as economic drivers and as tools for realizing knowledge societies based on freedom of expression, respect for cultural diversity and access to information. Women and girls in STEM and ICT careers will be empowered to drive change in scientific, social, economic and political spheres. To strengthen women's participation, much must be accomplished either by women or on their behalf, including reducing poverty, eliminating illiteracy, informing women of their legal and political rights, ending violence against women, and expanding their political activities. STEM and ICT careers can play a crucial role in all of the above, promoting the empowerment of women.

Obstacles to Empowerment

- Isolation. Girls and young women are marginalized and widely dispersed in rural areas, where they lack the ICT skills needed to access and share information, organize themselves, and advocate for issues that directly affect them.
- Government inefficiencies. Without the free flow of information, it is difficult to hold governments or politicians accountable. The political process is marred and incomplete, services are inaccessible, and education suffers.

Potential Solutions

- Increase access to ICT. This will enable women and girls to fully exploit the potential of ICTs and develop STEM careers. Increasing ICT access involves revamping global Internet policy, adopting national e-strategies that take women and girls into account, stimulating competition, revising ICT regulations, refining laws on intellectual property, developing infrastructure and systems architecture, and perhaps most importantly increasing STEM skills and understanding.
- Promote women as technology content developers. This will attract more girls to STEM and ICT careers. This involves training and developing women entrepreneurs, laborers, academics, policy makers and regulators in ICT.
- Use ICTs to end isolation. ICT use among girls and young women can enable them to share knowledge and information relevant to their homes, school, work, and communities. Networking is perhaps the most common ICT usage among women in developing countries. They use ICTs to address women's rights, communicate, spread information, mobilize action in times of crisis, debate policies, voice their opinions, and discover allies or peers across the Internet. In short, ICTs promote girls and women's interaction and sharing.
- Improve governance. ICTs can be used to strengthen women's participation in the electoral process, share information as voters, open avenues of direct participation with government agencies, and enable government officials to research and access information on issues directly related to women and girls.
- Improve statistics. Increase the availability of gender-specific data, particularly in ICTs.

(4) ***Combating Stereotypes***

In 2009, the Prime Minister of Iceland, Johanna Sigurdardottir, vowed to sweep aside Iceland's "age of testosterone" during which male leaders brought the nation to the verge of bankruptcy. The nation put its faith in Sigurdardottir and her cabinet, half of which was led by women. Some believe Iceland is a forerunner of things to come – a world in which women leaders are increasingly called upon as perceptions of gender roles evolve and as women in some countries shatter "glass ceilings." Much is now being published about women's changing role in society.

Journalist Hanna Rosin's book, "The End of Men: And the Rise of Women," published in 2012, points out that women form the majority of students in colleges and professional schools on every continent except Africa. Rosin adds that women in poor parts of India are learning English faster than men in order to meet the demands of global call centers; that women own more than 40% of private businesses in China; and that if the global recession has revealed anything, it is that there has been a profound economic shift as women make their presence felt in the workforce and outnumber men in certain job categories. Of the 15 job categories projected to grow the most in the U.S. during the next 10 years, primarily women occupy. Furthermore, unlike in industrial economies, our new service and informational economies do not

reward brawn so much as social intelligence, communication and a knack for being able to focus – areas that are not the sole province of men. All of these changes are inspiring a march forward in the pursuit of equal gender rights, while creating culture shock among men who cling stubbornly to conservative traditions that constrain women.

But for all that has been written about women's pivotal role in society, a myth that girls do not do well in science and technology persists. As a result, some people believe, the software programming industry is rife with gender discrimination. Dr. Madeline Heilman, a psychologist at New York University who studies gender stereotypes, suggested that there is bias in the system and it affects women's willingness to go into these situations because they know what they are in for. She also suggested that there is the perception that women somehow do not have the right stuff to fulfill these roles, and results in consequences for selection, promotion and task assignment. In a 2012 study on the role of stereotypes in undermining girls' performance and interest in STEM, Jenessa R. Shapiro and Amy M. Williams, of the psychology department at the University of California, Los Angeles, concluded that parents' and teachers' gender-related mathematics attitudes – including their stereotypes and anxieties – can transfer to girls and play a critical role in girls' development of mathematics attitudes and interests. This transfer puts girls at risk for self-imposed "stereotype threats" – a concern that poor performance could confirm in one's own mind that the stereotypes are indeed true of oneself or the group (Shapiro et al., 2012).

Obstacles to Eliminating Gender Myths

- Trapped in a stereotype. The myth of male superiority in science runs deep. By the time students reach middle school, basic ideas about perceived gender differences in STEM subjects have already been established among students, primarily through societal influences, according to Janelle Wilson, who teaches earth science in Gwinnett County, Georgia. In some countries, it is considered culturally taboo for a woman to pursue a STEM career.
- Unfulfilling careers. Many girls view ICT careers as "solitary," "passive," and "sedentary," according to a study by the American Association of UN Women.
- Few role models. There's little gender diversity in technology industry leadership. Just 6% of the CEOs of top 100 tech companies, and 22% of software engineers at technology companies are women, according to the US-based National Center for Women and Information Technology. Also, women own 40% of the private businesses in the U.S., but they create only 8% of venture-backed startups, according to Astia, a nonprofit group that advises women entrepreneurs.

Potential Solutions

- Award and reward success. One way to counter prevailing myths is to recognize women for STEM accomplishments. "Many young women I know who are pursuing STEM careers say that notable awards they won for achievement in

science—and the recognition they received from their communities and the news media as a result—had a real impact in boosting their confidence to pursue and excel in STEM fields," Jeniffer Harper-Taylor, president of the Siemens Foundation, which supports K-12 STEM education, has been quoted as saying.

- Educate the educators in order to stop "blaming the victim." African women, particularly in rural areas, have the lowest participation rates in the world in science and technology education. The Federation for African Women Educationalists attributed this to a "lack of self-esteem, poor self-image, and non-assertive behavior among girl students," according to one study, adding that many male science teachers in Africa hold outmoded views that girls cannot think or work scientifically and that science is too mechanical and technical for girls, thus discouraging female students.
- Create ICT programs that focus on women's needs. Microsoft is now developing a "gender playbook" of IT programs. It will contain a global directory of Microsoft programs for girls and women, along with guidelines for replicating them or creating new ones developed with UN Women. The book will also contain resource material and templates that can be tailored for local use, easing replication.
- Break the leadership mold. In a field in which women don't fit the "standard template" of leadership, there's great value in creating a class of women STEM leaders. There may be beneficial economic and social consequences for companies that seek the increased participation of women in STEM, since many Web startups, from socializing to shopping, attract more women than men.
- Encourage team diversity. According to the National Center for Women and nformation Technology, mixed-gender teams have produced information technology patents that are cited 26% to 42% more often than the norm.

CONCLUSION

A bright future in ICT could offer opportunities for a new generation of women, provided that national governments, the private sector, donors, civil society and educational actors acknowledge and support the central role of professional women in further developing and servicing the dynamic and competitive ICT sector. The growing demand for a range of ICT skills around the globe presents a unique window of opportunity to properly position girls and women in the industry and provide them with the tools necessary to succeed. Governments should ensure that current educational systems and infrastructure integrate science and ICT-related subjects with mainstream curricula; policies and programmes promote ICT skills among girl students; that women and girls are engaged at all levels of developing human talent and the right skill sets to build a vibrant and diversified ICT sector; that stakeholders change misconceptions about the industry, and demonstrate the employment and career opportunities that the ICT sector holds for girls and women.

Schools, colleges and academic institutions should ensure that courses remain relevant to industry needs, with teamwork and problem-solving, internships, mentoring and social networking; that careers guidance for middle-school and high-school girls informs them of opportunities in the ICT sector; that awareness-raising training and materials are made available for parents, teachers, career guidance counselors and recruiters, to shift their own mindsets, attitudes and preconceived notions about ICT careers for girls. ICT enterprises and investors should work with governments to promote on-the-job ICT skills and industry-based training initiatives, and provide feedback to educational bodies on the type of skills and training required; engage in career development in science, technology, engineering and mathematics through learning-by-doing training, mentorship, internships, creating online networks of girls and women in ICT, and other sponsorship for girls and women; involve women in research and innovation processes to increase the potential for creativity, new research content and user-centred design and application; create positive images through role models and awareness campaigns, using all media platforms; support women to establish a healthy and effective balance between work and other responsibilities.

Likely, there will be no single solution to the problem of enrolling more girls in ICT. Still, coordinated solutions can result in dramatic regional improvements and go a long way toward creating gender-sensitive ICT-focused cultures. A culture that celebrates mathematics, science and technology at all levels of society will naturally increase women and girls' participation. And more public-private partnerships and collaborations between academia, private enterprise, government, and NGOs will help to inspire women to become engaged in ICT.

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WONDER WOMAN IN MATHEMATICS: MARYAM MIRZAKHANI

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INTRODUCTION

Mathematics is seen as a male-dominated field and it has been an uphill battle for women trying to break into the field. For years, women in the mathematics field from all over the world have been overlooked, unappreciated and harshly judged based on their gender. Despite this, there have been several amazing women throughout history who have made significant contributions and impacts in the field of mathematics. Although there have been many improvements for women in the mathematics field in recent years, which will be discussed later on, the road to where we are now has not been an easy one. For centuries, women in mathematics have had to endure many hardships and discrimination based on their gender. Being a woman in mathematics was rough, as it was hard to be accepted as both a woman and a mathematician without facing criticism.

Among many countries in the world, Persia (now known as the Republic of Iran), was dubbed as a cradle of science in ancient times. There are other countries that have produced great mathematicians, namely Europe. Persian scientists have Egypt and China, but Persian scientists, in particular, have made important contributions to algebra and chemistry, invented the wind-power machine, and the first distillation of alcohol, among many others and contributed to the current understanding of nature, medicine, mathematics, and philosophy. Many of today's concepts in Science including Helio-Centric model of solar system, finite speed of light, and gravity were first proposed by Persian scientists. Science in Persia evolved in two main phases separated by the arrival and widespread adoption of Islam in the region. The international sanctions in almost all aspects of research during the past 30 years

has not stopped Iran from advancing in science and technology, including education and research. Iran's university population grew from a meager 100,000 in 1979 to 2 million in 2006 where seventy percent of its science and engineering students were women. However, since the establishment of the Islamic Republic of Iran in 1979, women education had suffered a great deal of challenges and obstacles imposed by the government at various stages of time. In 2002, approximately 800,000 students were enrolled at various levels in government-run universities and female students comprised almost half of the entire student population. The total number of students has increased 4.6 times over the past 24 years due to the increase of population and the need for highly trained and educated people to fill in the demand for new positions that required knowledge of technology and scientific expertise in addition the traditional jobs. Female enrollment and graduation rates at both primary and secondary schools and colleges/universities has increased. However, as of today, government policies on the banning of the co-education system, restricting the fields of studies that are open to women, gender stereotyping in school textbooks, and emphasizing feminine specializations which are deemed to be proper and appropriate for Iranian women are still one of the biggest challenges faced by the women in Iran.

This paper is written to recognize the triumph and momentous achievement of an Iranian woman mathematic wizard, Maryam Mirzakhani, who has crossed all borders and penetrated all possibilities to be at one of the highest level any man or woman could attain in this modern world. This proves that a woman with a strong determination, strong mind, will power and of course, hard work can make it happen. She is definitely a role model to all women in mathematics, not only to the women around the world, but closer to home as well – Iran.

LITERATURES

Since the last part of the 20th century, the world has witnessed more women than men completing tertiary education. Despite many obstacles that may hinder college attendance for women in many parts of the world, it is amazing to see how well they are doing in comparison to several decades ago. In 2011, Shahram Vahedi and Farahman Farrokhi from the University of Tabriz conducted a study on *"Confirmatory Factor Analysis of the Structure of Abbreviated Math Anxiety Scale"* on 298 college students (133 males and 165 females) chosen randomly majoring in different disciplines of human sciences at Tabriz University in Iran. They were enrolled in entry-level mathematics courses and voluntarily participated in the study. The aim of that study was to explore the confirmatory factor analysis results of the Persian adaptation of Abbreviated Math Anxiety Scale (AMAS), proposed by Hopko, Mahadevan, Bare & Hunt. Many students who suffer from mathematic anxiety have little confidence in their ability to do mathematics and tend to take the minimum numbers of required mathematics courses, which has greatly limited their career choice options (1). Results from researches had shown that mathematics anxiety

was a significant factor of learning success. Individuals with high mathematics anxiety tend to perform poorly in an upper-level college statistics course. Furthermore, individuals with mathematics anxiety have shown to avoid environments and careers that require the utilization of mathematics skills (2). Clute (3) and Hembree (4) also found that students who have a high level of mathematics anxiety have lower levels of mathematics achievement. They also noted that mathematics anxiety seriously constrains performance in mathematical tasks, and reduction in anxiety is consistently associated with improvement in achievement. Studies of gender differences and mathematics anxiety have mixed results. Many studies have reported that poor performance in mathematics and mathematics avoidance was more common among female students (5, 6, 7, 8 and 9). However, other studies have found no gender differences (10, 11, and 12). Resnick et al. (11) found that no sex differences existed in mathematics anxiety among college freshmen. In a study of mathematics and implications for women's career choice by Singer and Stake (12), gender differences were not observed in mathematics anxiety and perceptions of the usefulness of mathematics among sophomore college students but females were less likely to choose a mathematics-oriented career goal. The present study showed that there was a difference between girls and boys with respect to mathematics evaluation anxiety and not in learning mathematics anxiety. More specifically, boys reported higher mathematics evaluation anxiety than girls. Whether this finding represents an actual gender difference or is more a function of increased willingness of female students to endorse anxiety symptoms, data suggest that female students are more apt to avoid mathematics courses and careers that require mathematics skills (13). This finding is consistent with that of Pajares and Miller (14), Pajares and Kranzler (15), Shokrani (16) and Kabiri (17) who reported a higher mathematics anxiety for boys.

On August 6, 2012, the Mehr News Agency in Iran posted a bulletin that 36 public universities in the country had banned women from 77 fields of study (18). In recent years the *Majlis*, the parliament of the Islamic Republic of Iran, discussed the issue of number of females at higher education seriously. The discussion, which included employment opportunities for college-educated boys and girls, revealed that majority of college-educated women are not absorbed into the labor market economy. The reality is that only about 25% of college-educated women join the work force. Some authorities argue that giving women a college education is a waste of the nation's resources because they do not intend to work (19). For example, Oil Industry University, which has several campuses across Iran, announced that they no longer accept female students due to lack of employer demand for their female graduates. Similarly, for the same reason Isfahan University said that 98% of its female graduates in mining engineering degree ended up jobless. Some of the other reasons given are that certain fields of study are not suitable for women or the working conditions may be too challenging.

On August 6, Mehr reported that the 2012 manual published that month by Iran's National Education Assessment Organization (NEAO), a Science Ministry department,

had provided a long list of majors at various universities across the country that had been "single-gendered," meaning only males or females will be permitted to study that field. More than 60 universities across the country made the changes on "single-gendering" of about 600 majors. On August 4, 2012, Daneshjoo News article said that the 2012 academic year Iranian universities have "single-gendered" about 20% of mathematics and technical sciences major fields of study (including engineering), more than 30% in social sciences, 10% in traditional sciences, 34% in the arts/humanities, and 25% in foreign languages. Some universities have "single-gendered" majors for alternating semesters to enforce gender segregation but have not entirely banned access to either male or female candidates.

Banned majors for women include computer science, chemical engineering, industrial engineering, mechanical engineering, and materials engineering at Arak University; natural resource engineering, forestry, and mining engineering at Tehran University; and political science, accounting, business administration, public administration, mechanical engineering, and civil engineering at Esfahan University. At Emam Khomeini University, in Qazvin, all 14 social sciences majors were restricted to males. "Single-gendering" also restricts choices for male students. For example, at Esfahan University men are no longer allowed to major in history, linguistics, theology, applied chemistry, Arabic/Persian language and literature, sociology, and philosophy. According to Daneshjoo News, some of the larger universities with substantial "single-gendering" of major fields of study are Arak University (88%), Esfahan University (68%), Emam Khomeini University (82%), Lorestan University (100%), Ardebil Research University (100%), Golestan University (59%), and Alameh Tabataba'i University (43%). Shahid Chamran University in Ahvaz has "single-gendered" all of its 47 majors for men, even though it is officially a registered co-educational university. Only 3% have been "single-gendered" at Tehran University, one of the country's premiere public universities.

Despite all the "single-gendered" exercise, the total number of majors at universities throughout the country had actually increased by 14% and that the vast majority were still open to both male and female students. The results of the 2012-13 academic year national entrance exams recorded women made up 60% of the enrollment.
Hence, it is true that the authorities at the NEAO and elsewhere claimed that "Islamicization" policies do not adversely impact female students, and cite as proof the announcement that women still account for 60% of the 2012 enrollment. Quotas limiting the spaces and selection of majors for female university students followed a recommendation by the Iranian parliament's research center that encouraged restricting female enrollment to universities in local provinces to reduce the "destructive consequences" of female enrollment on family life. Nonetheless, with the imposition of the quota and "single-gendered" majors, women will somewhat feel that they no longer be able to pursue the education and careers of their choice.

Additionally, so many studies conducted worldwide have shown that women dropped out of science and mathematics in alarming numbers, not because there are sinister

or mysterious patriarchal forces at play, but because they either cannot cut it in the highly competitive environments or they simply change their minds about what they want from life. Even women who graduated with good degrees in science subjects often don't use them: they switched careers in their twenties, abandoning the hard sciences. In some cases, they simply dropped out of the workforce altogether. This is a disaster for the men who missed out on placements, and it's a criminal waste of public funds. Some studies suggest that there ought to be a cap on the number of women enrolling in the sciences, mathematics, philosophy, engineering, medicine and law because it is very expensive to train scientists, doctors, engineers and lawyers. If a big percentage of the women drop out of their career in STEM, then this will be a loss to the people and nation. Many studies have pointed out that there are many reasons why women dropped out of their career in their 20s and 30s: family, marriage, children, workplace abuse, unfavorable working environment, unfriendly office policy, stereotyping, culture, tradition, among others. Hence, perhaps the "single-gendered" majors may work in the case of Iran.

MARYAM MIRZAKHANI MAKES HISTORY

The pride of Iran, Maryam Mirzakhani, in 2014, became the first Iranian and woman ever in 78 years to win the most prestigious Fields Medal at the age of 38 (the Nobel prize for mathematics). She was awarded for her "stunning advances in the theory of Riemann surfaces and their moduli spaces" (20). The Fields Medal is awarded every four years by the International Mathematical Union to outstanding mathematicians under 40 years old who show promise of future achievement. The award was named after Canadian mathematician John C. Fields and has often been described as the "Nobel Prize of Mathematics". Fields Medal, or the International Medal for Outstanding Discoveries in Mathematics, can only honour two to four outstanding mathematicians under the age of 40 at one time in every four years since 1936. With the announcement of Mirzakhani and the other awardees, Arthur Avila, Manjul Bhargava, and Martin Hairer, there are now 54 male and 1 female Fields medalists to-date.

Maryam Mirzakhani is a professor at Stanford University who was recognized for "her outstanding contributions to the dynamics and geometry of Riemann surfaces and their moduli spaces." Her win proves that women are capable of doing mathematical research at the same level as men. This should encourage more women to nurture their mathematical talent to greater heights and break the glass ceilings as women are still very much under-represented in mathematics field not just in Iran but everywhere else in the world. Mirzakhani's Fields medal is revered and celebrated by all women in the mathematics field. It is considered comparable to Marie Curie's barrier-breaking Nobel prizes in physics and chemistry in the early 20th century. It is obviously a great honor in recognizing her excellent work in mathematics and women need a role model like Mirzakhani.

Mirzakhani was born and raised in Tehran in 1977. She did not initially realize her strength in mathematics and did very poorly in mathematics in middle school. As a matter of fact, as a child growing up in Tehran, Mirzakhani had no intention of becoming a mathematician. Her chief goal was simply to read every book she could find. She also watched television biographies of famous women such as Marie Curie and Helen Keller, and later read "Lust for Life," a novel about Vincent van Gogh. These stories instilled in her an undefined ambition to do something great with her life — she had wanted to become a writer. She was lucky to finish elementary school just as the Iran-Iraq war was ending and paving the way to greater opportunities to motivate students to get their education. She took a placement test and got into the Farzanegan middle school for girls in Tehran, which is administered by Iran's National Organization for Development of Exceptional Talents (NODET). In her first week at the new school, she met her lifelong friend, Roya Beheshti, who is now a mathematics professor at Washington University in St. Louis. As children, they loved to explore the bookstores near their school. To her dismay, Mirzakhani did poorly in her mathematics class that year. Her mathematics teacher didn't think she was particularly talented, which undermined her confidence. The following year, Mirzakhani had a more encouraging teacher and her performance improved enormously. Starting from the second year onwards, she became a mathematics star.

She then went on to the Farzanegan high school for girls. There, she and Beheshti got hold of the questions from that year's national competition to determine which high school students would go to the International Olympiad in Informatics, an annual programming competition for high school students. Mirzakhani and Beheshti worked on the problems for several days and managed to solve three out of six. Even though students at the competition must complete the exam in three hours, Mirzakhani was excited to be able to do any problems at all. Eager to discover what they were capable of in similar competitions, Mirzakhani and Beheshti went to the principal of their school and requested that she arranged for mathematics problem-solving classes like the ones being taught at the comparable high school for boys. Undeterred by the fact that Iran's International Mathematical Olympiad team had never fielded a girl the principal of the school was determined to make it happen for her girls. The principal was and has influenced Mirzakhani's life quite a lot ever since.

In 1994, when Mirzakhani was 17, she and Beheshti made the Iranian Math Olympiad team. Mirzakhani's score on the Olympiad test earned her a gold medal, the first female Iranian student to ever win this world's most distinguished mathematics tournament for pre-collegiate students. She returned in the 1995 International Mathematical Olympiad and became the first Iranian student to achieve a perfect score and to win two gold medals. Having entered these competitions to discover what she could do, she emerged with a deep love for mathematics.

She then obtained her BSc in mathematics in 1999 from Sharif University of Technology in Tehran. From there on she went to the United States for graduate

work, earning a PhD from Harvard University in 2004, where she worked under the supervision of the 1998 Fields Medalist Curtis McMullen. According to McMullen, gold medals at the mathematical Olympiad do not always translate into success in mathematics research because in these contests, someone has carefully crafted a problem with a clever solution, but in research, maybe the problem does not have a solution at all. He, however, praised Mirzakhani saying that unlike many other Olympiad high-scorers, Mirzakhani has the ability to generate her own vision.

When she started her graduate school in Harvard, she started attending McMullen's seminars. At first, she did not understand much of what he was talking about but was captivated by the beauty of the subject, hyperbolic geometry. She started going to McMullen's office and peppering him with questions, scribbling down notes in Farsi. She became fascinated with hyperbolic surfaces — doughnut-shaped surfaces with two or more holes that have a non-standard geometry which, roughly speaking, gives each point on the surface a saddle shape. In the century and a half since such hyperbolic surfaces were discovered, they have become some of the central objects in geometry, with connections to many branches of mathematics and even physics.

When Mirzakhani started graduate school, some of the simplest questions about such surfaces were unanswered. One concerned straight lines, or "geodesics," on a hyperbolic surface. Even a curved surface can have a notion of a "straight" line segment: it's simply the shortest path between two points. On a hyperbolic surface, some geodesics are infinitely long, like straight lines in the plane, but others close up into a loop, like the great circles on a sphere. Determined to look for answers she went on to conduct her research on simple geodesics on hyperbolic surfaces.

In her doctoral thesis completed in 2004 on "simple geodesics on hyperbolic surfaces and the volume of the moduli space of curves", Mirzakhani answered this question; developing a formula for how the number of simple geodesics of length L grows as L gets larger. Along the way, she built connections to two other major research questions and solving both. One concerned a formula for the volume of the so-called "moduli" space — the set of all possible hyperbolic structures on a given surface. The other was a surprising new proof of an old conjecture proposed by the physicist Edward Witten of the Institute for Advanced Study in Princeton, New Jersey, about certain topological measurements of moduli spaces related to string theory. Witten's conjecture is so difficult that the first mathematician to prove it — Maxim Kontsevich of the Institut des Hautes Études Scientifiques, near Paris — was awarded a Fields Medal in 1998 in part for that work. According to Benson Farb, a University of Chicago mathematician, "solving each of these problems would have been an event and connecting them would have been an event and majority of mathematicians will never produce something as good and that's what she did in her thesis". Mirzakhani did both. Mirzakhani's thesis resulted in three papers published in the three top journals of mathematics: Annals of Mathematics, Inventiones Mathematicae and Journal of the American Mathematical Society.

Her main research topics include Teichmüller theory, hyperbolic geometry, ergodic theory, and symplectic geometry. Her work has the potential to influence many areas of study, including material science, engineering, quantum field theory, and even theoretical physics as it applies to the origin of the Universe. One of her biggest achievements is her several contributions to the theory of moduli spaces of Riemann surfaces. Riemann surfaces are named after the 19th century mathematician Bernhard Riemann, who was the first to understand the importance of abstract surfaces, as opposed to surfaces arising concretely in some ambient space. In her early work, Mirzakhani discovered a formula expressing the volume of a moduli space with a given genus as a polynomial in the number of boundary components. This led her to obtain a new proof for the formula discovered by Edward Witten and Maxim Kontsevich on the intersection numbers of tautological classes on moduli space (21), as well as an asymptotic formula for the growth of the number of simple closed geodesics on a compact hyperbolic surface, generalizing the theorem of the three geodesics for spherical surfaces (22). Her subsequent work has focused on Teichmüller dynamics of moduli space. In particular, she was able to prove the long-standing conjecture that William Thurston's earthquake flow on Teichmüller space is ergodic (23).

In 2006, Mirzakhani began her fruitful collaboration with Alex Eskin, a University of Chicago mathematician, who considers her as one of his favorite collaborators. He commented that Mirzakhani's optimism is very infectious and when he works with her, he feels that they have a much better chance of solving problems that at first seems hopeless. And one of Mirzakhani's more recent contributions is a monumental collaboration with Eskin about the dynamics of abstract surfaces connected to billiard tables. According to Benson Farb, this is "probably the theorem of the decade" in Mirzakhani's highly competitive field. After several projects together, Mirzakhani and Eskin decided to tackle one of the largest open problems in their field. It concerned the range of behaviors of a ball that is bouncing around a billiard table shaped like any polygon, provided the angles are a rational number of degrees. Billiards provide some of the simplest examples of dynamical systems — systems that evolve over time according to a given set of rules — but the behavior of the ball has proven unexpectedly hard to pin down. Rational billiards got started a century ago when some physicists were sitting around and trying to understand a billiard ball bouncing in a triangle. Presumably, they thought they would be done understanding billiard balls bouncing in a week, but 100 years later, physicists are still thinking about it.

After years of work, in 2012 and 2013, Mirzakhani and Eskin, partly in collaboration with Amir Mohammadi of the University of Texas at Austin, succeeded in generalizing McMullen's result to all doughnut surfaces with more than two holes. Their analysis is a titanic work and that its implications go far beyond billiards. The moduli space has now been intensively studied in the last 30 years, yet there are still so much more that mathematicians do not know about its geometry. Most recently as of 2014, with Eskin and input from Amir Mohammadi, Mirzakhani proved that complex geodesics

and their closures in moduli space are surprisingly regular, rather than irregular or fractal (24 and 25). The closures of complex geodesics are algebraic objects defined in terms of polynomials and therefore they have certain rigidity properties, which is analogous to a celebrated result that Marina Ratner arrived at during the 1990s (25). The International Mathematical Union said that this is an astounding success to find that the rigidity in homogeneous spaces has an echo in the inhomogeneous world of moduli space (25). Mirzakhani and Eskin's work is "the beginning of a new era," as simply put like as if you had used a hatchet before to log a forest, but now they have invented a chain saw. As a matter of fact, their work has already been applied, for example, to the problem of understanding the sightlines of a security guard in a complex of mirrored rooms.

Mirzakhani's research connects to many areas of mathematics, including differential geometry, complex analysis and dynamical systems. She likes to cross the imaginary boundaries people set up between different fields. In her area of research, there are a lot of tools and no one knows which one would work. To her it is all about being optimistic and trying to connect things. McMullen said that sometimes, the connections that Mirzakhani makes are mind-blowing. In 2006, for example, she tackled the problem of what happens to a hyperbolic surface when its geometry is deformed using a mechanism akin to a strike-slip earthquake. He said before Mirzakhani's work, this problem was completely unapproachable, but with a one-line proof, she constructed a bridge between this completely opaque theory and another theory that's completely transparent.

Mirzakhani said that mathematics research is like writing a novel and her protagonists in the story line are hyperbolic surfaces, moduli spaces and dynamical systems. They are all of different characters and they evolve and change. She would follow her characters wherever they take her, along story lines that often take years to unfold. Mirzakhani has a reputation among mathematicians for tackling the most difficult questions in her field with dogged persistence and fearlessly. She projects an unwavering self-confidence and has an equal tendency, however, toward humility. Being very humble she does not think that she has made a very huge contribution in the field of mathematics. As a matter of fact, when she received an email saying that she would be receiving the Fields Award at the International Congress of Mathematicians in Seoul, South Korea, she assumed that the account from which the email was sent had been hacked. Many other great mathematicians describe her work as brilliant, her doctoral dissertation about counting loops on surfaces that have "hyperbolic" geometry was truly spectacular and the kind of mathematics one can immediately recognize belongs in a textbook.

Mirzakhani likes to describe herself as slow. Unlike some mathematicians who solve problems with quicksilver brilliance, she gravitates toward deep problems that she can chew on for years so as to see the very different aspects of a problem. There are problems she has been thinking about for more than a decade and still there

is not much she can do about them yet. She has big plans for the next chapters of her mathematical story. She has started working with Alex Wright, a postdoctoral researcher at Stanford, to try to develop a complete list of the kinds of sets that translation surface orbits can fill up. Such a classification would be a “magic wand” for understanding billiards and translation surfaces.

In the meantime, while she feels greatly honoured to have been awarded a Fields Medal, she has no desire to be the face of women in mathematics. She said that her ambitious teenage self would have been overjoyed by the award, but today, she is eager to deflect attention from her achievements so she can focus on her research. Her notable awards include: American Mathematical Society Blumenthal Award (2009), AMS Ruth Lyttle Satter Prize (2013), Clay Research Award (2014), and Fields Medal (2014).

She was, among others, a 1995-1999 IPM fellow at the University of Tehran, a 2003 junior fellow at Harvard, a 2004 research fellow of the Clay Mathematics Institute, and a professor at Princeton University. Since 2008 she became a professor of mathematics at Stanford University. She is married to Jan Vondrák, a Czech theoretical computer scientist who works at IBM Almaden Research Center and the couple has a daughter named Anahita.

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PROSPECTS FOR WOMEN IN SCIENCE AND TECHNOLOGY IN JORDAN

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INTRODUCTION

Jordan, officially known as the Hashemite Kingdom of Jordan, is an Arab kingdom covering an area of 81,208 sq. km in Western Asia, on the East Bank of the Jordan River. Jordan is bordered by Saudi Arabia to the south and east, Iraq to the north-east, Syria to the north, and Israel and Palestine to the west. Since the dawn of civilization, the country's location at the crossroads of the Middle East has served as a strategic nexus connecting Asia, Africa and Europe. In 2013, the total population of the country was estimated at 6.53 million (excluding the number of refugees from neighboring countries) with an average growth rate of 2.2 and an average family size of 5.4. During the last decade, Jordan has experienced a tremendous influx of refugees from neighboring countries, mainly from Iraq and Syria due to the political instability of these countries. According to the United Nations Refugee Agency (UNCHR) records, it is estimated that about 642, 000 refugees, where women and children comprise 80%, are residing in Jordan as of January 2014. Majority are from Syria since Iraqi refugees only amounted to about 30,000 as of March 2013 (UNCHR website, 2014).

In 1946, Jordan became an independent sovereign state officially known as The Hashemite Kingdom of Transjordan. The same year, Abdullah I took the title King of Jordan. The name of the state was changed to The Hashemite Kingdom of Jordan on 1 December 1948. Women constitute about 48.5 % of the total population. It is characterized as having a young population with 59 % below the age of 25 and only 7.4% above the age of 55 (Jordan Statistical Yearbook 2013, Department of statistics of Jordan, 2014).

Jordan is a major tourist destination in the region and is especially popular with western expatriates seeking to live or study in its capital Amman. Not only is the Kingdom considered to be the safest country in the Middle East, but it is also considered as the safest Arab country. Although Jordan is a constitutional monarchy, the King holds wide executive and legislative powers. It is classified as a country of "high human development" by the 2014 Human Development Report with an "upper middle income" economy and enjoys "advanced status" with the European Union since December 2010, and is a member of the Euro-Mediterranean free trade area. It is also a founding member of the Arab League and the Organisation of Islamic Cooperation (OIC). Jordan has a well developed medical sector, making it as a medical hub in the Middle East region. it has one of the world's highest life expectancies—over 80 years ranking it as the second highest in the entire MENA region. Although Jordan has very few natural resources, but it has large investments, the reason behind this is the country's highly skilled workforce.

JORDAN'S FUTURE ECONOMIC PROSPECTS AND COUNTRY COMPETITIVENESS

(1) Industry

Jordan has a very well developed industrial sector, which includes mining, manufacturing, construction, and power, accounted for approximately 26% of gross domestic product in 2004 (including 16.2% in manufacturing, 4.6% in construction and 3.1% in mining. More than 21% of the country's labour force was reported to be employed in this sector in 2002. The main industrial products are potash, phosphates, pharmaceuticals, cement, clothes, and fertilizers. The most promising segment of this sector is construction. In the past several years, demand has increased rapidly for housing and offices of foreign enterprises to be based in Jordan to have a better access of the Iraqi market. Jordan is now considered to be a leading pharmaceuticals manufacturer in the MENA region led by Jordanian pharmaceutical company Hikma. The Group is listed on the London Stock Exchange. In 2015, it acquired Roxane Laboratories making Hikma the sixth largest company in US generics. Phosphate mines in the south have made Jordan into one of the largest producers and exporters of this mineral in the world. Jordan aims to benefit from its large uranium reserves with three nuclear plants underway. Natural gas was discovered in Jordan in 1987. The estimated size of the reserve discovered was about 230 billion cubic feet, a modest quantity compared with its other Arabian neighbours. The Risha field, in the Eastern Desert beside the Iraqi border, produces nearly 30 million cubic feet of gas a day, which is sent to a nearby power plant to produce nearly 10% of Jordan's electricity needs. Despite the fact that reserves of crude oil are non-commercial, Jordan possesses one of the world's richest stockpiles of oil shale where there are huge quantities (5th largest oil-shale reserves in the world) that could be commercially exploited in the central and northern regions west of the country. This shale oil sits under 60% of Jordan's surface.

(2) Medical tourism

Jordan has been a medical tourism destination in the Middle East since the 1970s. A study conducted by Jordan's Private Hospitals Association (PHA) found that 250,000 patients from 102 countries received treatment in the kingdom in 2010, compared to 190,000 in 2007, bringing over $1 billion in revenue. It is the region's top medical tourism destination as rated by the World Bank and fifth in the world overall. It is estimated that Jordan received 55,000 Libyan patients and 80,000 Syrian refugees, who also sought treatment in Jordanian hospitals, in the first six months of 2012. The 55,000 Libyans spent JD140 million while 800 Yemenis spent JD15 million during their treatment as of October 2015. Jordanian doctors and medical staff have gained experience in dealing with war patients, throughout years of receiving such cases from various conflict zones in the region. Jordan's main focus of attention in its marketing effort is the ex-Soviet states, Europe, and America. Most common medical procedures on Arab and foreign patients included organ transplants, open heart surgeries, infertility treatment, laser vision corrections, bone operations and cancer treatment.

(3) Science and technology

Science and Technology is the country's fastest developing economic sector. This growth occurs across multiple industries including Information and Communications Technology and Nuclear Technology. Jordan contributes 75% of the Arabic content on the Internet. In fact, the Information and Communications Technology sector is the fastest growing sector in Jordan's economy with a 25% growth rate. The sector accounts for more than 84,000 jobs, and contributes 14% to the GDP. There are 400 companies in Jordan that are operating across the spectrum of telecom, IT, on-line and mobile content, business outsourcing, and video game development. It has been estimated that these subsections of the Information and Communications Technology industry will create over 18,000 jobs over the next five years (2015–2020). Nuclear Science and Technology is also expanding. The country is planning to build two nuclear power plants by 2020 near Qasr Amra. Additionally, a small 5MW reactor called the Jordan Research and Training Reactor, located in Jordan University of Science and Technology campus in Ar-Ramtha city, is currently under construction. The intent of the research reactor is to help train nuclear engineers in Jordan using the existing nuclear engineering program. Jordan was also selected as the location for the Synchrotron-Light for Experimental Science Applications in the Middle East (SESAME). This particle accelerator will allow collaboration between scientists across the Middle East despite the political conflicts.

WHAT DOES THE LITERATURE REVIEW SAY?

In spite of more women are attending college at unprecedented rates and constitute more than half of university and college populations, they continue to be under-represented in science, technology, engineering, and mathematics (STEM) fields

(Planty, Kena, & Hannes, 2009). The decline in STEM enrollments along with retention problems raise concerns about the "shrinking" and "leaking" pipeline, the metaphor most often used to describe declining enrollments and the differential retention of women in STEM fields (e.g., Camp, 2002; Major & Morganson, 2008). As enrollments of women in STEM majors continue to decline, the pipeline "supplying" them to these fields is said to be shrinking (Camp, 2002). College-age women have been reported to be less likely to major in STEM fields and to be retained at a lower rate than are men (Freeman, 2004; Planty et al., 2009). When women complete undergraduate training, they continue to be under-represented in and are more likely to leave the workforce than are men (Freeman, 2004). The STEM environment is often characterized as a chilly climate, which tends to be male-dominated, highly impersonal, and individualistic (Foster et al., 1994; Seymour & Hewitt, 1997; Suresh, 2006). The lack of support in the traditional STEM environment may be particularly harmful to women given that researchers and theorists (e.g., Fletcher, 2004; Jordan, Kaplan, Miller, Stiver, & Surrey, 1991) have repeatedly emphasized the importance of relationships and interpersonal connections to women's psychological development and well-being. Scholars (e.g., Camp, 2002; Gürer & Camp, 2002; Margolis & Fisher, 2002) have identified numerous barriers to the success and persistence of women in STEM curricula, including lack of viable mentors, low self-efficacy, and the glass ceiling effect.

Exploring which coping strategies are effective for girls and women in STEM curricula has implications for school, career counselors and for academic policies. By understanding the barriers that women in STEM curricula face and the coping strategies known to be effective in STEM environments, counselors can help the female students to recognize obstacles and learn to cope in ways that are likely to be effective. Coping is a transportable skill that can continue to assist girls and women in overcoming barriers as they move forward in their careers. In terms of policy, identifying the most effective coping strategies for women in STEM fields can provide information regarding where additional resources should be allocated and what kind of resources are likely to help girls and women in STEM curricula to cope (cf. N. W. Brown & Cross, 1997).

OVERVIEW OF JORDANIAN WOMEN IN SCIENCE AND EDUCATION

A recent report by the World Bank on gender assessment showed that half of Jordan's educated females were unemployed, despite a growing awareness of the importance of women's role in science. The Arab Spring has largely reshaped the Middle East's political landscape and should pave new opportunities for women in the Arab countries. But new laws sometimes do not translate into practice. There are still changes that need to be made which must ensure women, especially in the fields of medicine and science, to advance a long way. It is also important to note that those changes must be designed on a long term basis in order to guarantee a generational

transformation rather than a temporary improvement. Globally, the small proportion of women in academic sciences has been the issue of intense discussion everywhere.

The Arab world has seen major advances in the status of women over the last decade; with new policies being introduced to preserve the many rights for women. Some of these legal improvements have since set the stage for empowering women so that they can play an active role in the politic, economic, education and social sectors. While some laws may empower women, men still dominate academia, especially at the top. Jordan is not spared. In the recent human resources report produced by the EU, one concern was the low number of female academics in higher education. Similarly the recent report by the World Bank on gender assessment showed that 50% of educated females in Jordan were unemployed – despite the fact that Jordanian women dominate the education ranks until the tertiary stage. It is enlightening to note that males and females in Jordan have equal access to primary and secondary education. According to the Jordanian Ministry of Higher Education and Research, at the university level, females comprise half of the student population in many disciplines, including nearly two thirds in natural sciences, medicine, dentistry, pharmacy, paramedical and veterinary medicine combined. In post graduate education, female enrollment is significantly higher; 57% of master degree candidates and 56% of PhDs are female. More than four in ten women who go to university in Jordan go into science, engineering or medicine. Women outnumber men on courses in natural science, pharmacology and agriculture; numbers are equal in mathematics and computer science; and one in three engineering students in Jordan is a woman.

According to Rana Dajani and Kamal Bani-Hani (Female education and workforce trends in health-related disciplines in Jordan http://www.natureasia.com/en/nmiddleeast/article/10.1038/nmiddleeast.2014.285), in the Arab culture, one reason why females tend to achieve higher grades is that while boys have more freedom to go out as and when they please, girls usually stay home and therefore are less distracted by outings and more focused on studying. This works to the advantage of the women as the admission eligibility into the universities in Jordan is based entirely on grades. To add, more and more families in Jordan now are eager to provide their daughters with a high education in ensuring them an independent life and not being controlled by the men. Unfortunately, in spite of the high number of females in education in the schools, it is not being reflected in the same high number in higher education. One reason is because many Jordanian women get married at a very early age and consequently stay at home. Even those who pursue higher studies are not compelled to work for a living after marriage because in the Arab tradition, men will always be the main breadwinners in the family. However, in recent times, many Jordan women are being pressured to seek employment resulting from the economic crisis.

As seen from the records by Jordanian Ministry of Higher Education and Research, females comprise half of the student population in many disciplines at the under-graduate level and more than half at the post - graduate level. Eventhough women

outnumbered men in higher education, it is still very glaring to see that the academic senior positions and faculty positions are still being dominated by men. Only 32% of assistant professors 26% of associate professors and 19% of professors in health related fields are women. Official figure also shows that 35% of grant holders from the largest funding organization in Jordan, the National Research Fund, are female. This encouraging percentage is a promising reflection of Jordanian women scientists' achievement as compared to the Jordanian men scientists despite the fact that women constitute only 16.5% of faculty members. That percentage says a lot about the achievement and success of Jordanian women scientists in contributing towards the scientific advancement in Jordan.

With an education system that ensures equal access to both genders, Jordan has a highly educated female population that will help benefit Jordan in the future. Despite ongoing progress, women in Jordan remain under-utilized and often sidelined in society due to enduring norms and traditions. Traditional beliefs and norms within families and communities are major barriers to both males' and females' life choices and aspirations. Furthermore, violence against women is prevalent and under-reported due to social and familial pressures. Despite having closed or reversed the gender gap in female education at all levels, Jordan continues to have one of the world's lowest rates of female participation in the workforce. Only 16% of Jordanian women participate in the economy.

DISCUSSIONS

(1) Challenges faced by women scientists in Jordan

The daunting obstacles and challenges women face in full empowerment and equality in the science, technology, engineering and mathematics fields are similar everywhere: access to education, familial pressure, social norms, unfavourable policies, companies' rules and regulations, unfavourable working environment, discrimination at the workplace, financial constraint and lack of women role models in STEM. In Jordan, the challenges mostly lie in the institutions, the Arab culture, and the women themselves. Although many point to religion as a reason for the degradation of the status of women in the Arab world, throughout the history of Islam, women have been given equal rights – and this is backed up by texts in the Quran. It was only with the demise of the Islamic civilization at the end of the Ottoman empire, followed by colonialism and dictatorships that women's rights in the Arab world were diminished.

A lack of education and the withdrawal of freedoms resulted in social norms that led to injustice and subjugation of women, undermining their work and achievements, and which ultimately lead to fewer female professionals in the present day (Rana Dajani and Kamal Bani-Hani "Female education and workforce trends in health-related disciplines in Jordan" http://www.natureasia.com/en/nmiddleeast/article/10.1038/

nmiddleeast.2014.285). They further added that there are cultural reasons that hamper more women scientists to advance further in academia. For instance, even if a woman achieves an advanced academic career position she is not considered as part of the "club" because academia is noted as a male-dominated realm. Henceforth, there are fewer opportunities for the women academia to participate in interaction with colleagues, mentoring and informal advice. Because these women scientists are lacking of mentoring and networking, it is then essential for them to widen their network in exchanging ideas and experience, and progress their careers through better professional opportunities or research collaborations.

According to Dr. Rana Dajani (Assistant Professor and Former Director of the Center of Studies at the Hashemite University, Jordan) in her article on "How women scientists fare in the Arab world," published in Nature in November 2012, she argues that true equality for women scientists requires recognition of their family roles as well. She feels that due to family commitments, women are unable to network. Hence, resulting in a a lesser number of opportunities due to a lack of mentoring and networking. For this reason, she feels that mentoring projects are required in the Arab world so as to support women in distilling both their personal and professional duties.

The article highlights that Jordanian women are generally discouraged and/or criticized for studying science and/or pursuing a career in science due to the following:

- based on the preconception that women should study something useful for their future lives, which most of the time is limited to the home. If what they study was not related to their future, it was considered a loss of time and money. Women were not part of the work force, so there were no career options.
- when the economy made it essential that the women workforce was needed, the concept then became to work for money and not for pursuing a career or a dream. Women were encouraged to study so that they could provide an income for their families as life was getting increasingly expensive, or otherwise, in the case of being unmarried or divorced, the woman could survive on her own without any form of dependency. Yet another viewpoint is that many believe women work not out of pursuing a dream or being ambitious, but because it is better than merely sitting at home.
- how a working female may be able to strike a balance with her family life. Her motherhood role is considered the most important in the Islamic and Arab world. The West has imposed a view of belittling/undermining the role of a mother.
- that the society is adopting the Western perspective, view and history, in analyzing the issue of science and this approach is flawed and biased.
- the reason for the low numbers of females in higher academic positions is because there are no PhD programs in the Arab world, including Jordan. If a woman has to travel abroad to get her PhD it will be very challenging for her, for example like living alone for a long period, financial expenses and other challenges.

(2) Advancing women's empowerment in Jordan

When women can reach their full potential, communities will flourish and economies grow. Due to that, across the world, countries have made enormous strides in ensuring that all girls and women have the opportunity to make full use of their talents and abilities. More than half of the university students in Jordan are women, and the number of women pursuing masters and doctoral degrees has soared over the years. This is definitely a great achievement for the Jordanian women. Jordanian women have emerged as leaders and visionaries not only at all levels of government, but also in academic, research, business, media, and many sectors in the economic industry. In science and technology fields, they are making their presence more felt than ever. Their role and participation stand as an inspiration for the next generation of young women. For instance, in the mid-1990s, Randa Ayoubi marketed her computer-based educational materials from a rented van that she drove from village to village. Today, her company, Rubicon, is a global leader in multimedia education. Rubicon has 150 employees in Amman; more than 250 workers in offices in Los Angeles, Manila, and Dubai; and clients around the world. Many ICT companies in Jordan have come to a similar recognition that hiring women makes good economic sense because women are more flexible. The family-friendly policies have boosted women's economic participation in this sector to a robust 30%, making ICT as one of the most dynamic sectors in the Jordanian economy. This shows that more Jordanian women are getting more and more involved in computer programming, robotics, mobile application building and web design and development.

However, expanding women's economic participation in science and technology remains a struggle in Jordan as they are very much still under-represented. Much need to be done to narrow the gap between men and women employment in the science and technology fields because when women work, the Jordanian economy will grow at a much faster rate. As it is in Jordan, only 16% of its women are working – this means that there is a huge potential and prospects for the women to participate in the labor force and the potential impact this will bring to the Jordanian economy is astounding.

There need to be real changes made in enforcing women's empowerment and combating the obstacles and challenges to women's participation in science and technology fields. The Government of Jordan needs to make serious commitment in increasing opportunities for girls and young women to study science and technology, and ensuring fair opportunities for employment to encourage broader female economic participation. All parties in Jordan need to support in sending out strong messages on the importance of women in the business and economic sector of Jordan, in particular in science and technology, through public commitments and appointing visible female role models in these fields. Harnessing the strength of the women will promote greater prosperity and growth which is vital in achieving peace and stability. When the women are co-players in the workforce, their participation will strengthen the economy and their contribution towards science and technology will increase the level of innovation in the country.

As Her Majesty Queen Rania has said, “as the political, social and economic plates shift and settle around our region, there’s never been a better time for girls to rise up and share their talents with society. And, girls, society has never needed you more.”

CONCLUSION

In 2015, Jordan ranked 7th most competitive Arab country in the latest economic index, scoring as high as 25th globally on the availability of engineers and scientists but as low as 142 out of 144 countries on ratio of women to men in the labour force. Similarly, Jordan ranked 64 worldwide in the World Economic Forum’s (WEF) 2015-2016 Global Competitiveness Index (GCI). The WEF identified difficulty in accessing financing, an inadequate educated workforce, policy instability, tax rates, restrictive labour regulations and inefficient government bureaucracy as the major problematic factors facing businesses in Jordan. The 2015 IMD World Competitiveness Yearbook and the World Bank’s Doing Business Report 2015 suggests that Jordan needs to have a comprehensive governmental plan with applicable programs, including suggestions from the private sector, to improve the Kingdom’s performance in all pillars, not only the lagging ones, in order to enhance its competitiveness that will directly impact the living standards and development levels of its people.

Jordan has been a medical tourism destination in the Middle East since the 1970s due to its well developed medical sector. At the same time, it contributes 75% of the Arabic content on the Internet. In fact, the Information and Communications Technology sector is the fastest growing sector in Jordan’s economy with a 25% growth rate and providing more than 84,000 jobs, and it will create another 18,000 jobs over the next 5 years. Nuclear Science and Technology is also expanding as it is planning to build two nuclear power plants by 2020. Jordan, too, has very well developed industrial sectors in mining, manufacturing, construction, and power and is also a leading pharmaceuticals manufacturer in the MENA region. Clearly, with all these great potential Jordan has in store, the women in STEM now would have better prospects in science and technology careers in Jordan.

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WOMEN IN SCIENCE AND TECHNOLOGY: MALAYSIAN PERSPECTIVE

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INTRODUCTION

In the Malaysian socio-economic scenario, Malaysian Vision 2020 has clearly placed Science & Technology (S&T) and Information and Communication Technology (ICT) as a critical pathway to achieve the status of a developed nation and to help enhance Malaysia's survival in the K-based economy respectively. Notably, emphasis on human resource development in S&T continues into the 10th Malaysia Plan (2011-2015). In 1969, the Malaysian government has set a target to achieve a 60-40% composition of students in science versus arts field at tertiary level of education. This policy aimed at producing more scientists, engineers, doctors and technicians who would be highly specialized for the development of various economic and social sectors, in line with the increase in population and importance of quality of life. It continues to be emphasized in every five-year development plans because it is believed that the supply of manpower in science and technology can further develop the economy sectors such as agriculture, industry and trade (Hussin & Zakuan, 2009). Based on the aspiration to achieve the status of a developed country by 2020 where Malaysia would need more expertise, the formulation of this policy is to provide an adequate manpower in science and technology. To ensure the success of the plan, the Higher Education Planning Committee has set a transition ratio of the projected enrolment of students in science and technical compared to arts students. It gradually began in 1970 with a ratio of 45% of students in science and technical to 55% of students in the arts. The Committee has recommended that the projected enrolment, especially at the level of upper secondary education and higher levels in the ratio of 60% in science and technical and 40% in the field of arts (Hussin &

Zakuan, 2009). However, Phang et al. (2012) reported that until 2012, the percentage of student participation in science-based programs has never even achieved 60% implying the under-achievement of the government effort. Another important concern, besides the under-achievement of the policy, is the declining academic performance of students in science subjects. Based on the Trends in International Mathematics and Science Study Report in 1999, 2003 and 2007, the science and mathematics scores of students aged 14 years have been declining.

There is however an equally serious issue concerning the composition of science-arts trained Malaysians namely the withdrawal of science-based trained graduates from science related jobs. There is a dearth of research looking at the choice of occupation among these graduates in which those who are trained in the field of science and technology are no longer contributing their expertise when they get into the labor market. This issue magnifies the under-achievement of government's aim to increase the number of scientists in the country.

WOMEN IN COMPUTER TECHNOLOGY IN MALAYSIA

The Malaysian government wants 60% of high school graduates to specialize in science, technology, engineering, and mathematics by 2020. This is the country's goal in science and technology field. But then until 2012, the percentage of student participation in science-based programs has only reached up to 40%. Since Malaysia gained independence in 1957, Malaysian women have participated and contributed towards the social and economic development of the country. This was made possible by the policy standpoint of the Malaysian government which considers women are an important pool of resource that can be mobilized towards achieving the national development agenda. In Malaysia where the use of computers is widespread, women have been found to indulge and benefit from modern technologies as they have access to computers and internet as men.

According to Ulf Mellstrom, a professor of gender and technology at Luleå University of Technology in Sweden and a Clayman faculty research fellow, "In the U.S., technology and masculinity are very connected, which is not the case for Malaysia". According to US national studies, women hold more than half of all professional occupations in the country but fewer than 24% of all computing-related occupations, representing a huge pool of untapped talent. In 2008, women represented only 18% of all computer science degrees as compared to 37% in 1985 (Schechter 2010). What are the factors that discourage women from entering this field? However, unlike the US, in Malaysia, women make up between 50 and 60% of the computer industry's employees and many hold mid- and upper-level management positions. The country's burgeoning technology industry has brought about dramatic changes to women's roles in society, changing traditional perceptions of class, ethnicity and gender (Schechter 2010). The author of "Masculinity, Power and Technology: A Malaysian Ethnography," Mellstrom has been conducting a long-term survey of female students in preparation for a

new book on Malaysian women in the computer industry. In contrast to the U.S., in Malaysia, jobs in technology are seen as appropriate for women: Men do not perceive indoor work as masculine and much of society stigmatizes women who work outdoors as lower class. Computing and programming are seen as "women-friendly" professions, with opportunities opening up since men are not interested in competing for these types of jobs (Schechter 2010). According to Mellstrom in his study, he found that initially the women left their villages to seek for urban opportunities in the electronics industry, working in indoor production work. As the electronics jobs are slowly being replaced by technological ones, this opens up new doors for the fresh women graduates. This transition happens very easily because women in computer science have role models in their electronic predecessors, which does not exist in the US computer science industry (Schechter 2010).

Though women have the drive and capability to succeed in S&T, there seems to be a phenomenon whereby the percentages of female began to wane at the working level (and at higher postgraduate level) – what it is called as the "leaky pipeline". The leaky pipeline is a concept that has been used to refer to the steady attrition of girls and women throughout the formal S&T system, from primary education to tertiary and postgraduate levels to S&T decision making, as well as all aspects of careers in S&T.

In a Report by UNESCO's Asia and Pacific regional bureau "A Complex Formula: Girls and women in science, technology, engineering and mathematics in Asia", which is a synthesis of seven case studies in Cambodia, Indonesia, Malaysia, Mongolia, Nepal, South Korea and Vietnam. The report stated that the issue is complicated in that, despite a higher proportion of female enrolments in sciences in tertiary institutions in Malaysia, Mongolia and South Korea, the trend has not increased women's participation in most STEM fields of study, including engineering and technology, and physics. The report stated that a higher proportion of females are found in disciplines such as pharmacy, medicine and biology but they remain under-represented in computer science and engineering. In 2012, more than 72% of pharmacy students in Malaysian universities were women compared with 36% in engineering. The report says the situation was similar in Mongolia where 73% of students enrolled in biology in 2013 were women, compared with 30% in computer science and just 24% in engineering. As of 2011, the proportion of females enrolled at bachelor level in South Korea stood at 52% in science and 19.5 % in engineering – but, at doctoral level, female enrolment was 38% in science and just 12% in engineering. The emerging picture is consistent in that, last year, only 15% of those enrolled in engineering in South Korean universities were females, an observation similar to other countries in the region, especially Nepal (19%), Mongolia (23%) and Malaysia (36%). In comparison, Malaysia is on the way to becoming a regional beacon of hope regarding women's attempts to achieve parity in STEM professions. The report notes that, in 2014, 31.6% of graduate engineers were women. Areas where women were highly represented were in medicine (46.7%), dentistry (63.5%), veterinary medicine (41.4%) and pharmacy (72.9 %).

According to the Ministry of Women, Family and Community Development of Malaysia, from 2012-2013, the registered professionals by profession and gender recorded the highest percentages of women in the human health and social work as well as the education industry. From the total women employed, only 3.3% are in scientific and technological careers. However, the number of women in science, technology and information (STI) is still lower than men (which is also a widespread global phenomenon). The trend is even more distinct in professional, managerial and leadership positions. S&T related registered professions highly involved by professional women are as follows: dentist (64.3%), medical doctor (47.8%), veterinary surgeons (41.5%), O & G (34.9%), psychiatrist (28.7%), lawyer (50.5%), professional architects (34.7%), architects (17.5%), pro engineers (4.7%), and graduate engineers (21.6%). (Source of Registered Professionals by Profession and Gender, 2012-2013 is from the Ministry of Women, Family and Community Development Malaysia, 2013).

LITERATURE REVIEW

What is Computer Technology?

According to Anderson, Lankshear, Timms, C., & Courtney (2008), Computer Technology (CT) jobs usually involve roles such as "designing and developing software and hardware systems; providing technical support for computer and peripheral systems; and creating and managing network systems and databases" (p. 1305). Zarrett and Malanchuk (2005), on the other hand, distinguish between "soft" and "hard" computer-related jobs. They indicate that soft computer jobs include occupations such as help desk, telecommunications, statistics, Internet journalism, research, resource guides and teaching, whereas hard computer jobs include programmer, computer engineer, database administrator, network administrator, systems administrator, and information systems/technology (see also the work of Burger, Creamer, & Meszaros, 2007). However, many research suggest that for the "hard" computer jobs, women are particularly under-represented in those jobs (Kirkup, 2011; Valenduc, 2011; Zarrett & Malanchuk, 2005).

The "Leaky Pipeline" Metaphor

A number of studies have investigated why women are underrepresented in Information Technology (IT) majors and in the industry (Barker & Aspray, 2006; Burger et al., 2007; Klawe et al., 2009; Singh, Allen, Scheckler, & Darlington, 2007; Thomas & Allen, 2006). The literature indicates that equally capable girls in the United States decide against technology and the other STEM fields before they leave high school (Klawe et al., 2009; Meszaros, Lee, & Laughlin, 2007; Singh et al., 2007). This scenario is not limited to the United States alone. In Australia, a majority of the female students reported that they dropped IT as a subject in junior high school (Thomas & Allen, 2006). Sáinz and López-Sáez (2010) reported that eventhough girls in Spain

tend to excel in technology-related studies when compared to boys, they tend to choose non-technical subjects "when planning their academic and professional future" (p.578). Similar incidents have been found in other European countries (e.g., see Palmen, 2011; Sainz, 2011). Previous studies indicate that the under-representation of women in the Computer Technology field is essentially a "leaky pipeline" issue. The leaky pipeline metaphor refers to the continued loss of women in Computer Technology from courses in elementary school through the tertiary level and from jobs in Computer Technology fields. It has been hypothesized that women "leak" from the pipeline either by considering other choices or failing to progress through to the different stages of the pipeline. Consequently, a leak at one stage of the pipeline logically accounts for the shortage in later stages (Soe & Yakura, 2008;Varma, 2010).

CAUSES OF THE LEAKS IN THE PIPELINE TO COMPUTER TECHNOLOGY

The under-representation of women in advanced studies and careers in Computer Technology has been attributed to both psychological and social factors. The following highlights some of the main factors related to this perception that have been identified as the cause of the leaks in the pipeline in relation to the field of CT.

(1) The stereotypical "nerd"

One factor that is often cited for the loss of women along the pipeline has to do with the perception that the computer technology profession is filled by stereotypical "nerds," leading some women to choose what they perceive to be more people-oriented majors or occupations (Anderson et al., 2008; Harris et al.,2009; Howe, Berenson, & Vouk, 2007; Papastergiou, 2008; Thomas & Allen, 2006). In a study of male and female first-year students at the University of Melbourne in Australia, for example, Thomas and Allen reported that 85.7% of the female participants said they stopped studying IT at the secondary school because they "didn't want to be classified a nerd" (p. 170).

(2) Lack of female role models/mentors

Another potential factor is the lack of role models/mentors both in the school environment and in Computer Technology fields (American Association of University Women, 2010; Dryburgh, 2000; Harris et al., 2009; Klawe et al., 2009). In the Thomas and Allen (2006) study of Australian students, participants were asked to "name any women they know who work in the IT industry" (p. 173). The results of the study showed that 59.2% of the participants could not name any female professionals in the IT industry. When participants were also asked to name any IT role models portrayed in the media, more than half of the total number of participants said they did not know any, and 8.2% listed cartoon characters as role models. On the basis of this result, Thomas and Allen argued that female IT professionals are not normally reported on in the news, shown on television shows, or portrayed in movies. The situation may

be improving in recent times as there are several more strong female role models in the tech industry than there were a decade ago. American technology executives include Marissa Mayer (the current president and chief operating officer of Yahoo), Sheryl Sandberg (the chief operating officer of Facebook), and Danese Cooper, who was appointed in the spring of 2014 as the first ever head of open source software of PayPal (Barasch, 2014; Finley, 2014; Somerville, 2014). Yet, a recent study (Bell & White, 2013) showed that almost half (45.3%) of the 150 Silicon Valley companies did not have women in the executive positions.

(3) Male domain/culture

The literature indicates that girls, college students, and parents perceive that STEM-related fields are male dominant (e.g., Archer, 2013; Papastergiou, 2008; Thomas & Allen, 2006). For example, Archer interviewed the parents of young UK students about their views on science-related careers; half of the parents considered science careers as male-dominated areas. Considering the influence parents have on career aspirations and choices for their daughters, then these findings are troubling, and perhaps have led the girls to describe STEM fields as "geeky" and "uncool" (Papastergiou, 2008; Thomas & Allen, 2006). The perceptions of parents and students in this regard are further supported by the reality that many women in CT fields have experienced themselves. Approximately 50% of women working in STEM leave their fields because of hostile work environment according to Hewlett, Buck Luce, & Servon, 2008. However, not all studies, show that women perceive IT as male dominant. According to Black, Jameson, Komoss, Meehan, and Numerico (2005), while men in China dominate the IT field, Chinese women believe that IT is an occupation for the unisex, i.e. both men and women. Surprisingly, graduate-level college women in China prefer to pursue careers in IT rather than other professions (Black et al., 2005). Similar results can be seen in Malaysia as well, where women dominate computer science classes and IT-related jobs (Lagesen, 2008; Mellstrom, 2009). Culture may possibly play a role in these perceptions.

(4) Family influence

The influence of family plays a key role in girls' Computer Technology career choices. Parents and siblings' attitudes and beliefs about technology can influence a girl's perceptions about computers (Creamer, Lee, & Meszaros, 2007; Zarrett & Malanchuk, 2005). Studies that have explored the influence of parents on children's interest in and attitude toward computing conclude that fathers are more likely to buy computers and to provide support on how to use the machines for their sons; girls rarely receive such things and support from either parent (Barker & Aspray, 2006). Girls who pursue education and careers in IT tend to be those who received support from their parents. In a study by Virginia Tech on high school and college women who were pursuing Computer Technology careers, the majority of the participants indicated that their parents, especially their mothers, played a key role in their Computer Technology career choice (The Office of the Vice President for Research, 2006).

(5) Students' relationships with teachers

In the classroom, teachers communicate their attitudes and beliefs about computer technology and appropriate sex roles for males and females to their students through verbal and non-verbal interactions. For instance, boys are considered by their teachers to be more competent in computing than girls. Consequently, in mixed-gender classes such as computing, science, and mathematics, teachers subconsciously give more support and encouragement to boys than they do to girls. Such attitudes and perceptions of teachers can negatively influence girls' decisions to study computing (Barker & Aspray, 2006).

(6) The impact of computing experience

The stage in life by which children are exposed to computers can influence their attitudes, confidence and interests toward Computer Technology fields. For instance, children who are provided with early access to computers are more likely to pursue computer-related courses (Zarrett et al., 2006). According to Cohoon and Aspray (2006), pre-college experience with computing has to do with a student's experience with computing classes, computer games, and applications - areas we have already seen in which girls are at a disadvantage. Barker and Aspray (2006) also maintain that there is a positive correlation between a girl's experience with a computer and her attitude towards it: an assertion further confirmed by a team of researchers at Virginia Tech in a study on women in Information Technology careers. They found that women who pursue careers in IT are mostly women who were exposed to computers at a very young age and learned to use computers for various communication purposes (The Office of the Vice President for Research, 2006). In another study of ninth-grade German students, the researchers noted that girls who were given laptops were inclined to learn more about computer software, hardware and the Internet and also used computers at home and school more than those who were not given laptops (Barker & Aspray, 2006). However, compared to males, females often lack the prerequisite computing experience relevant for college Information Technology academic programs, and as a result of this, they often lack confidence and tend to give up on Information Technology academic programs at higher rates than their male counterparts (Barker, Snow, Garvin Doxas, & Weston, 2006; Cohoon & Aspray, 2006). Of course, some of these factors may be different now with more prevalent use of Internet in the home. Average daily computer use by children between the ages of 8 and 18 has more than doubled from 1999 to 2009 from an average of 58 minutes to 2 hours and 17 minutes, and the percentage of those who use the computer has increased from just under half to almost two-thirds of children in that age range (Kaiser Family Foundation, 2010). As many as 93% of children in the United States now have a computer at home, and 84% have Internet access (Kaiser Family Foundation, 2010). This is true in other countries as well. In Spain for example, most young people own personal computers and start to use computers and the Internet more often at home from an early age than they do at school (Sainz,2011). At the same time, recent research points out that parents still believe technology-related careers are more appropriate for boys than girls (Archer,

2013), which suggests that the exposure to technology in the home may still be likely to be different for girls than for boys. And there is further evidence of a gender gap in daily computer use as girls enter their teen years. Boys between the ages of 8 and 18 spend an average of 15 minutes more per day on computers than girls of the same age; by the time they are between 15 and 18 this gap has risen to 42 minutes per day (Kaiser Family Foundation, 2010). The disparity appears to be attributable primarily to a decrease in the time girls spend playing video games over this time (Kaiser Family Foundation, 2010), which is further evidence as to why it is critical to get more women into the computer game industry.

FACTORS WHY WOMEN CHANGED SPECIALIZATION FROM SCIENCE-BASED TO NON-SCIENCE BASED AMONG MALAYSIAN EDUCATED WOMEN

In an online study conducted on 268 Malaysian women who took a degree in pure science, technical and Information and Communications Technology (ICT) who are classified as graduates from the science field, more than a third of respondents have changed to other areas of their specialization (Suhaida, Nurulhuda, and Su Fei Yap 2015). A total of 109 women (40.7%) of respondents majored in pure science, 92 women (34.3%) in technical while 67 women (25.0%) majored in ICT. As reflected in the racial composition of Malaysia, the respondents were dominated by the Bumiputeras which comprised 86.6%. The majority of respondents consist of those between the age of 25 to 34 years (94.8%) and those who are married (60.1%) (Suhaida et al., 2015). In order to find out whether the respondents change their specialization while working, they were asked whether their current career was in parallel with their field of study. To further confirm their answer, the respondents were also asked to state the name of their career. The study reveals that 36.9% of graduates from science field commented that they do not consistently work in the same field of their studies. Among those in the science-based field, the largest number of respondents who have changed to other fields when working are the Pure Science graduates (Suhaida et al., 2015). Suhaida, Nurulhuda and Su (2015) study reveals their main finding that many of the women were indeed trained in science-base have changed their field when they enter the working world. 18.2% of the women who had changed to other field when working feel that their personalities are not in accordance with their chosen field of study. 21.2% of those who have changed their fields disagree that the field of study chosen has bright career prospects for them. With the implication of exchanging fields, 28.3% were found facing difficulties in managing their work (Suhaida et al., 2015). 40.4% of the women who had changed to the other fields had difficulties in finding a job. In the study, the data shows that those who remain in the same field of study and work only 55% of the women commented that they have an advantage of worthwhile earnings compared to those who have changed to another field of career. 37.4% of those who have changed their field of study agree that the income they

receive is more worthwhile. 83.4% of the women in the science and technical that remain in the same field stated that they have no problem in expanding their careers as compared to those who have changed field, only 45.5% said that they have no problem; however, the other 26.3% indicated difficulties in expanding their careers in the future (Suhaida et al., 2015).

Suhaida, Nurulhuda and Su (2015) suggested that from their study changing of specialization of study still occur eventhough the women graduates have solid interests in science and technology and that they are confident of a bright future for their careers. This means that interest of the respondent and confidence about the future of their areas is not enough to sustain them in the chosen field of specialization (Suhaida et al., 2015). The study also found that graduates in science who change into another field face a difficult situation to find a job and earn a salary that is worthy of their qualification. This is certainly related to the change of field which created difficulties in finding a job and having to compete with those existing job seekers in the market. Their skills in science and technical fields probably are not required by the employer and lack of knowledge in the field of arts will impact them in the form of a lower salary than what they actually deserve (Suhaida et al., 2015).

CONCLUSION

As the Malaysian government is trying various measures to increase enrolment to 60% of students in science, many of those who are indeed in science dropped out from the field (as the finding shows in Suhaida et al. 2015). It is also seen from data and other studies that many Malaysian women graduates who were educated in science change to the field of education or join the government service. In their difficulty to secure jobs that commensurate with their education degrees, they settle for lower positions with low salary and perks. What is of concern to Malaysia is that while the government is trying all efforts and putting all measures to realize the goal to achieve a 60% of Malaysian graduates in science and technology by 2020, with the pipeline leakages and changing of field of study among the women, the country is going to have a great deal of challenge to see this dream come to a reality. According to Ministry of Education statistics from 1981 to 2010, the percentage of high school students in the sciences has never reached the targeted ratio of 60:40 (Phang et al., 2012). The main problem is the participation of students in science and technology is not encouraging enough (Phang et al., 2012) and this issue is also common in other developing countries (Harris & Farrell, 2007; Noaillya et al., 2011). According to Phang et al. (2012), the Malaysian government has enacted the existing policy and introduced a range of policies and educational plans and taken a variety of approaches to overcome the shortage of students in science. However, the target is still unreachable. Many have asked if this goal of 60:40 is realistic and achievable. Therefore, it is suggested that we need more research be carried out to identify the reasons as to why Malaysian women have changed their field of specialization.

This is because it is seen as a big loss to the nation as the country is losing all the talents in science and technology which is critical in bringing about innovation and modernization to the people and nation.

When entering higher education, women constitute the majority in many countries, and yet it seems that at each consecutive stage, from graduation to PhD to full professorships, more and more women prefer to drop out (Müller, Castaño, González, & Palmén, 2011). Furthermore, when starting to work, most females have jobs not related to their qualifications. As a result, they cannot utilize their abilities and education properly (Chaudhry & Jabeen, 2010). The main worry is that those women would have spent at least five years of their lives being enrolled in tertiary level within their specialized field, cannot fit in with their own life expectations, facing direct consequences in terms of individual well-being and life circumstances besides a loss of transferability of skills (Mora, 2010). From these studies, we can see that the finding found in Suhaida et al. (2015) is consistent with theirs. This is a world phenomenon among women. Hence, the Malaysian government should place a greater emphasis and focus in this concern and find real solutions in preventing the leakage and the switching of fields among women graduates in science and technology fields. More universities and researchers are also encouraged to conduct frequent and deeper studies on this and collaborate with the government in addressing this critical issue.

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WOMEN OF METTLE: THEIR INVENTIONS WERE PATENTED

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Abstract

Historians have given us a picture of women inventors in the 19th century as a group that faced and often overcame significant hurdles to achieve their goals. Their one common bond is an innate curiosity that spurs them on to find something new, something better. Today, only about 10% of all patents are awarded to women. Much of the history of contemporary women inventors remains to be written. Hopefully, as we learn more about these creative women, their stories will inspire future generations of women inventors. Eleven remarkable women are profiled in this collection of short, anecdotal biographies demonstrating that necessity, ingenuity and luck all play a part in successful inventions. Women inventors are still outpaced by their male counterparts but the number and impact of these innovators is growing and they stand on the shoulders of the trailblazers whose stories are told here. Throughout the 20th century and now into the 21st, famous women inventors have played a vital role in the world of innovation. In fact, women have become increasingly prevalent in the field and are responsible for many momentous advances. Because female inventors are under-recognized for their accomplishments, this article features short biographies of these famous women including what they invented and how they conceived the idea.

INTRODUCTION

Although growing in numbers, today's female inventors still only account for around 10% of the US Inventor Population. In 1980, only 1.7% of all the patent filings were filed by women. The first U.S. patent was issued in 1809 to Mary Dixon Kies, a Connecticut native who invented a process for weaving straw with silk or thread. First Lady Dolley Madison publicly thanked her for boosting the nation's hat industry.

Unfortunately, this historic patent was destroyed in the great Patent Office fire in 1836. Until about 1840, only 20 other patents were issued to women, all related to apparels, tools, cooking stoves, and fire places. From 1855 to 1865, women received an average of 10.1 patents per year while their male counterparts received 3,767.4 patents. During the next decade, from 1865 to 1875 the number of women-issued patents increased to 67.3 compared to men's 11,918.4 patents.

By 1910, the number of patents by women was still only 8,596, just 0.8 per cent of the total patents issued in the United States. The reasons behind this tend to fall into four broad categories: legal, economic, social, and education. Legal rights of married women in the early-nineteenth century were virtually non-existent. Along with women not being able to vote, many women in the past were not allowed equal rights of property ownership. Patents are a form of intellectual property and for this reason many women patented their inventions under their husband's or father's names.

A number of historians point to married women's inability to control their own property as both a deterrent to invention by women and a distortion of the true numbers. One very early example is Sybilla Masters, the first female inventor in recorded history, who invented a way for cleaning and curing the Indian corn crops that the colonist in early America received as a gift from the native people. Sybilla Masters's innovation allowed the corn to be processed into many different food and cloth products. The patent was issued in her husband Thomas' name by the British courts in 1715. Women and minorities at that time had no rights to own patents.

While legal status may have slowed the number of inventions by women, economic considerations encouraged it. Prospects for making money were a big drive for women in the late 1800s. History tells us that 75% of the patents issued to women between 1895 and 1900 were profitable. Profits were part of the motivation for Beulah Henry of Memphis who created about 110 inventions and held 49 patents. Beulah Henry was considered as one of the "Lady Edisons" for her prolific career in inventing. Some of her inventions included the vacuum ice cream freezer (1912), an umbrella with a variety different colored snap-on cloth covers (1924), the first bobbinless sewing machine (1940), "Protograph" - worked with a manual typewriter to make four copies of a document (1932), "Continuously-attached Envelopes" for mass mailings (1952), "Dolly Dips" soap-filled sponges for children (1929), "Miss Illusion" doll with eyes that could change color and close (1935).

The social appeal for women to become inventors at that time was best expressed when Scientific American tried to assure them "that there was nothing inherently unladylike about the process of invention. Like novel writing, it could be done in the parlor at home and did not require traffic in the factory or marketplace." The social environment for women inventors began to change with the 1876 Philadelphia Centennial Exposition, a World Fair-like event held to celebrate the progress of

the century-old United States. The leaders of early feminist and women's suffrage movements aggressively lobbied for the inclusion of a woman's showcase in the exposition. As a result, the Centennial Women's Executive Committee was established and a separate Woman's Pavilion was erected. Scores of women inventors either with patents or with patents pending displayed their inventions.

WOMEN'S INVENTIONS THAT CHANGED THE WORLD

Mary Anderson Inventor of Windshield Wipers

As a woman from the South where cars were not all that common at the turn of the 20th century, Mary Anderson was hardly a likely candidate to invent the windshield wiper especially considering she filed her patent before Henry Ford even started manufacturing cars. And unfortunately, Anderson failed to reap financial benefits from her invention during her lifetime. Aside from the date and location of her birth (1866 in Alabama), Anderson's life was largely unknown until around 1889 when she helped built the Fairmont Apartments in Birmingham on Highland Avenue. Around 1900, it is said that Anderson came into a large inheritance from an aunt. Eager to make exciting use of the money, she took a trip to New York City during the thick of winter in 1903. It was during this trip that the inspiration struck her. While riding a streetcar during a particularly snowy day, Anderson observed the agitated and uncomfortable behavior of the vehicle's cold driver, who had to rely on all sorts of tricks like sticking his head out of the window, stopping the vehicle to clean the windshield in order to see where he was driving. Anderson returned to Alabama and in response to the problem she witnessed, drew up a practical solution: a design for a windshield blade that would connect itself to the interior of the car, allowing the driver to operate the windshield wiper from inside the vehicle. For her "window cleaning device for electric cars and other vehicles to remove snow, ice or sleet from the window," Anderson was awarded the U.S. Patent No. 743,801. However, Anderson was unable to get anyone to bite on her idea. All the corporations she approached including a manufacturing firm in Canada had turned her wiper down out of a perceived lack of demand. Many people were initially leery of Anderson's windshield wiper invention, thinking it would distract drivers, but by 1916, windshield wipers were standard on most vehicles. By the time her patent expired in 1920, the prevalence of automobiles (and, therefore, the demand for windshield wipers) had skyrocketed. Over the years, windshield wipers gradually improved. Now computerized, we can adjust them to suit our needs. But Mary Anderson started it all, and we can thank this maverick woman for challenging the men of her time and for making driving safer and more pleasurable for all of us. Following Anderson was also another woman who had invented and patented the first automated windshield wiper in 1917 (Charlotte Bridgwood's "Storm Windshield Cleaner").

Marion Donovan Inventor of Disposable Diapers

Born in Fort Wayne, Indiana in 1917, Marion Donovan was instilled with an inventive spirit at a young age. She spent the greater part of her childhood hanging around the manufacturing plant run by her father and uncle, two men who combined to invent, among other things, an industrial lathe for grinding automobile gears and gun barrels. Years later, as a post-World War II housewife and mother of two in Connecticut, she was frustrated by the thankless, repetitive task of changing her youngest child's soiled cloth diapers, bed sheets and clothing, She decided to craft a diaper cover to keep her baby and the surrounding area dry. She sat down at her sewing machine with a shower curtain and after several attempts, she completed a waterproof diaper cover. Unlike the rubber baby pants that were already on the market, Donovan's design did not cause diaper rash and did not pinch the child's skin. The soon-to-be famous female inventor subsequently perfected her invention, adding snap fasteners in place of the dangerous safety pins that were commonly used. Donovan named her diaper cover the "Boater" and explained that "at the time I thought that it looked like a boat". When no manufacturers would even consider her invention, Donovan struck out on her own and the Boater was a huge success from the day it debuted at Saks Fifth Avenue in 1949. Donovan received a patent in 1951 and promptly sold the rights to Keko Corporation. Her next project was a fully disposable diaper for which she had to fashion a special type of paper that was not only strong and absorbent, but also conveyed water away from the baby's skin. Donovan took her finished product to every large manufacturer in the country but once again she found no takers. Incredulously, everyone she talked to told her that the idea was superfluous and impractical. It was not until nearly a decade later, in 1961, that Victor Mills drew upon Donovan's vision to create Pampers®. In keeping with her innovative heritage, this "mother of invention" explored numerous ventures that were completely unrelated to her diaper improvements. She earned a total of 20 patents in her lifetime and also received an Architecture degree from Yale University in 1958.

Stephanie Louise Kwolek Inventor of Kevlar®

Born in New Kensington, Pennsylvania in 1923, Kwolek was interested in science and medicine as a child. She attended the women's college of what is now Carnegie Mellon University in Pittsburgh, and earned a BS in Chemistry in 1946. She was working as a chemist at the DuPont's Pioneering Research Laboratory Company in Wilmington, Delaware when it opened in 1950. Relying on experience and instinct, in 1965, Stephanie Kwolek invented one of the modern world's most readily recognized and widely used materials stronger than steel fibre known as the Kevlar® which is a lightweight fibre used in bulletproof vests and body armour. It was initially intended to be used in automobile tyres. DuPont put its Pioneering Lab to work in finding a viable commercial version of Kwolek's new crystalline polymers was Kevlar® which was first marketed in 1971. Kevlar® is a fiber five times stronger ounce for ounce than

steel, but about half the density of fiberglass. Kevlar® is best known to the public as the material from which bulletproof vests are made; and in this use alone Kwolek's discovery has saved thousands of lives. In fact, Kevlar® has dozens of important applications, including radial tires and brake pads (a replacement for asbestos), racing sails, fiber optic cable, water, air and spacecraft shells, and mooring and suspension bridge cables. It is now used to make skis, safety helmets and hiking and camping gear. In commercial terms, Kevlar® generates sales of hundreds of millions of dollars per year worldwide. She was a recipient or co-recipient of 17 US patents, including one for the spinning method that made commercial aramid fibers feasible, and 5 for the prototype from which Kevlar® was created.

Maria Telkes Inventor and Innovator of Solar Power

Physicist and solar-power pioneer, Dr Maria Telkes teamed up with a lady architect named Eleanor Raymond, to build the first home entirely heated by solar power in 1947. They used a chemical that crystalized and retained the heat and then radiated it back to keep a constant temperature. The plant used no auxiliary power source but still kept the five-room house in Dover, Massachusetts cozy through the winter. Telkes also developed a solar salt-water still for the Navy in World War II which saved the lives of torpedoed sailors and downed airmen. She spent many years experimenting with stoves that used solar energy for their heat that were simple and cheap enough for use by villagers in poor arid regions. In the 1970's she also worked on an air-conditioning system that stored ''coolness'' at night for use on the next day. The idea was to reduce power demand during hot spells and lower the risk of electrical ''brownouts'' and "blackouts". Born in Budapest, Telkes received a doctorate in physical chemistry at the University of Budapest where she started her career as an instructor. In 1925, she came to the United States to visit a cousin who was then the Hungarian consul in Cleveland. Telkes stayed when the Cleveland Clinic Foundation hired her as a biophysicist. She worked there for 12 years under Dr. George Crile. In a series of experiments, they invented a photoelectric mechanism capable of recording brain waves. Later, she carried out research at the Massachusetts Institute of Technology, New York University and the University of Pennsylvania, among others. She retired in 1977 as a senior scientist at the University of Delaware but remained active as a consultant for many years after that. Telkes was an advocate of putting the sun's energy to use and one of the first researchers to do so in an experimental residence.

Josephine Cochrane (1839 – 1913) Inventor of the Dishwasher

Josephine Cochrane's early childhood is not known. After her mother died and her sister moved out, she lived with her father, John Garis, in Ohio and Indiana. He worked as a supervisor in mills and as a hydraulic engineer, perhaps he had instilled in his daughter an instinctive knack for the mechanical. She attended a private high school but when it was burnt down, Garis sent Josephine off to live with her sister in

Shelbyville, Illinois. After high school graduation, Josephine's life took a traditional turn. At the age of 19, she married 27 year old William Cochran. The Cochrans had a busy social life and in 1870 when they moved into what could be considered a mansion, they had the perfect house for entertaining. They threw dinner parties using heirloom china allegedly dating from the 1600s. After one event, the servants did the washing up and carelessly chipped some of the dishes. She then decided to wash the dishes on her own and that was when the idea to invent a dishwasher struck her. Her husband had an untimely death in 1883 and left her a mound of debt and only $1,535.59. Now, developing the dishwasher was not only for convenience but survival. Cochrane showed her design to a few men for their input which ended up being a frustrating experience. Finally, she got help with the construction from mechanic George Butters and received her first patent on the Garis-Cochran Dish-Washing Machine on December 28, 1886. Cochrane's first customers were not the housewives she thought she was helping as they did not want to spend the money on something they did not really need. Her first client was the Palmer House hotel in Chicago and then the Sherman House hotel in Chicago. In 1893, Cochrane convinced restaurants at the World's Columbian Exposition in Chicago to use her invention and it was an exhibit in Machinery Hall. That success led to her opening her own factory in an abandoned schoolhouse. Her customers extended to hospitals and colleges for whom the sanitizing effects of the hot water rinse were important. Homemakers finally started using it, too. In 1912, at 73 years old, Cochran was still personally selling her machines. She died in 1913. In 1916, her company was bought out by Hobart which became KitchenAid and is now Whirlpool Corporation. Cochrane is considered as the founder.

Randice-Lisa Altschul Inventor of Disposable Cell Phone

In November 1999, Randice-Lisa "Randi" Altschul was issued a series of patents for the world's first disposable cell phone. Trademarked the Phone-Card-Phone®, the device is the thickness of three credit cards and made from recycled paper products. Altschul thought of the invention after being tempted to toss her cell phone out of her car in frustration over a bad connection. She realized cell phones were too expensive to lose or to be thrown away. After clearing the idea with her patent lawyer and making sure no one else had already invented a disposable cell phone, Randi Altschul together with engineer Lee Volte, patented both the disposable cell phone and the super thin technology (STTTM) needed for the Phone-Card-Phone and other intended products. The 2" by 3" cell phone was manufactured by Altschul's Cliffside Park, New Jersey company, Dieceland Technologies. The entire phone body, touch pad and circuit board was made of paper substrate. The paper-thin cell phone uses an elongated flexible circuit which is one piece with the body of the phone, part of the patented STTTM technology. The ultra thin circuitry is made by applying metallic conductive inks to paper. Altschul and Volte have also created a paper laptop computer, which was sold for twenty dollars and serve as an internet access device. The STTTM technology has opened up the potential for creating countless

new electronic products and countless cheaper versions of pre-existing products. If STTTM is all that it seems to be, this technology should be considered a milestone in electronic innovation.

Patricia Bath Inventor of Cataract Laserphaco Probe

Patricia E. Bath, an ophthalmologist and laser scientist, is an innovative research scientist and advocate for blindness prevention, treatment, and cure. Her interest, experience, and research on cataracts lead to her invention of a new device and method to remove cataracts—the laserphaco probe. When she first conceived of the device in 1981, her idea was more advanced than the technology available at the time. It took her nearly five years to complete the research and testing needed to make it work and apply for a patent. The Cataract Laserphaco Probe was patented in 1988. It uses the power of a laser to quickly and painlessly vaporize cataracts from patients' eyes, replacing the more common method of using a grinding, drill-like device to remove the afflictions. Patricia Bath also holds patents for her invention in Japan, Canada, and Europe. Today the device is being used worldwide. She received her medical degree from Howard University College of Medicine in Washington, D.C., interned at Harlem Hospital from 1968 to 1969, and completed a fellowship in ophthalmology at Columbia University from 1969 to 1970. As a young intern shuttling between Harlem Hospital and Columbia University, Bath observed that at the eye clinic in Harlem, half the patients were blind or visually impaired. At the eye clinic at Columbia, by contrast, there were very few obviously blind patients. This observation led her to conduct a retrospective epidemiological study, which documented that blindness among blacks was double that among whites. She reached the conclusion that the high prevalence of blindness among blacks was due to lack of access of ophthalmic care. As a result, she proposed a new discipline, known as community ophthalmology, which is now operative worldwide. Community ophthalmology combines aspects of public health, community medicine and clinical ophthalmology to offer primary care to underserved populations. This outreach has saved the sight of thousands whose problems would otherwise have gone undiagnosed and untreated. Bath was also instrumental in bringing ophthalmic surgical services to Harlem Hospital's Eye Clinic, which did not perform eye surgery in 1968. She persuaded her professors at Columbia to operate on blind patients for free and she volunteered as an assistant surgeon. The first major eye operation at Harlem Hospital was performed in 1970 as a result of her efforts. Sexism, racism, and relative poverty were the obstacles which she faced as a young girl growing up in Harlem. There were no women physicians and surgery was a male-dominated profession. There were no high schools existed in Harlem which is a predominantly black community. Additionally, blacks were excluded from numerous medical schools and medical societies. And her family did not possess the funds to send her to medical school. In 1975, when she became the first woman faculty member in the Department of Ophthalmology at UCLA's Jules Stein Eye Institute, she was offered an office "in the basement next to the animals lab." Despite university policies extolling equality and condemning

discrimination, Professor Bath experienced numerous instances of sexism and racism throughout her tenure at both UCLA and Drew. Determined that her research not be obstructed by the "glass ceilings," she took her research abroad to Europe. Free at last from the toxic constraints of sexism and racism, her research was accepted on its merits at the Laser Medical Center of Berlin, West Germany, the Rothschild Eye Institute of Paris, France, and the Loughborough Institute of Technology, England. At those institutions she achieved her "personal best" in research and laser science, the fruits of which are evidenced by her laser patents on eye surgery. In 1977, she and three other colleagues founded the American Institute for the Prevention of Blindness, an organization whose mission is to protect, preserve, and restore the gift of sight. Her "personal best moment" occurred on a humanitarian mission to North Africa, when she restored the sight of a woman who had been blind for thirty years by implanting a keratoprosthesis.

Rachel Fuller Brown and Elizabeth Lee Hazen Inventor of the World's First Useful Antifungal Antibiotic Nystatin

With Elizabeth Lee Hazen, Brown (1898-1980) developed the first effective antibiotic called nystatin against fungal disease in humans—the most important biomedical breakthrough since the discovery of penicillin two decades earlier. The drug, patented in 1957, has cured sufferers of life-threatening fungal infections, vaginal yeast infections, and athlete's foot. It is also used to cure many disfiguring, disabling fungal infections as well as to balance the effect of many antibacterial drugs. In addition to human ailments, the drug has been used to treat such problems as Dutch Elm's disease and to restore water-damaged artwork from the effects of mold. The two scientists donated the royalties from their invention, over $13 million dollars, to the nonprofit Research Corporation for the advancement of academic scientific study. Brown took a job as an assistant chemist at the Division of Laboratories and Research of the New York State Department of Health in Albany, New York. In 1948, she embarked on the project with Hazen, a leading authority on fungus, that would bring them their greatest acclaim: the discovery of an antibiotic to fight fungal infections. Penicillin had been discovered in 1928, and in the ensuing years antibiotics were increasingly used to fight bacterial illnesses. One side effect, however, was the rapid growth of fungus that could lead to sore mouths or upset stomachs. Other fungal diseases without cures included infections attacking the central nervous system, athlete's foot, and ring-worm. In 1950, Brown and Hazen announced at a meeting of the National Academy of Sciences that they had found a new antifungal agent. They patented it through the non-profit Research Corporation, naming it "nystatin" in honor of the New York State Division of Laboratories and Research. The license for the patent was issued to E. R. Squibb and Sons, which developed a safe and effective method of mass production. The product—called Mycostatin—became available in tablet form in 1954 to patients suffering from candidiasis. Nystatin has also proved to be valuable in agricultural and livestock applications, and has even been used

to restore valuable works of art. In 1951, the Department of Health laboratories promoted Brown to associate biochemist. Brown and Hazen, in continuing their research, discovered two additional antibiotics, phalamycin and capacidin. In 1975, Brown and Hazen became the first women to receive the Chemical Pioneer Award from the American Institute of Chemists.

Gertrude Elion Inventor of Leukemia-Fighting Drug

In 1954, Gertrude Elion patented the leukemia-fighting drug 6-mercaptopurine and has made a number of significant contributions to the medical field. Dr. Gertrude Elion's research led to the development of Imuran, a drug that aids the body in accepting transplanted organs, and Zovirax, a drug used to fight herpes. Including 6-mercaptopurine, Elion's name is attached to some 45 patents. In 1988, she was awarded the Nobel Prize in Medicine with George Hitchings and Sir James Black. She was inducted into the National Inventors Hall of Fame in 1991 and continued to be an advocate for medical and scientific advancement until her death in February of 1999. The child of Lithuanian and Polish immigrants, Gertrude Elion decided to become involved in cancer research after losing her grandfather to cancer when she was 15 years old. At age 19, she graduated with the highest undergraduate honors in chemistry from Hunter College. However, 15 institutes rejected her application for graduate school because of the unfair discrimination towards women in the sciences that existed at that time. Elion was forced to work as an unpaid lab assistant in order to have the opportunity to further her research in science. In 1944, Burroughs Wellcome, a pharmaceutical company, hired Gertrude Elion to work with nucleic acids. During her 39-year career there, Gertrude Elion made most of her scientific advances, including the development of 6-mercaplopurine used in chemotherapy to treat children with leukemia that had won her the Nobel Prize.

Ann Tsukamoto Co-inventor of a process to isolate the human stem cells

Ann Tsukamoto is the co-patentee of a process to isolate the human stem cells that had secured her a patent in 1991. Stem cells are located in the bone marrow and serve as the foundation for the growth of red and white blood cells. Understanding how stem cells grow or how they might be artificially reproduced is vital to cancer research. Ann Tsukamoto's work has led to great advancements in comprehending the blood systems of cancer patients and may one day lead to a cure for the disease. In 1998 Tsukamoto joined StemCells, Inc. as the first of a world-class team of researchers focused on the discovery and development of major human stem cells, including the neural, liver and pancreatic stem cells. Under her direction as the Company's Executive Vice President of Research and Development from September 2008 to June 2013, the Company identified and purified the human neural stem cells and populations of human liver and pancreatic cells with stem cell-like properties; successfully transitioned into clinical translation; and initiated and completed its first

human clinical trials. Her scientific team has discovered the human central nervous system stem cell and has initiated and completed early clinical studies with these cells. Before joining StemCells Inc, Tsukamoto was a co-discoverer of the human hematopoietic stem cell while at SyStemix, Inc. (1989 – 1997), a stem cell and gene therapy company. She co-discovered the human hematopoietic stem cell and played a leading role in the launch of the clinical research program for this cell. In 2013, she was appointed Executive Vice President for Scientific and Strategic Alliances after serving as the Company's EVP, Research & Development. She received her Ph.D. in Microbiology & Immunology at University of California, Los Angeles and did her postdoctoral work with Dr. Harold Varmus at the University of California, San Francisco, where she worked on the wnt-1 gene, a key player in the stem cell self-renewal pathway. Ann Tsukamoto has been working in the stem cell field for more than 25 years. She is an inventor on seven issued U.S. Patents of which six are related to the human hematopoietic stem cell.

CONCLUSION

Historical studies have shown that the rate of female patenting from 1637 to the mid-20th century failed to exceed 2% of total patenting. Contemporary studies suggest that women may continue to be under-represented; however, studies on rates of female patenting are largely mono-disciplinary, localized, and lack explicit connections to the types of settings where the patenting is conducted. Women contributed less than 8% of all inventorships for the entire period (1976–2013) and contributed 10.8% in the most recent year (2013); an increase from 2.7% in 1976. Male dominance in patenting is found in nearly every country, with 42 countries listing no female inventors. These results demonstrate that women's patenting remains lower than would be predicted given their representation in science, technology, engineering, and mathematics fields and professions. Patenting, of course, does not encompass the entire spectrum of innovative activities. However, women seem to be at a disadvantage across this spectrum. While they might be included on publications related to the patent, women's names disappear between the article about the patent and the patent itself and even fewer women see the commercialization and licensing of their patents.

The number of patents issued to women did increase beginning with changes in the mid-century property-rights laws. Beyond the women represented on the patent rolls, however, are scores and scores who never undertook the formal process of patenting an invention. These women are very difficult to document and, unfortunately, many of their stories are lost to us. As the 19th century continued, prospects for women inventors brightened up. The 1876 Centennial Exposition in Philadelphia and the 1893 Columbian Exposition in Chicago both had women's buildings that featured exhibitions of inventions by women. Many women inventors, however, were successful financially. Warner stated that 75% of the patents issued to women between 1895

and 1900 were turning a profit. Olive Gunby, writing for the *Scientific American Supplement* in 1901, agreed: "Men acquainted with the field say that fully one hundred of the patents taken out by women within the past five years are yielding unusually large returns to the inventors, and that others not yet put on the market are destined to be equally successful."

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FACTORS WHY WOMEN IN MENA COUNTRIES ARE UNDER-REPRESENTED IN STEM FIELDS

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Abstract

This paper explores into the factors that deter women in science, technology, engineering and mathematics (STEM) from participating in the economic sector of Middle East and Northern Africa (MENA) countries. In spite of more women students pursuing STEM education all over the MENA region now, unfortunately this large increase is not being reflected in the workforce. Leakages are happening everywhere due to various factors, mostly cultural and social norms, as well as work environment and unfavorable legislation. As MENA countries are an oil-producing region, most of the career opportunities are in the STEM areas. Women, by nature of the Arab culture and social norms, fall out of their career in the STEM fields as early as in their 20s. This fall out from the workforce is damaging to the overall human and economic development of the whole MENA region. This paper suggests some of the measures that can be considered to attract more women into STEM education and to choose their careers in STEM fields. More importantly, is to encourage and retain these women in the workforce and subsequently to rise up to the middle and high level in their career.

Keywords: *MENA, STEM, Arab culture, social norms, STEM education*

INTRODUCTION

Most of the world's poor which is over 1 billion people, are women and children. And women make up a large portion of any nation's human resources, providing a rich

potential supply of talented scientists and innovators. Science's role in improving quality of life is now more prominent than ever. And according to the UN Education, Scientific and Cultural Organization (UNESCO), women's active inclusion and participation in science is crucial in countries' efforts to alleviate poverty. Encouraging women to take part in science would allow any country to maximise its valuable human assets, empower its women, and improve its economic prospects.

The Middle East and North Africa (MENA) region has witnessed positive growth over the past one decade, essentially fuelled by the government's willingness to migrate from energy-based economies to knowledge-based. It is, therefore, very important to acknowledge that if more women are encouraged and allowed to play a bigger and active role in science, technology, engineering and mathematics (STEM) fields, MENA region will be able to sustain its long-term economic and social activities for its people.

EDUCATION IN STEM

Although the number of women representation in STEM education is still very small globally, but the Arab Middle Eastern countries are witnessing a more positive trend. Women enrolment in STEM-based education in countries such as the US and UK have experienced a decline over the last few years, while it has comparatively increased in the Arab region. A report published by the *ICEF Monitor*, a dedicated market intelligence resource for the international education industry had earlier stated: "The Middle East continues to see dramatic growth in education capacity, driven especially by booming population growth and burgeoning demand for tertiary education by women. Aside from simply keeping up with demand, it seems clear that these significant new investments are being made with a larger purpose. Scientific research and innovation in the region and increasing education in applied sciences, research, and technology in particular, are seen as an important drive of social and economic development."

According to a report on *Accelerating Growth: Women in Science and Technology in the Arab Middle East by the Economist Intelligence Unit:* "In Palestine, 56% of undergraduate enrolments in 2010 were women, compared to 47% a decade earlier. This is especially pronounced in science: in Saudi Arabia, 73% of all enrolments in science degrees in 2010 were women, versus 40% a decade earlier. Sadly, this rising number of Arab women graduating in science is not, however, translating into more women scientists in the workplace. Women account for just 1% of researchers in Saudi Arabia, 19% in Palestine and 22% in Libya, markedly lower than the world's average of 30%. And despite their high proportions in undergraduate places, many do not pursue postgraduate research. Women make up just 34% of participants in science masters courses in Saudi Arabia, and 29% in PhD programmes."

In Kuwait, Qatar, and the United Arab Emirates, nearly two thirds of all university students are women. For example, at the prestigious *Masdar Institute of Science and Technology* in Abu Dhabi, 60% of Emirati graduate students are female. Likewise, 56% of the UAE's federal university graduates in science, technology, engineering and mathematics are women. More importantly, most of these women also have aspirations of becoming the next generations' leaders. Women are making an especially strong showing in science, technology, environmental, and mathematics areas in those countries now. According to the *2013 Global Gender Gap Report,* the UAE is the only Arab country in the MENA region that has fully closed the educational attainment gender gap. Today, 91% of Emirati women are literate, with a significantly higher number of women in secondary and tertiary education. In a region where gender inequality rates are amongst the highest in the world on many levels, UAE female students outnumber their male counterparts, where nearly half the pupils registered in over the 1,250 schools across the country are girls.

Quite surprisingly, statistics at the tertiary level are even more impressive, discrediting many of the stereotypes about the local culture. Emirati women constitute 77% of total university students, the highest percentage of women in higher education in the world, which is also the biggest pride and achievement of the government in the field of education today. In fact, in a country that is still believed to abide by the traditional gender roles and the predominant social norms of the region, women also outperform their male counterparts academically and are leading the way in faculties that were previously considered to be an exclusively a male domain.

CAREERS IN RESEARCH AREAS OF STEM

The fields of science, technology, engineering and mathematics have historically been dominated by men. In the US, 17% of chemical engineers and 22% of environmental scientists are women. On an international scale, women who choose to pursue vocational or educational careers in these areas are hindered by a common set of disadvantages: a shortage of mentors, a lack of acceptance from co-workers and supervisors, and sexual discrimination within the workplace. Despite these obstacles, many Middle Eastern women surpass not only their male colleagues but also female scientists in Germany and the United Kingdom in receiving science degrees. UNESCO defines female researchers as "a percentage of the total number" of researchers; this number includes part-time and full-time researchers. According to UNESCO (2013), the total percentage of female researchers in Germany is 24.9% and 37.9% in the United Kingdom. These percentages are either lower than or very close to their North African counterparts. In Tunisia, female scientists constitute 47.4% of all science researchers, in Egypt 35.2%, in Sudan 40%, and in Algeria, 34.8%. Women in these countries make up a total of one-third of researchers in all science fields. In Morocco, 70% of students enrolled in science programs at university level are women.

A survey conducted by McKinsey & Company (2013) examined universities which were most likely to attract high-achieving women to pursue degrees in STEM fields found that 37% of high-performing Moroccan women were likely to pursue STEM degrees which surpassed the 4% of women in the United States. In Algeria, 52% of students studying science are women. Algerian women surpass their male counterparts in the fields of science and medicine. In Tunisia, female graduate students represent three-quarters of students pursuing degrees in life sciences. Tunisian women are just as likely as men to pursue degrees in the physical sciences, with 51% of women pursuing such degrees.

Each year, fifteen international scientists are chosen for the annual L'Oreal-UNESCO award for Women in Science. In 2014, three were Arabs and two were from North Africa. Adila Elobeid from Sudan received recognition for her work in neuropathy and Farah Ouechtati from Tunisia for her work in neuroscience. Since 2010, the U.S. Department of State's annual *"Women in Science Hall of Fame"* has honored women scientists throughout the Middle East and North Africa who have made outstanding contributions to their fields. Between 2010 and 2013, eight out of the thirty-seven female scientists being honored were from the North African countries of Morocco, Tunisia, and Egypt.

On the good note, according to a Minnesota State Colleges and Universities Career and Education Resource (2015) said that not all the STEM fields are dominated by men worldwide. Many people believe that all STEM jobs are dominated by men. While not all STEM fields have an equal mix of men and women, some have a higher percentage of women than most people assume such as in the following areas:

- 37% are women database administrators
- 46% are women Biological scientists
- 78% are women clinical laboratory technologists
- 91% are women registered nurses

MAJOR OBSTACLES FACED BY MENA WOMEN IN STEM

The following will discuss some of the biggest contributing factors to the under-representation of women in the STEM fields in the MENA region.

(1) ***Culture and Social Norms***

Cultural barriers and social norms continue to remain as one of the most challenging factors that contribute to reinforce the gender gap, thus constraining women's economic participation in the STEM fields. First and foremost, it is the persistence of the traditional gender stereotype that contributes to the reproduction of inequality in the society. Highly resistant norms and perspectives still give women the primacy in reproduction and familial roles. Women's labor participation in the MENA reaches

its peak earlier than in other regions of the world, with the peak occurring between the ages of 20 and 24, after which it starts to decrease. Hence, with the peak corresponding roughly to the age of marriage and early childbearing, this implies that marriage in the region entails other kind of responsibilities, which oblige women to renounce their jobs. For the MENA women, within the traditional model of marriage, men are defined as the breadwinners and women as the homemakers; thereby setting a priority for domestic and reproductive roles for women, which severely limits their post-marriage employment and career growth prospects.

Mothers in the MENA culture have the tendency to tell girls not to bother too much with their studies as they will end up cleaning the house. Women are often raised to put their career prospects at the bottom of their priorities. Marriage, husband and children come first than their education and an extremely demanding scientific career does not always go well with the rest of their commitments. For a long time, science is considered as an exclusive, gentlemen profession until the inception of the feminist movement, which opened the way for more women to access scientific careers. Although the situation is marginally better today, women still need to fight much harder than men to win recognition and they often lack the confidence to do so. The poor quality of research labs in the Middle East do not help either, often hampering a graduate's ability to shine. Families are also reluctant to allow women to travel alone to work in better facilities abroad.

The societies have long imposed unhelpful gender stereotypes by differentiating between what is expected of boys and girls–that boys get education and training because they are expected to provide a family's income and future economic stability. Girls, on the other hand, are brought up to become good wives, mothers and housekeepers. To this day, in some cultures, misconceptions about girls' capabilities in science are still abound. Girls who are lucky enough to be in primary and secondary education are often discouraged from pursuing technical or mathematics-based fields. They are being steered by well-meaning parents and advisors towards non-science fields instead. These traditional definitions of women's roles in society and false myths of girls' intrinsic unsuitability for science have been fostered and passed down through generations. While they may be easy to disprove scientifically, they will not be so easy or quick to remove from entrenched cultural attitudes.

The laws also play a key role in tackling the issues of women's under-representation in the STEM fields. Today, women's economic opportunities in the MENA region are seriously constrained by the presence of gender-specific mandates establishing categories of gender-appropriate and inappropriate professions. It is also important to focus on the role people themselves can play in the process by their adherence and capability to question their own attitudes and mentalities as having to do with whether the general societal norms in MENA region will tolerate their women to work outside the home. Without the women's contribution, there can be no change or development in the Arab and Northern African countries. Hence, women also need to stand up for

their own rights and denounce the many sources of their everyday exploitation and ultimately claim their due to fight the gender imbalance in the science community.

(2) ***Discrimination***

As in the case of Egypt, even though more than half of the scientists are female, private companies, especially in the petroleum industry, do not hire women. They deem women as unsuitable for the job which often involves travelling to rough areas in the desert, in addition to the other "*issues"* women face, namely marriage and children. During and after her pregnancy, a woman cannot honour her responsibilities effectively towards her company. One of the main factors behind the low female participation rates in MENA is the institutional structure of the MENA labor market today. The structural adjustment in the MENA region has, in general, resulted in a de-feminization of the private sector. Due to this, MENA women workers are mostly concentrated in the public sector. As a matter of fact, 82% of the total workers in the public sector in Algeria today are women, 52% in Jordan and 58% in Egypt. In the ministries for example, they do not ruminate between sexes as they work to provide better work environment, facilities and salaries for all their scientists. Women in STEM fields working for the public sector are offered equal opportunities in terms of scholarship possibilities or attendance to international conferences. However, the public sector's poor future growth prospects means women are the first to suffer from the situation, putting them in a marginal and vulnerable position. Lack of protection for women at work and harassment are among the factors that keep women out of the workplace too.

But things are not as bleak everywhere in the Arab world as Oman is an exception case. Female scientists in Oman have the same opportunities as men to embrace a career in science. Women are given a three-month paid maternity leave in the public sector and can enjoy flexible shifts. There is no rumination at the hiring process. Men and women scientists have the same salary which is strictly based on their level of education, where this may not be the case in many Western countries.

According to the UNESCO report (2014), 59% of women in the workforce feel they are treated fairly and receive equal opportunity to their male counterparts, compared to only 24% feeling a biasness against them. However, over 40% feel they stand a lower chance of getting promoted in their work than their male counterparts.

(3) ***Career Barriers and Struggles***

According to a report by the Economist Intelligence Unit (EIU) *UAE Economic Vision: Women in Science, Technology and Engineering (STE)*, women account for 50.7% of graduates in STE and mathematics-related courses across all institutions, and 56.8% in government universities in the 2011-2012 academic year. The report showed that among those studying STE and mathematics (STEM), and wanting to stay in STE in the UAE, the energy sector was the second most attractive industry to work in (17%) after green technology (22%). However both professional and cultural barriers

continue to prevent women from making a smooth transition from university into the workforce. The very nature of MENA economies and the specialization of MENA markets contribute to hinder female labor supply in the STEM fields because most of the MENA region's economies are oil-based and, therefore, only offer a few jobs which tend to target men. Out of the twelve member countries in the *Organization of the Petroleum Exporting Countries* (OPEC), eight are MENA countries, notably Libya, Algeria, Saudi Arabia, UAE, Iraq, Iran, Kuwait and Qatar. Ultimately, MENA women today are also discriminated against – when it comes to market hiring preferences where male and female-owned firms in the region tend to hire, on average, far fewer women in comparison to world's averages. According to the same EIU report, 60% of STEM respondents with experience working in an STE environment believe that female employees face obstacles when trying to manage work-life balance and 66% of STEM respondents see cultural issues as a barrier to women in those fields.

Once a MENA woman scientist does manage to hurdle the obstacles and successfully finishes her first or advanced degree, new barriers emerge. Since this phase in a scientist's career often coincides with a woman's childbearing years, it introduces a difficult dilemma between conforming to work expectations in order to advance in her career, that is competing for a tenure-track position, for example, and focusing on long-term personal relationships and family responsibilities.

Another potential obstacle is gender discrimination in various aspects of science careers and employment, such as job interviews, peer review processes in publications, grant award and funding selection, competition for fellowships and job promotions. Whether such discrimination exists and how far it goes has been hotly debated over and over in recent years, mostly in the West. But what is not challenged in those debates is that women in science generally receive less pay for equal work, compared with their equally-qualified male colleagues. Also they are less likely to be promoted, hence women are consistently found in the lower tiers of the scientific career ladder.

Career review processes tend to overlook gendered productivity or publication patterns. For instance, research suggests that generally, women write more comprehensive and concise journal papers than their male counterparts, resulting in fewer, but more widely-cited, publications. The low numbers of women in senior research positions could be explained by a wide range of factors, including the struggle to maintain a healthy work-life balance, gendered criteria for performance measurement and promotion, and inflexible policies in research institutions. Clearly, if an academic institution's career progression system is better suited to men, involving long work hours, limited family responsibility outside work, emphasis on early accomplishments, and being identified as a scientist to the exclusion of other roles, then it is only to be expected that women will not advance as quickly as their male colleagues. But in many parts of the world, not just in MENA region, it is still rare to

find women working in scientific fields. It is also rare to find female researchers, those that continue to actively practise science after obtaining higher education degrees.

In Jordan, Syria and Lebanon, for example, one of the major obstacles women face when choosing a career in science occur at two levels: inadequate legislation from the government, and from within her family. In Jordan, Syria and Lebanon, the women scientists are not supported by a strong legal system that enforces maternity leaves, flexible shifts and childcare.

Several Arab countries express enthusiasm for building greater knowledge-based societies. Yet women are often not supported by strong legislation to help them enter the workforce or achieve long-term economic prospects in science. While women have made headway in STEM education, they still lag behind men as far as pursuing careers or retaining high-ranking positions in all sectors of the professions. In Qatar, for example, women make up less than 12% of the workforce. Similarly in Morocco, according to UNESCO, 70% of students enrolled in scientific universities are women; but few achieve leadership positions in the research field.

(4) ***Lack of Inspiring Role Models***

Some female scientists are convinced that creating women scientist role models can encourage girls to pursue science careers and break down the common perception that men are better suited for the job. Although there are many MENA women in the STEM fields who are making great success, unfortunately, the media rarely puts them under the spotlight. In 2010, the collaboration between UNESCO Cairo office and L'Oreal company resulted in the creation of the *Pan-Arab Regional Fellowship for Women in Science.* Although historically, women have been on the forefront of many scientific disciplines, unfortunately their contributions have generally not been recognized as reflected in the fewer than 3% of the scientific Nobel prizes in Science have been awarded to women. This is why L'Oreal and UNESCO believe how important it is to celebrate great women scientists, of the past and of today, to create role models and inspire the next generation.

(5) ***Failures of Women Network for Women in Science in Arab Countries***

The Arab Network of Women in Science and Technology (ANWST) was created by UN Educational, Scientific and Cultural Organization (UNESCO) in 2005. After the office was transferred to Egypt in 2010, the ANWST has become inactive in its mission to foster young women's participation in science and technology in the Arab countries due to budget constraints and lack of leadership. It was aimed to strengthen the collaboration among women scientists through providing training, workshops, seminars, round-tables and fellowships, and by establishing effective channels for communication and information sharing.

Another similar failed story is a regional network for female scientists, the Arab Women Network for Research and Development (AWNRD), which was set up by the Arab Science and Technology Foundation in 2008. But the network has never organised

any activities and now it and its website have vanished, leaving little information behind. The main reason why this network had failed is due to the situation in the Arab spring countries, most of the researchers were busy with what was going on in their own countries and had stopped reacting to online discussions as well as funding problems. Also another major problem is that those networks were moderated by volunteers and not full-time employees, hence they could not function well. Such networks need to work like organisations and to have an experienced coordinator to activate them and work on achieving specific tasks to achieve its goals.

(6) ***Education***

It is imperative to have the right set of programmes in STEM education. There is a need to develop a course that essentially stimulates students into action, combining the right sequence of practice and theory. Because if it is based on theoretical knowledge alone, people will lose their interest very quickly. As it is seen everywhere in the MENA region, the conversion rate for girl students to become professionals or pursuing careers in STEM fields is comparatively low especially in traditional communities. But this can be addressed by businesses becoming more flexible. For instance, a computer science graduate and a mother can easily work two to three days from home. Hence, the business world needs to accommodate women better in the workplace.

There is also another concern where not all women go to university to receive degrees to work with. For many of them, university is the only social outlet in their conservative societies where they can mix and mingle with friends freely. While boys have more freedoms in the Middle East, girls often go to universities to enjoy similar freedoms and make friends. Others continue their university education so they can find a 'better husband' or to fill up their time before marriage.

RECOMMENDATIONS/ CONCLUSION

Contrary to common belief, choosing a career in STEM poses many obstacles for women, arising not only at the workplace but actually from home and, consequently, in school. From early childhood, girls are conditioned to act, play and explore their surroundings in a certain 'socially correct' fashion. It is vital to provide girls with a positive environment early on at home. They should have an opportunity to try out and explore how things work in a safe, healthy environment. It is also very important to encourage them to ask questions and be curious about their surroundings. In schools, teachers need to be more supportive of girls. There was a study conducted some time ago revealing that in a classroom situation, educators tend to unconsciously choose boys over girls to answer questions when both raise their hands. Once teachers realize what they are inadvertently promoting and consciously make a choice to encourage girls to speak up, we will begin to see a marked difference. It is important

to build teams that allow girls to create things on their own and also to make them understand that it is alright to fail.

On the professional front, more women in MENA countries must be encouraged to pursue their careers in the STEM fields as soon as they graduate from their disciplines. It is important to have a proper support system for women at the workplace in order for them to grow. Being in STEM is both challenging and incredibly rewarding at the same time. Retaining women in the STEM fields especially in mid to high level positions has been relatively difficult. Although there is a very high percentage of women getting a STEM education, this figure is not translated into the number of those employed in STEM-related professions. About 50% of women opt out of the field owing to personal and professional barriers. Acknowledging the low conversion rates of women studying STEM to women in various STEM professions, new legislations have to be made, private sectors need to change their policies on women employees, workplace has to be more female-sensitive, and the culture and social norms have to change to accept that women can be good scientists as men. Overall, stakeholders such as business leaders, communities and governments will not only have to rethink their policies to motivate women in STEM to participate in the workforce, but they will also have to find the means to reconnect professionally educated women with the job market.

Equality and the gender divide have faced many a battle over the past many years. There has been 30 years of research done on why women have a lesser ratio of participation in STEM compared to men and realistically speaking, things have not changed even till today. For instance, as MENA's biggest economic sector is the oil and gas industry, there must be a greater unified effort from this sector in encouraging women to pursue careers in the oil and gas industry, which statistics still continue to show to be a male-dominated field.

However, a study by PricewaterhouseCoopers (2014) in association with the Women's Oil Council looked at the 100 largest listed oil and gas companies in the world and found that only 11% of board seats were held by women. The study shows that while it is clear why women play a pivotal role in the energy sector, achieving progress remains a challenge. Offering opportunities for professional development is key to making the oil and gas industry a viable career choice for women. The oil and gas companies can retain women in their sector by offering them leadership positions and growth in their career. Leading and mentoring are two important challenges that need to be looked at for women in the oil and gas sector in order to achieve a higher number of women in the leadership role. As a matter of fact, this is not just a MENA regional challenge, but it is a global challenge. The oil companies need to have a pro-active plan in place that goes beyond a recruitment quota. For example, Shell is addressing the gender imbalance by implementing supportive and inclusive corporate policies, from designating fieldwork timings, to protocols that address work-life balance. Such policies can change the dynamics of the work environment, and ultimately how people perceive the industry. Managers must be continuously educated about what

is needed to overcome these challenges. For example, in addition to mandating that 30% of their field engineers must be women, the company offers female employees a rotation schedule that encourages them to get experience on the field. They also must have specially dedicated nursing rooms for new mothers.

There is also a need for a few strong female networks that are crucial to building a sustainable professional environment for women in the industry in MENA countries. With this strong support system, there is a 'sisterhood' network that will create a strong bond where they can address issues and challenges together.

With a local, regional, and global mission to recruit more women in the energy sector, young female graduates must not be discouraged. Women who are truly interested in engineering should not let anyone force them to change their career paths. It can be challenging at times, but the key is to focus on the positive and not the negative. The Emirati women are at a more advantaged position than some parts of the MENA region as everywhere in the UAE, people are encouraging women to pursue their dreams as it is part of the vision and mission of its leadership. People subjecting women to gender profiling must realise that half of the global population is female, and not harnessing the talents of women because of their gender is not only discriminatory, but also a waste of human resources. Money literally goes down the drain if women are unable to pursue careers due to familial and societal issues either after they graduate or go on a hiatus. In the long run, it is not sustainable to get people from outside when equally talented local women are present. The key here is to invest in training women who are out of touch due to parental leaves, etc., in order to reintroduce them into the world of business.

In this sense, integrating MENA women in the economy would be of double-benefit: it will reinforce the role of women in the society, and stimulate the economic activity of the region. Therefore, because women's participation in the economy is an integral part of their empowerment as well as a pre-condition to the human and economic development of the whole region, it has become a major imperative and challenge for the MENA region today. However, in some parts of MENA, there are still strong cultural and social barriers that need to be addressed, and this will take time to change.

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WOMEN PARTICIPATION IN SCIENCE, TECHNOLOGY, ENGINEERING AND MATHEMATICS IN NIGERIA: CHALLENGES AND WAY FORWARD

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Abstract

Gender disparity in education has attracted great attention over the years. Efforts to close the gap has recorded significant success except in the field of science, technology, engineering and mathematics (STEM). Women are still poorly represented in STEM. This gender gap in STEM does not favour development, particularly in this knowledge economy that is driven by science and technology innovations. This paper traces the root of the gender gap in STEM to cultural belief and socialization pattern. Other factors includes poor self-image/attitude, societal expectation, learning environment etc. the paper noted the need for gender parity in STEM and made recommendations for the way forward.

INTRODUCTION

Science, Technology, Engineering and Mathematics (STEM) is the key driving force in today's economic development. Future success of nations increasingly depends on their scientific and technological capabilities. It is not out of place to say that the process of critical thinking using STEM and understanding its social impacts; are very important in today's ever changing world of complexities. Thus basic knowledge of STEM, at least, is now among the generic skills for survival in the new economy.

Unfortunately, women underrepresentation in STEM has persisted over the years, despite efforts to close the gender gap. Elan (2012) opined that the presence of women in the fields of STEM remains significantly lower than that of men, even in some of the world's wealthiest regions. The low participation of women in STEM must be jettisoned, if Nigeria really aspires for socioeconomic emancipation. In the light of this, the paper reviews the statues of women in STEM in Nigeria, challenges to women participation in STEM and suggests ways forward.

STATUS OF WOMEN IN STEM IN NIGERIA

Throughout the world, women continue to be significantly under-represented in science, technology, engineering and mathematics (STEM). Men outnumber women as students, educators, researchers, and workers in STEM fields. While the number of women enrolling in higher education is increasing rapidly in many countries and in some has surpassed male enrollment, men significantly outnumber women in science and engineering disciplines (UNESCO, 2010). Several studies in Nigeria (Badekale, 2003; Aguele & Agwagah, 2007; Udeani & Ejikeme, 2011; Aderemi, Hassan, Siyanbola & Taiwo, 2013) have consistently observed low participation of women in STEM. Although remarkable improvement has been recorded in women enrolment in education generally, however, the gender gap in STEM has persisted.

National Bureau of Statistics (2014) observed that enrolment of Girl-Child into primary, secondary and tertiary institutions are on the increase. NBS observed that the proportion of girls enrolled in some States (Akwa-Ibom, Anambra, Bayelsa, Kogi, Lagos, Ogun and Rivers) was above 50% in 2013. Table 1A & 1B show educational enrolment and out-turn in Nigeria by gender from 2010 – 2013; while Tables 2A & 2B show enrolment by gender in STEM fields in Nigerian polytechnics and Tables 3A & 3B show enrolment by gender in STEM fields in Nigerian universities. The data presented in these tables were derived from the 2014 report of National Bureau of Statistics. The data do not represent comprehensive enrolment during these periods, as some institutions and Ministries did not supply required information (cf. NBS, 2014).

It is evidenced in Table 1 A & B that women enrolment in education generally has improved across all levels of education in Nigeria. Women enrolment has remained above 40% across the levels of educational institutions and across the years. It should be noted that percentage of women enrolment has remained highest in the Colleges of Education across the years, where women enrolment is greater than that of men (above 67%). Whereas percentage of women in the Universities and Polytechnics is lowest (below 45%). However, gender disparity is more pronounced in the STEM fields particularly in the Technology and Engineering fields. Tables 2A & B and Tables 3A & B revealed that there is gross low enrolment of women in STEM particularly in

engineering; where women constitute as low as 9.7% in Polytechnics in 2011 and 7.3% in Universities in 2013. This is consistent with the opinion of Baram-Tsabari and Yarden (2011) that studies from multiple countries point to a trend in which girls have a greater preference for the biological sciences than boys, who prefer the physical sciences or have a broader range of preferences. They further revealed that children often hold stereotypical views about the physical sciences being for boys and the biological ones being for girls. Similarly, Nyerere (2009) noted that in 1998, women constituted only 1.4% in mechanical engineering, 4.4 per cent in electrical and electronic engineering, and 5.0 per cent in building and civil engineering. This also translates to the workforce. Women make up only 17% of all science researchers in Nigeria (UNESCO 2010). They constitute 2.4% of architects, 3.5% quantity surveyors, 8.4% of obstetricians and gynecologists, and 33.3% of pediatricians (Ojo, 2002).

When enrolment is compared with out-turn, it could be said that women are not doing bad. In essence, women's low participation in education or in some aspects of education (STEM), is not as a result of inability to perform well or cope with the tasks. Instead it could be as a result of low self-esteem and lack of motivation and confidence to aspire high. This could explain why there are more women in Colleges of Education than in the Polytechnics and Universities. Although one may argue that, owing to gender stereotype, women are more inclined to teaching; therefore they enroll more in Colleges of Education. This may be true, but it does not explain why women constitute low proportion of teachers in tertiary education; whereas the proportion in primary and secondary education is greater than men (Okorafor, Nnajiofor, Okorafor & Enemuoh, 2013). Anarfi & Appiah (2012) acknowledged that female students are more inclined towards life skills and commercial courses, which are referred to as less prestigious and less academically demanding whilst the males are more inclined towards sciences, mathematics, technical or masculine subjects and industrial subjects which many females shy away from.

THE NEED FOR GENDER EQUITY IN STEM

The rationale for clamoring for gender equity in STEM was well captured in the statement of Federico Mayor in 1999, the then Director General of UNESCO; when he said:

> *On a worldwide scale, science and even more technology, is still a man's business. This situation is no longer acceptable. It is economically unacceptable because of the waste of human resources that it entails; it is humanly unacceptable since it prevents half the population from taking part in building the world; it is intellectually unacceptable as it deprives scientific and technological research of ideas and methods, in a word, of creativity. Furthermore, it mortgages the future since it nullifies any prospect of a general mobilization in support of science in the service of a lasting peace and sustainable development (UNESCO 2006, p. 34)*

Table 1A: Enrolment and Out-turn into Nigerian Educational Institutions by Gender (2010 – 2011)

Type of Institution	2010						2011					
	Enrolment			Out turn			Enrolment			Out turn		
	Female	*Male*	*% F*	*Female*	*Male*	*% F*	*Female*	*Male*	*% F*	*Female*	*Male*	*% F*
Primary	7617305	9045314	45.7	1545695	1760983	46.7	7956532	9382531	45.9	1612846	1870703	46.3
Secondary	3302022	3980621	45.3	731633	823014	47.1	3564982	4341694	45.1	1051492	1208206	46.5
College of Edu	311495	147495	67.9	29320	25547	53.4	317274	156218	67.0	19006	18767	50.3
Polytechnic	36761	52470	41.2	22625	29147	43.7	38237	52596	42.1	21423	31685	40.3
University	49411	70792	41.1	12341	24345	33.6	49107	65823	42.7	8864	19437	31.3

Data in Table 1A derived from NBS, 2014 Report

Table 1B: Enrolment and Out-turn into Nigerian Educational Institutions by Gender (2012 – 2013)

Type of Institution	2012						2013					
	Enrolment			Out turn			Enrolment			Out turn		
	Female	*Male*	*% F*	*Female*	*Male*	*% F*	*Female*	*Male*	*% F*	*Female*	*Male*	*% F*
Primary	9416722	10296048	47.8	1452362	1642736	46.9	4577032	4974233	47.9	1212307	1387998	46.6
Secondary	3975671	5003301	44.3	1100954	169054	86.7	4657882	5177358	47.4	1017604	1158055	46.8
College of Edu	353072	153017	69.8	26164	25863	50.3	328642	158456	67.5	18714	13860	57.5
Polytechnic	44911	65994	40.5	22997	35412	39.4	27711	40828	40.4	15697	21201	42.5
University	61684	83266	42.6	10418	21968	32.2	46292	59143	43.9	9068	48864	15.7

Data in Table 1B derived from NBS, 2014 Report

Table 2A: Enrolment and Out-turn in STEM Fields in Nigerian Polytechnics by Gender (2010 - 2011)

Discipline	2010						2011					
	Enrolment			Out-turn			Enrolment			Out-turn		
	Female	Male	% F	Female	Male	% F	Female	Male	% F	Female	Male	% F
Engineering	1753	9501	15.6	993	5843	14.5	1064	9955	9.7	806	5653	12.5
Computer Science	1428	2563	35.8	1293	1970	39.6	1859	3520	34.6	2236	1924	53.8
Estate Mgt	581	1309	30.7	697	871	44.5	971	1636	37.2	659	1151	36.4
Food Tech.	557	290	65.8	371	151	71.1	590	33	94.7	397	187	68.0
Building Tech.	115	1141	9.2	122	920	11.7	109	1397	7.2	158	1884	7.7
Architecture	148	1024	12.6	91	470	16.2	278	1397	16.6	180	567	24.1
Statistics	223	573	28.0	132	277	32.3	82	455	15.3	78	220	26.2

Data in Table 2A derived from NBS, 2014 Report

Table 2B: Enrolment and Out-turn in STEM Fields in Nigerian Polytechnics by Gender (2012 - 2013)

Discipline	2012						2013					
	Enrolment			Out-turn			Enrolment			Out-turn		
	Female	Male	% F	Female	Male	% F	Female	Male	% F	Female	Male	% F
Engineering	1417	9545	12.9	827	6711	11.0	1324	9550	12.2	440	2788	13.6
Computer Science	1971	3104	38.8	1632	2091	43.8	1786	3089	36.6	818	1163	41.3
Estate Mgt	809	1319	38.0	749	1040	41.9	573	1191	32.5	117	414	22.0
Food Tech.	734	334	68.7	441	223	66.4	700	295	70.4	299	96	75.7
Building Tech.	120	1892	6.0	104	1151	8.3	210	1488	12.4	102	583	14.9
Architecture	148	1093	11.9	184	510	26.5	279	1199	18.9	82	274	23.0
Statistics	274	593	31.6	115	191	37.6	394	892	30.6	144	382	27.4

Data in Table 2B derived from NBS, 2014 Report

Table 3A: Enrolment and Out-turn in STEM Fields in Nigerian Universities by Gender (2010 - 2011)

Discipline	2010						2011					
	Enrolment			Out-turn			Enrolment			Out-turn		
	Female	Male	% F	Female	Male	% F	Female	Male	% F	Female	Male	% F
Medicine	1512	2118	41.7	407	154	72.5	478	750	38.9	242	448	35.1
Phamacy	376	379	49.8	22	24	47.8	236	311	43.1	8	17	32.0
Engineering	554	3116	15.1	183	2006	8.4	652	3609	15.3	115	791	12.7
Sciences	8181	13040	38.6	1459	2509	36.8	7916	10495	43.0	1098	1991	35.5
Agriculture	1941			461	1109	29.4	1376	1471	48.3	363	1376	20.9
Environmental Tech	630	1997	24.0	35	115	23.3	452	734	38.1	94	142	39.8
Nursing	111	262	29.8	3	8	27.3	152	300	33.6	69	272	20.2
Med. Lab. Sc.	118	123	49.0	4	12	25.0						

Data in Table 3A derived from NBS, 2014 Report

Table 3B: Enrolment and Out-turn in STEM Fields in Nigerian Universities by Gender (2012 - 2013)

Discipline	2012						2013					
	Enrolment			Out-turn			Enrolment			Out-turn		
	Female	Male	% F	Female	Male	% F	Female	Male	% F	Female	Male	% F
Medicine	483	585	45.2	214	316	40.4	668	838	44.4	244	373	39.5
Phamacy	427	456	48.4				205	272	43.0			
Engineering	469	4733	9.0	245	1436	14.6	385	4913	7.3	25	53	32.1
Sciences	8395	12413	40.3	1569	7957	16.5	6853	11177	38.0	736	787	48.3
Agriculture	1819	1831	49.8	339	1283	20.9	1276	1523	45.6	101	62	62.0
Environmental Tech	437	1669	20.8	90	188	32.4	244	676	26.5	535	442	54.8
Nursing	219	483	31.2	48	29	62.3	219	498	30.5			
Med. Lab. Sc.	162	306	34.6	15	26	36.6	103	235	30.5	14	29	32.6

Data in Table 3B derived from NBS, 2014 Report

Women constitute about half (49%) of the Nigerian population (British Council Nigeria, 2012). Their exclusion from the generation and application of scientific knowledge represents a tremendous waste of human potential. It is a neglect of half of potential human capital available in the economy, which will threatened the economic competitiveness and advancement. Also it is like walking on one leg in the race towards technology driven economy; which will not only be frustrating but may take forever to achieve.

It has not been proven that ingenuity is a factor of sex. Men and women alike have hidden potentials that when developed can turn a new page for the world's development. Women participation in STEM has been greatly hampered by the fallacy that they lack the potentials to thrive in this fields. From Table 2A&B and 3A&B, when you compare percentage of female enrolment with that of out-turn, you can confidently say that women perform as good as men in STEM. Performance in WAEC (2011 – 2013) showed that girls constituted above 49% of candidates that had five credits and above including Mathematics and English (NBU, 2014).

Some women have made landmarks in STEM, even in Africa. Professor Tebello Nyokong, a South African women, won the Africa-Arab State 2009 L'Oréal-UNESCO Award for Women in Science for her pioneering research into photodynamic therapy which looks at harnessing light for cancer therapy and environmental clean-up. Nyokong is the third South African Scientist to receive this award. Dorothy K. Gordon is the Director-General of Ghana Advanced Information Technology Institute (AITI-KACE), the Ghana-India Kofi Annan Centre of Excellence in ICT. Florence Seriki is the Chief Executive Officer and founder of Omatek Computers. Omatek Computers Limited was one of the first companies to locally assemble desktops and notebooks in Africa. Florence is a fellow of the Nigerian Society of Chemical Engineers, Nigerian Computers Society (NCS) and the Institute of Directors. She holds a Bachelors of Science degree in Chemical Engineering from University of Ife (now Obafemi Awolowo University) and an MBA from the Lagos Business School. Also is Grace Alele Williams, who was the first Nigerian woman to obtain a doctorate, in mathematics education, and who then rose to become the first female vice chancellor of the University of Benin. These are clear indications that women can compete favorably in STEM if given the necessary motivation and opportunity.

Innovation and technology changes have led to the demand for STEM competencies beyond traditional STEM occupations. The creativity and critical thinking skills that come with a foundation in STEM are in high demand for many jobs. Just as language literacy was a requirement in the 20th century; STEM literacy is a requirement in the 21st. Thus, gender equality in STEM is an effective development strategy without which, according to Randell and Gergel, (2009), the world has no chance of achieving many of the ambitious health, social and development targets it has set for itself. This means that development cannot be tied to a particular sex. Thus any nation neglecting gender parity in a field such as STEM is missing a great target for development.

CHALLENGES TO GENDER EQUITY IN STEM IN NIGERIA

It is not as if efforts have not been made to encourage women participation in STEM. Key policy initiatives with a gender focus in Nigeria include: Blueprint on Women's Education 1986, National Commission for Mass Literacy and Non-formal Education 1991, Family Support Basic Education Program 1994, National Policy on Women 2001, Strategy for Acceleration of Girls' Education in Nigeria 2003, etc. However, women are still grossly under-represented in STEM.

A key contributing factor to this menaces has been the cultural belief and socialization process. Males and females are brought up within the society to conform to the norms and ethics of the society. The socialisation pattern has strong influence on the conscious and sub-conscious mind of the child, which determines the roles the child wilfully and happily plays even when it does not favour them. African occupational gender stereotyping has continued to influence the choice of career path of students; and this has negative effect particularly on the female folk. Socialisation of the female child into stereotypical passive sexual role from a very early age has gradually become entrenched in their collective consciousness. While girls are protected and discouraged from explorative and risky activities, boys are encouraged to be assertive and challenge their mental powers. This has conditioned their apprehension and interpretation of the world around them. Chabaya, Rembe and Wadesango (2009) recapitulated that socialisation was practised not to prejudice the child against the other sex, but to let it grow naturally into its predestined role and to make the child look forward with pleasure to its allotted task. For instance, girls perform more tasks at home than boys, which impacts negatively to their study time and sometimes denied them access to education. But they whole heartedly accept these tasks as they believed they are preparing themselves as future good wives and home makers. Imhanlahimi, & Eloebhose (2006) opined that this socialization process leads to certain personality characteristics regarded as masculine or feminine: independent qualities, initiative and assertiveness for boys; and dependency, submissiveness and complacency for girls. They maintained that these personality characteristics affect the attitude of girls towards science and technology education, as girls believe they are inferior to boys physically and mentally.

Personal hindrances to female participation in STEM such as poor self-image/attitude, lack of confidence and subordinate status etc. are the products of socialisation. There is this perception that STEM subjects are difficulty; perhaps because most of the subjects are taken in abstract, especially in developing countries where there are inadequate instructional aids. Thus girls having been brought up to be soft and tender, perceive STEM as masculine discipline. Girls tend to believe they lack the ability and toughness to succeed in STEM. They develop cool interest toward STEM and perceive it as unappealing in the future prospect it offers.

Still is the issue of environment where the girl child finds herself. Akinsowon and Osisanwo (2014) asserted that the environment plays a larger role in making STEM interesting for women. The interaction one has with people around (teachers, parents and peers) greatly influence ones attitude. The society has role expectations for male and female, which they deem fit to preserve. In Nigeria and many other countries, girls are expected to be submissive, reserved and unquestioning. This shapes their interaction with parents, teachers and even peers; and as such affects their learning (Kassahun & Kedir, 2006). Based on the standards and expectations of the society, a girl's choice to venture into STEM is seen as weakening her identity as a girl and as making her appear less feminine (Brotman & Moore, 2008). Those who continue in STEM are stigmatized as aberrant, or at best, deemed exceptional. This translates even to the world of work. People tends to believe that women in STEM careers are not as good as their male counterparts, except they are extremely and outstandingly good at what they do. This according to Akinsowon and Osisanwo, puts the female at a cross-road as her likability tends to diminish because both likability and competence are needed for success in the workplace. It takes extra determination and motivation for girls to succeed in this kind of situation.

In science classroom environments throughout Nigeria, girls are often actively discouraged from engaging in science subjects and activities Their self-confidence is eroded, and very little is done to inspire and enhance their motivation to pursue science. Hassan (2000) opined that girls, as well as their families, teachers and school peers, question the relevance of science to their lives. Kitetu (2001) reported that girls and boys engaged in different activities within the same classroom, with girls showing minimal involvement in activities requiring physical exertion. Also teachers treat boys harsh but are gentle with girls. Adding to the problem is the lack of role models for the girls in the schools. There are fewer female teachers in STEM (NBS, 2014), which further strengthens the belief that science is not for girls. These observations are underpinned by society's cultural belief and socialisation pattern, which holds that boys should be tough, active and brave while girls are soft. Consequently this has negative influence on girls' attitude and performance in STEM subjects.

CONCLUSION

Many young Nigerian girls will want to change the world. But little do girls know that venturing into STEM will give them greater opportunity to achieve their goals. Therefore there is the need to encourage female participation in STEM. It is through STEM that problem solving and critical thinking skills are developed to tackle critical issues of environment, health, energy, national security and agriculture. If women are excluded, it means the future is being created without the ideas, input, vision and perspective of much of the citizenry. A diverse workforce is a more creative workforce capable of challenging old attitudes and practices and bringing fresh thinking and greater innovation for development.

RECOMMENDATIONS

1. *Reorientation Campaign*: If females are to be acculturated to scientific and technological thinking and behavior, developing awareness is the first step for correcting the false impression that females are soft and less mentally assertive. The reorientation will be more effective if it starts from the family even before the girl child attain school age. It means that their parents, guardians and other adults in their lives must be involved. Therefore a good step to take is to reorient the entire society to give children equal opportunity (male and female alike) to explore their world. The parents and guardians should be made to know that the treatment given to children at the very tender age conditions their consciousness; which reflects in their behavior later in life. The situations where the boy kid is given toy cars while the girl kid is given teddies should be discouraged. Parents and guardians should be made to understand the implications and later effects of this discrimination at the early stage of the child. The girl child should be encouraged to confront challenges like the boy. Therefore it is important to carry out campaign to develop public awareness on this issue. Such campaign can be initiated and conducted by professional STEM associations and women organizations including the ministry of women affairs and women development commissions.
2. *The STEM Teacher*: Effort should be made to have as many female STEM teachers as there are male. The gross gender disparity in teaching staff in STEM sends a signal to the female folk that it is not meant for them. Also the teachers should be re-oriented to desist from discouraging female students in their class. They should avoid criticisms that dampens girls' self-image or perception of their capabilities to succeed in STEM. This could be achieved through workshops and conferences organized by professional bodies or women organizations.
3. *Role Models:* Successful females in STEM have a big role to play in wooing more females into the field. Most times females are discouraged to pursue their career in STEM because there is no model to look up to. It will be an effective strategy for successful females in STEM to organize seminars for students especially at the secondary school level. This will motivate the female students to follow suit. Also professional bodies and women organizations can use such female giants in STEM for reorientation campaigns.
4. *Learning Environment:* The learning environment should be enriched, as it facilitates learning. Learning in STEM is as effective as there are adequate provision of instructional aids. Therefore government, professional bodies, NGOs and well-meaning individuals should join hands to provide adequate instructional materials for STEM. Also teachers should employ teaching approaches (constructivism, guided inquiry etc.) that will get the students fully and actively involved in the learning process. This will not only help to bring abstract concepts in STEM to observational level of students, but also disprove the belief by females that STEM is very difficult and meant for boys. The teachers

should encourage high degree of interaction between boys and girls in STEM classes and ensure that girls participate fully in their groups. School based STEM society should be encouraged. This society should engage in activities as inter/intra school debate, exhibitions, career talks from role models, and excursions. Professional bodies and women organizations can sponsor such societies.

5. *Scholarship:* Giving scholarship to female students who venture into STEM will motivate more female students to enroll in STEM fields. Government, professional bodies, NGOs and well-meaning individuals should encourage more female participants in STEM through scholarships.
6. *Employment and Promotion*: There is need for policies that will enhance the employment of females that have completed their studies in STEM in their profession. Also discrimination in promotion in the workplace should be checked. The idea of not employing or promoting a female unless she is twice as good as the male counterpart should be discouraged.

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REMARKABLE WOMEN MATHEMATICIAN ROLE MODELS: HISTORICAL ACCOUNTS AND ACHIEVEMENTS

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Abstract

A few studies have suggested that it is possible that women leave mathematics field due to their lowered sense of belonging in mathematics caused by stereotype threat. When the stereotype threat was eliminated, women performed better than when they felt the external pressure. The results of this study clearly show that the tendency of women to perform lower than men in mathematics is not due to lack of ability or knowledge, but rather the societal stereotypes and pressures that they feel when taking tests. Women have been for centuries involved and excelled in mathematics breaking the norm, tradition, culture and the stereotype threat. These remarkable women mathematicians have carved their names in mathematics, many of their work are being studied by students till today. This article looks at a study on stereotype threat on women as well as taking a gander at a few most renowned women mathematicians of all times who are role models to the modern women in mathematics.

Keywords: *Stereotype threat, role model, woman mathematician, sense of belonging.*

INTRODUCTION

Data gathered by the Association of Women in Science in 2010 show that women in the sciences and mathematics do not win peer recognition at a rate that

commensurates with their numbers in the profession. For instance, in 2010, women made up 24% of all tenure-track mathematics faculty at colleges and universities, but in the decade from 2001 through 2010, they won just 8.7% of the research and writing awards from the three major mathematical societies. Men are more likely to fit into preconceived notions of what a scientist is. For instance, one way to identify profound mathematical ability (though certainly not the only way) is to look at high school students who have won international mathematics competitions. But an in-depth study by researchers at the University of Texas and elsewhere suggested that socio-cultural factors washed out any other potential explanations for the gender gap. Moreover, girls are succeeding at the highest levels in mathematics at far higher rates today than in previous generations, suggesting there is nothing intrinsically non-mathematical about being female. And girls raised in cultures with strong traditions in problem-solving competitions do much better in mathematics competitions than girls from cultures without such traditions. In the USA Math Olympiad, almost all of the girls who have won have been foreign-born, Asian American or home schooled — groups that place a high emphasis on mathematics. Other theories for the low rates of women winning recognition in the sciences include that they put less time into their scholarship than men, because they are more likely to prioritize their family. Or that women are not publishing enough. These pipeline issues must be studied and addressed. Based on many research conducted the likely contributing factor may be due to implicit bias, whether unconscious or unintentional judgments, that lead employers to prefer a man over a woman even when their applications are identical.

SENSE OF BELONGING TO AN ACADEMIC DOMAIN

As suggested by Catherine Good, Aneeta Rattan and Carol S. Dweck (2012), a key factor driving students' intent to pursue mathematics should be their personal sense that they belong in mathematics. Sense of belonging to an academic domain likely contains various components, but at its heart it reflects the feeling that one fits in, belongs to, or is a member of the academic community in question. In addition to viewing oneself as being inside a discipline rather than on the fringes of it, sense of belonging may also entail a sense of being valued and accepted by fellow members of the discipline. Thus, sense of belonging, as we conceptualize it, involves one's personal belief that one is an accepted member of an academic community whose presence and contributions are valued. When sense of belonging is reduced, individuals may opt out of the domain—even when achievement remains high—to pursue studies and professional goals within a different discipline that better enable this sense of belonging to take root. Although the assumption that women are lacking in the desire to pursue mathematics may serve as a readily available explanation for their departure from the field, but it is also possible that a lack of desire to remain in mathematics stems from a lowered sense of belonging is a factor.

THE POTENTIAL EFFECTS OF STEREOTYPES AND STEREOTYPE THREAT ON SENSE OF BELONGING

Stereotypes of women's lesser ability in mathematics compared with men are alive and well, as illustrated by Harvard University former president's suggestion that the representation gap between males and females may stem, in part, from the lack of capable women at the upper level of mathematics ability (Summers, 2005). As over a decade of research has shown, ability-impugning stereotypes such as these can trigger psychological processes that can undermine the performance of stereotyped individuals, including females in mathematics (Dar-Nimrod & Heine, 2006; Good, Aronson, & Harder, 2008; Spencer, Steele, & Quinn, 1999; Steele & Aronson,1995), especially on high-stakes tests like the SAT (Danaher & Crandall, 2008). Negative stereotypes, however, may have the power to disrupt more than performance; they may also carry a strong message that certain groups are less valued or accepted. That is, the gender stereotype in mathematics, when made salient, may lead women in particular to feel less accepted members of the mathematics community and thus to have a lower "sense of belonging" to mathematics. Consequently, negative stereotypes may, in fact, influence women's representation in the mathematics pipeline by means other than underperformance on high-stakes tests. Although traditional stereotype threat theory primarily accounts for underperformance, sense of belonging to mathematics may account for under participation above and beyond what deficits in performance on standardized tests can explain. It is not hard to imagine that stereotyped individuals may be less interested in and willing to pursue a domain of study in which their sense of belonging has been undermined, despite their high achievement. Past work has discussed the theoretical importance of feeling a sense of belonging to a domain (Steele, 1997) and has begun to examine the ways in which cues in the environment (such as the numerical representation of men vs. women) can make stereotypes salient, by lowering both trust within that context (Purdie-Vaughns, Steele, Davies, Ditlmann, & Crosby, 2008) and ambient sense of belonging for members of negatively stereotyped groups (e.g., Cheryan, Plaut, Davies, & Steele, 2009; Murphy, Steele, & Gross, 2007). However, research has yet to examine the longer term effects of belonging-relevant cues outside of a laboratory environment.

In a study published by Catherine Good, Aneeta Rattan and Carol S. Dweck (2012), they suggested that students' sense of belonging is an important variable to study when considering the causes and cures of the representation gap in mathematics and science domains. Students who believe that their colleagues view mathematics ability as acquirable are able to maintain a high sense of belonging, which in turn reduces the power of perceived stereotypes to impair females' desire to pursue mathematics and their achievement in mathematics. Consequently, supporting females' sense of belonging by communicating an incremental view of mathematics intelligence in educational environments may begin to address pipeline issues for

women in science, mathematics, engineering, and technology. In doing so, it may help to eliminate the culture of "talent" and the mentality of the "weed-out system" that pervades many of these classrooms and that can send fixed-ability messages to women. Learning environments that foster a culture of potentiality in which anyone can develop their skills may create room for many more females to feel that they belong in these fields and, thus, to encourage many more females to pursue mathematics and science degrees.

In another study conducted by Steven Spencer, Claude Steele, and Diane Quinn (1999), they analyzed the effects of stereotype threat on the performance of women in mathematics. Spencer, Steele and Quinn acknowledged that there is a negative stereotype that women have weaker mathematical abilities (Spencer, Steele and Quinn 1). They defined stereotype threat to be the risk women face of being judged by this negative stereotype when they perform mathematical tasks (Spencer, Steele and Quinn 1). They picked groups of highly qualified individuals with strong backgrounds in mathematics and conducted two studies. The purpose of the first study was to demonstrate the differences in mathematical achievement between men and women when stereotype threat was high, and the second study was to show that when stereotype threat is lowered, women perform better (Spencer, Steele and Quinn 1, 8). The researchers mentioned a study in which seventh and eighth grade students, all with the same amount of prior mathematics coursework, were given the mathematics section of the Scholastic Aptitude Test (SAT) (Spencer, Steele and Quinn 24). The students who scored above 700 were overwhelmingly males, outnumbering the females by a factor of 10 to 1 (Spencer, Steel, and Quinn 24). The conductors of this study however, did not acknowledge that just because students are in the same class does not mean that they have the same experiences. That is what Spencer, Steele and Quinn tried to achieve in their study by eliminating any pressure that students may feel when taking tests: a level playing field. They found that when the stereotype threat was eliminated, women performed better than when they felt external pressure (Spencer, Steele and Quinn 25-6). The results of this study clearly showed that the tendency of women to perform lower than men in mathematics is not due to lack of ability or knowledge, but rather the societal stereotypes and pressures that they feel when taking tests (Spencer, Steele and Quinn 25-6).

In a book dedicated to their daughters, Stephen Ceci and Wendy Williams explained why they believed women do not pursue careers in mathematics. They believe that women simply have higher preferences for careers in fields not relating to mathematics and the choices in career often have to do with fertility and its consequences for work (Ceci and Williams 180). They explained that women choose to start families at times that jeopardize career progress and would have even greater effects in a mathematics-related career (Ceci and Williams 180). They acknowledged that smaller effects such as spatial and mathematical ability, hormones, stereotype threat, and biases are not trivial, but yet they have smaller effects on the pursuit of careers in mathematics than the preference/choice factor (Ceci and Williams 180). They describe how various

factors contribute to the under-representation of women in the mathematics field: (1) fewer women scoring at the right tail in mathematics which reduces their chances of acceptance into mathematics-intensive graduate fields for which the GRE-Q scores are an important consideration for admission; (2) fewer women who do score at the right tail in mathematics preferring to enter mathematical fields even though they have the mathematical aptitude to be successful, preferring instead more organic, people-oriented fields; (3) fewer women opting to compete for tenure-track posts upon receipt of their doctorates; (4) more women leaving the field for family reasons; and (5) more women leaving the field as they advance, for career changes. (Ceci and Williams 188-189)

REMARKABLE WOMEN MATHEMATICIAN ROLE MODELS: HISTORICAL ACCOUNTS AND ACHIEVEMENTS

If we collect data from all over the world on women mathematicians who have long broken the glass ceiling and became role models to the modern women mathematicians, the number is much more than what we think. However, this number is still very small as approximately half of the world's population is women. In spite of the fact that for centuries women have been mathematicians, only recently in 2014, a woman from Iran named Maryam Mirzakhani, a mathematics professor from Stanford University, has been recognized for her work and was awarded the Fields Award (Nobel prize for Math). She is the only woman Fields Award winner among 54 men in more than 76 years since the award has been given as the highest recognition to honor mathematicians in the world. Maryam is the first ever woman and Iranian to win that prestigious award. Surely we would think that more awards and recognitions should be given to women but the reality is still that women is under-represented in the mathematics field, academic or research or even in the industry, and women are not being equally recognized as men. Throughout history there have been numerous other women whose contributions to the field of mathematics have made significant impacts. Let's look at these remarkable women mathematicians of all times, whom many of us have heard about from our early education in school.

HYPATIA OF ALEXANDRIA (AD 350 TO 370 – 415):

She was born nearly 17 centuries ago in Alexandria, Egypt, which is one of the centers of mathematical thought at the time. Hypatia of Alexandria is recognized as the first woman to have a significant impact in the field of mathematics and some have referred to her as the "mother of mathematics". Hypatia was a brazen, highly intelligent woman who excelled in the fields of science, mathematics and philosophy, which at the time (and for hundreds upon hundreds of years further) were seen squarely as the domain of men. Hypatia's foremost teacher was her father, Theon Alexandricus,

a mathematician and philosopher, who she would later go on to contribute to several mathematical works with. Hypatia herself was a teacher, as well as being the inventor of the hydrometer.

She studied all areas of thought, but she flourished the most in mathematics, science and philosophy. Eventually she exceeded her father's knowledge, so he sent her to study in Athens, the mathematics center of the world. When she completed her studies in Athens, she traveled around Europe for about ten years. Not only was Hypatia an excellent student and researcher, but she excelled in teaching as well. When she returned to Egypt, she was asked to teach at the University of Alexandria. Her favorite subject to teach was algebra, but it was a new field so she taught geometry and astronomy to people from all over who came to Alexandria specifically to learn from her. Even when she was teaching, she continued learning and researching many different subjects. Hypatia mainly focused her studies on astronomy, astrology, and mathematics. She is most well known for her work on conic sections, which were first introduced by Apollonius. She developed the ideas of hyperbolas, parabolas, and ellipses while editing her text *"On the Conics of Apollonius"*. She was known for writing commentaries on books in which she gave explanations of difficult and dense topics that were easier to understand than the original books. Because of her work on several famous books and important topics, her work has endured through many centuries. Though she forged ahead in a time when women were all but ignored in the realm of mathematics, she eventually met with a tragic death when her chariot was attacked and she was brutally murdered by a gang of Christians. Though her life was cut short, while she was alive, through her accomplishments, Hypatia was able to lay the groundwork for future female pioneers of mathematics.

GABRIELLE ÉMILIE LE TONNELIER DE BRETEUIL, MARQUISE DU CHÂTELET (DECEMBER 17, 1706 – SEPTEMBER 10, 1749):

A woman of many intellectual interests, Émilie was a mathematician, author, and physicist who hailed from France. Born into a well-to-do family, Châtelet was a gifted child with a natural penchant for linguistics. Given her family's high social status, Émilie was able to receive a degree of education far above the vast majority of French women at the time. Her place in society also put her in a position wherein she was able to mingle with some of the leading minds of her time (such as Voltarie who would go on to become one of her lovers). In 1740, Châtelet published a book entitled *Institutions de Physique,* which put forth some of her knowledge regarding both science and philosophy. In her last year of life, Émilie translated Newton's well-known *Principia Mathematica.* In her early forties, she became pregnant and though she initially survived the delivery, a few days later both she and her newborn child passed away. Émilie was an independent, articulate and highly intelligent

woman, who was somehow able to hold down both her role as a leading lady in French high society and as a mathematician, an equation which deserves respect in its own right.

AUGUSTA ADA BYRON KING, COUNTESS OF LOVELACE (DECEMBER 10, 1815 – NOVEMBER 27, 1852):

English born Ada Lovelace was the daughter of the famous poet Lord Byron, though she had never met her father. Ada had an unusual upbringing for an aristocratic girl in the mid-1800s. At her mother's insistence, tutors taught her mathematics and science. From early on, Lovelace showed a talent for numbers and language. She received instruction from William Frend, a social reformer; William King, the family's doctor; and Mary Somerville, a Scottish astronomer and mathematician. Around the age of 17, Ada met Charles Babbage, a mathematician and inventor. The pair became friends and the much older Babbage served as a mentor to Ada. Through Babbage, Ada began studying advanced mathematics with a University of London professor Augustus de Morgan. Ada was fascinated by Babbage's ideas. Known as the father of computer, he invented the difference engine, which was meant to perform mathematical calculations. Together, Lovelace and Babbage worked on the theoretical principles of the Analytical Engine, a machine which Babbage had designed but was never finished in their lifetime. The engine was designed to perform vast quantities of complex calculations using a complicated mechanism of wheels and cogs, saving mathematicians a lot of time and effort. Lovelace realised that a calculating machine could be programmed in the same way as a weaving machine, using cards with holes punched in them in a specific arrangement. Lovelace was ahead of her time in this field, as she believed that computers held the capacity to do more than just simply act as calculators. Lovelace contributed some highly original ideas to how it could be used to automate very difficult mathematical processes. Babbage also created plans for another device known as the analytical engine, designed to handle more complex calculations.

Ada was later asked to translate an article on Babbage's analytical engine that had been written by Italian engineer Luigi Federico Menabrea for a Swiss journal. She not only translated the original French text in English, but also added her own thoughts and ideas on the machine. Her notes ended up being three times longer than the original article. Her work was published in an English science journal in 1843. Ada used only the initials "A.A.L.," for Augusta Ada Lovelace, in the publication. In her notes, Ada described how codes could be created for the device to handle letters and symbols along with numbers. She also theorized a method for the engine to repeat a series of instructions, a process known as looping that computer programs use today. Ada also offered other forward-thinking concepts in the article. For her work, Ada is often considered to be the first computer programmer. Ada's article attracted little attention when she was alive. Ada Lovelace's contributions to the field of computer

science were not discovered until the 1950s. Her notes were reintroduced to the world by B.Y. Bowden who republished them in *Faster Than Thought: A Symposium on Digital Computing Machines in 1953.* Since then, Ada has received many posthumous honors for her work. In 1980, the U.S. Department of Defense named a newly developed computer language "Ada," after Lovelace. Like many of the great women mathematicians in this article, Ada met with an early death; she was only 36 when she died due to uterine cancer in London on November 27, 1852. Today Lovelace is still remembered fondly as the first female computer programmer in an era before the modern computer came into existence.

SOFIA VASILYEVNA KOVALEVSKAYA (JANUARY 15, 1850 – FEBRUARY 10, 1891):

Sofia Kovalevskaya (various spellings found in different sources) was born in 1850 in Moscow, Russia to a family of minor nobility. She was raised by a very strict governess, which resulted in her being very nervous and withdrawn for most of her life. When she was very young, the walls of her room were covered in her father's old calculus notes, due to a lack of wallpaper. She studied these notes, as well as discussed abstract and mathematical concepts with her Uncle Peter. Kovalevskaya's father did not believe women should be highly educated, so when she showed skill in mathematics, he told her to stop studying the subject. She continued to study mathematics, but hid it from her father and governess. At the age of fourteen, she taught herself trigonometry in order to understand a book that she was reading. The author of the book, also a neighbor to her family, was so impressed by Kovalevskaya's knowledge and skill that he convinced her father to let her study mathematics. After finishing secondary school, she wanted to continue her education. The nearest university that would accept women, however, was in Switzerland and unmarried women were not allowed to travel alone. So in September 1868, she married Vladimir Kovalevskaya. Two years later, she began to study under Karl Weierstrass at the University of Berlin. She was not allowed to officially register at the university, but she studied under Weierstrass for four years. In July 1874, she received her doctoral degree from the University of Göttingen. After having trouble finding work, she returned to her family in Moscow. In 1878, she and Vladimir had a daughter, and while at home taking care of her, Kovalevskaya worked on developing her literary skills, writing fictional stories, theater reviews and scientific articles. In 1880, she was still struggling to find work in the mathematics field, so she moved back to Berlin, but without Vladimir. Shortly after arriving there, she heard that Vladimir had committed suicide after all of his business ventures had collapsed. Kovalevskaya was devastated and threw herself into her work. She spent the next two years working on a research project in Berlin and Paris. In 1883, she was offered a five-year contract as a professor of mathematics at the University of Stockholm. In 1888, she entered her paper, *"On the Rotation of a Solid*

Body about a Fixed Point," in the Prix Bordin competition through the French Academy of Science and won the prestigious award for her profound theory. In 1889, she was elected an associate of the Imperial Academy of Sciences, a huge honor since a woman had never been elected before. Prior to her relatively young passing due to pneumonia, Kovalevskaya had published numerous papers on topics pertaining to mathematics and mathematical physics. Sofia Kovalevskaya fit the traditional views of a woman, and therefore struggled throughout her career to find acceptance in the field of mathematics. However, she is recognized for publishing many groundbreaking theories as well as laying a foundation for future mathematicians to build upon.

AMALIE EMMY NOETHER (MARCH 23, 1882 – APRIL 14, 1935):

Emmy Noether was born in 1882 in Erlangen, Germany. Noether was always interested in mathematics, but it wasn't until she finished her certification for teaching foreign languages that she decided to pursue mathematics as a career when the conditions for women in mathematics were improving then. Considered by Einstein to be the most important woman in the history of mathematics, Noether was an early twentieth century German mathematician with a passion for such areas as theoretical physics and abstract algebra. She was an accomplished university professor and a prolific writer of mathematical papers, as well as someone with a profound ability to grasp abstract thought. As the Nazi stronghold grew in Germany during the 1930s, Emmy found herself, like so many other Jewish professors, barred from teaching. Towards the end of 1933, Noether was able to escape Germany and took up a position at the American College of Bryn Mawr. She is most known for her work in abstract algebra, specifically rings, groups, and fields. The structure known as Noetherian rings was named in her honor. Noether changed the way mathematicians look at the subject and she cleared a path toward the discovery of new algebraic patterns that had previously been obscured. She was extremely involved in the development of an axiomatic approach to mathematics. Noether taught at Bryn Mawr College until her death in 1935, days after undergoing a surgery. After her death, Albert Einstein wrote in a letter to the New York Times, *"In the judgment of the most competent living mathematicians, Fräulein Noether was the most significant creative mathematical genius thus far produced since the higher education of women began. In the realm of algebra in which the most gifted mathematicians have been busy for centuries, she discovered methods which have proved to be of enormous importance in the development of the present day younger generation of mathematics"* (Osen 151). To this day Noether's many contributions towards mathematics and theoretical physics are highly revered, and many remain relevant to the math of the twenty-first century.

DAME MARY LUCY CARTWRIGHT (DECEMBER 17, 1900 – APRIL 3, 1998):

An accomplished British woman mathematician, Cartwright pursued her D.Phil in mathematics under the supervision of G. H. Hardy and E. C. Titchmarsh, and received the degree in 1930. Her thesis was on *"The Zeros of Integral Functions of Special Types."* After finishing at Oxford, Cartwright obtained a Yarrow Research Fellowship at Girton College, Cambridge University, where she continued her work on the theory of functions. During the 1940's Mary Cartwright worked with John Littlewood on the solutions of the Van der Pol equation and discovered many of the phenomena that later became known as "chaos". The two worked on solutions of the Van der Pol equation which describe the output of a nonlinear radio amplifier when the input is a pure sine-wave. The whole development of radio in the World War Two depended on high power amplifiers, and it was a matter of life and death to have amplifiers that did what they were supposed to do. The soldiers were plaqued with amplifliers that misbehaved and blamed the manufacturers for their erratic behavior. Cartwright and Littlewood discovered that the manufacturers were not to be blamed. The equation itself, as a matter of fact, was to be blamed. Cartwright had a distinguished career in analytic function theory and university administration, publishing more than 100 papers on classical analysis, differential equations and related topological problems. In 1935, she was appointed a lecturer in mathematics at Cambridge. She held the position of University Lecturer from 1935 until 1959, and then Reader in Theory of Functions from 1959 until her retirement in 1968. In 1947, Cartwright became the first woman mathematician to be elected as a Fellow of the Royal Society of England. She put forth a theorem regarding analytical function known as the Cartwright's Theorem. She was elected as President of the London Mathematical Society in 1951, received the Sylvester Medal of the Royal Society in 1964, the De Morgan Medal of the London Mathematical Society in 1968, and in 1969 became Dame Mary Cartwright (the female equivalent of a knighthood). After her retirement Cartwright held visiting professorships at universities in England, America, and Poland. She died in Cambridge on April 3, 1998.

JULIA HALL BOWMAN ROBINSON (DECEMBER 8, 1919 – JULY 30, 1985):

An American mathematician who was born in St. Louis, Robinson is known for her work regarding Hilbert's tenth problem and the field of decision problems. Though plagued by health problems for most of her life, Julia did not let this stand in the way of her love for mathematics and the pursuit of knowledge. As a mathematician, Julia Bowman Robinson will long be remembered for her many important contributions to questions of algorithmic solvability and unsolvability of mathematical problems, in particular for her part in the negative solution of Hilbert's "Tenth Problem." And,

despite her expressed wish, she will be remembered as the first woman to be elected to the mathematical section of the National Academy of Sciences in 1976, as well as the first woman to be president of the American Mathematical Society. She was a professor in mathematics at the University of California in Berkeley and was also elected to the American Academy of Arts and Sciences in the mid 1980's, just a few short years before she passed away from leukemia in 1985.

MARY FAIRFAX GREIG SOMERVILLE (DECEMBER 26, 1780 – NOVEMBER 29, 1872)

Mary Somerville taught herself mathematics at home because at that time girls didn't learn mathematics at school. She was married twice, and her second husband was interested in mathematics and science. He introduced her to all kinds of famous mathematicians who were amazed to find that she understood their work extremely well, which was more than could be said for a lot of the men working in mathematics at the time. In 1827, a friend asked her to translate a very important work by a French mathematician called *Laplace's Mecanique Céleste and Newton's Principia* (Osen 106) and she not only translated it, but added some original work and made it much easier for other people to understand. Her writing reached a larger audience by communicating the concepts clearly through simple illustrations and experiments that most people could understand. *The Mechanism of the Heavens* was a great success, probably the most famous of her mathematical writings. In recognition, a portrait of her was commissioned by her admirers in the Royal Society and placed in their great hall, now in the headquarters of the society in London. In the summer of 1825, she carried out experiments on magnetism and in 1826, she presented her paper entitled *"The Magnetic Properties of the Violet Rays of the Solar Spectrum"* to the Royal Society. The paper attracted favourable response and aside from the astronomical observations from the famous Caroline Herschel, it was the first paper by a woman to be read to the Royal Society and published in its Philosophical Transactions. Although the theory presented in her paper would eventually be refuted by the investigations of others, it however distinguished her as a skilled scientific writer who was respected among her colleagues. While in Europe for eleven months in 1832-1833, she largely completed her second book, which was published in 1834. With *The Connection of the Physical Sciences,* which was an account of physical phenomena and the connections among the physical sciences, came new scientific distinctions. She and Caroline Herschel were elected in 1835 to the Royal Astronomical Society, the first women to receive such an honor. In 1848, at the age of sixty eight, Mary Fairfax Somerville published yet another book, *Physical Geography*, a work for which she was preached against in York Cathedral, proved to be her most successful yet and was widely used in schools and universities for the next fifty years. She lived to complete two more works before her death in Naples in 1872. Her last scientific book, *Molecular and*

Microscopic Science, which was published in 1869 when Mary was eighty-nine, was a summary of the most recent discoveries in chemistry and physics. In that same year she completed her autobiography, of which parts were published by her daughter Martha after her death.

CONCLUSION

Many of the women mathematicians featured in this article were still quite restricted in what they were allowed to do and often depended on male collaborators to make their work seemed respectable. Thanks to their great success and determination, opinions have changed, although it happened very slowly. Today there are hundreds of thousands of women working in mathematics field, pushing the boundaries of knowledge and doing award-winning research. There are more opportunities and prospects now for the next generation of women in the mathematics field and we can expect to see bigger success and more recognition to be given for their great work.

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