

Research Article

Underrepresentation of Women in Science, Technology, Engineering and Mathematics (STEM)-Related Education and Careers in Sri Lanka

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Abstract

In Sri Lanka, females are underrepresented in some of the Science, Technology, Engineering and Mathematics (STEM)-related fields at the tertiary level of education and also in some of the STEM-related careers. This paper analyses available statistics of undergraduate and postgraduate students and that of STEM-related professions viz. engineers, university academics and scientists to identify in which STEM-related fields women are underrepresented. More importantly, a survey was conducted among the females, who were unemployed for at least a six months period or who are currently unemployed, with the aim of identifying the reasons for unemployment. In addition to the information related to unemployment of responders, their suggestions were obtained to identify the ways and means of creating a conducive work environment for females. Hence, results of the survey are presented and recommendations are given for making a better work environment.

Keywords: Science, technology, engineering, mathematics

1. Introduction

With the ever-changing global economy, current jobs are disappearing and new jobs are evolving as a result of the technological advancements. Consequently, competency development of students making them proficient to meet the future demands of the job market arises as a timely requirement. Hence, curricular, teaching and learning methodologies, and modes of communication and interaction between students and teachers need to be enhanced in association with novel technologies promoting innovations. STEM education plays a vital role to be successful in the new information-based and highly technological society (Technology and Innovation Statistical Handbook, 2013 – 2015). As initiatives have been taken to strengthen the role of women and minorities in STEM-related fields, understanding the female representation in STEM education and trends is important (Settles, 2014).

There are 22 numbers of state universities and higher educational institutes in Sri Lanka, for which the selection and assignment of students were done by the University Grants Commission (UGC) of Sri Lanka and 18 out of them offer bachelor degree programs in the fields related to STEM (University Grant

Commission, Sri Lanka., 2018). All those 18 universities or higher educational institutes offer Bachelor of Science degree programs in a wide range of disciplines viz. physics, chemistry, mathematics/statistics, information technology/ computer science, electronics, biology, agriculture, food science, radiography, fisheries & marine and animal science. Bachelor of Engineering Technology degree programs in the specialized fields of construction, electrical, mechanical & manufacturing, materials, and instrumentation & automation are offered by 9 universities. Only 6 universities offer Bachelor of Science in Engineering degree programs specialized in civil, chemical, computer, electronics, electrical, material, mechanical, biomedical, marine & naval architecture, earth resources, textile & clothing. Further, 11 universities offer Bachelor of Science degree programs specialized in mathematics, while one university offer Bachelor of Science (Joint Major) degree program with a major discipline of mathematics.

Table 1: Number of universities which have STEM – related degree programs

STEM-related Degree Program	Number of Universities
Bachelor of Engineering Technology	9
Bachelor of Science in Engineering	6
Bachelor of Science degree programs (Mathematics)	11
Bachelor of Science (Joint Major) (Mathematics)	1

Entrants to the state universities in Sri Lanka are selected based on the performance of the students at the G.C.E. (A.L.) examination. The minimum requirement to get selected for a state university in Sri Lanka is having a Simple Pass (S) for each of the three subjects and minimum mark of 30 (out of 100) for the Common General Paper. Approximately 65% of the school candidates sit for the G.C.E. (A.L.) examination get eligible for university entrance, as per the records of past 5 years (Department of Examinations, S.L., 2018). However, only about 19% of the students who meet the minimum requirements get the opportunity to be enrolled at a state university (University Grant Commission, Sri Lanka., 2012 - 2018). There are higher education institutes affiliated to foreign universities and private universities or campuses as well in Sri Lanka, which offer bachelor degree programs in Science, Technology, Engineering & Mathematics fields, but a course fee needs to be paid. The students who are affordable or get scholarships may enroll in overseas universities as well.

Male to female ratios in Sri Lanka and among university entrants are approximately 48.2:51.8 and 37.1:62.9 respectively (University Grant Commission, Sri Lanka, 2017 - 2018). It was a good indication for higher female representation in tertiary level of education. As per the records of past 5 years, 42% of the females who enter state universities enroll for degree programs in the arts stream while female

undergraduates are underrepresented in the fields of Engineering, Architecture and Technology (University Grant Commission, Sri Lanka, 2017 - 2018). The situation was worse in STEM-related careers due to various reasons. However, no research was conducted in the Sri Lankan context to identify and analyze the reasons for female underrepresentation of women in STEM-related careers, to the knowledge of the authors. In this research, statistics of women in STEM-related education were collected from various sources and analyzed as a background study in Section 2. Statistics related to women in STEM-related careers were also collected and the analytical results are presented. Section 3 demonstrated the online survey conducted to understand the reasons for underrepresentation of females in STEM-related careers in the Sri Lankan context. Results of the survey are presented and discussed in Section 3. Finally, the findings of the survey are concluded in Section 4.

2. Materials and Methods

2.1 Female Representation in STEM-Related Undergraduate Degree Programs

In this section, representation of females in undergraduate degree programs and postgraduate studies in the Sri Lankan context are compiled and analyzed. Statistics of university undergraduates were analyzed to identify in which fields women are underrepresented. University entrants for bachelor degree programs in previous years (2014 - 2017), based on the gender is shown in Figure 1 (University Grant Commission, Sri Lanka, 2015 - 2018). 62% of the students enroll for undergraduate degree programs annually in the recent past are females (University Grant Commission, Sri Lanka, 2017 - 2018). Data were further analyzed based on the stream for which the students enrolled. According to the statistics, females were underrepresented in the subject streams of Engineering & Architecture and Technology with a female percentage of 30% and 45% respectively (Figure 2). Females knowing that they have to bear more responsibility in the management of household and family in the Asian context get discouraged to enter these fields of study (Fernando *et al.*, 2018a). However, there was no significant difference in the way university academics intentionally treating the female students differently (positively or negatively) (Fernando *et al.*, 2018b). Even when the statistics of university graduates are considered, females are well represented with 67% (Figure 3). However, it was due to the higher number of females graduated with bachelor's qualifications in Arts, Management and Commerce. Therefore, it can be inferred that the majority (about 63%) of the students enroll for, and graduate with bachelor degree programs offered by state universities and higher educational institutes in Sri Lanka are females.

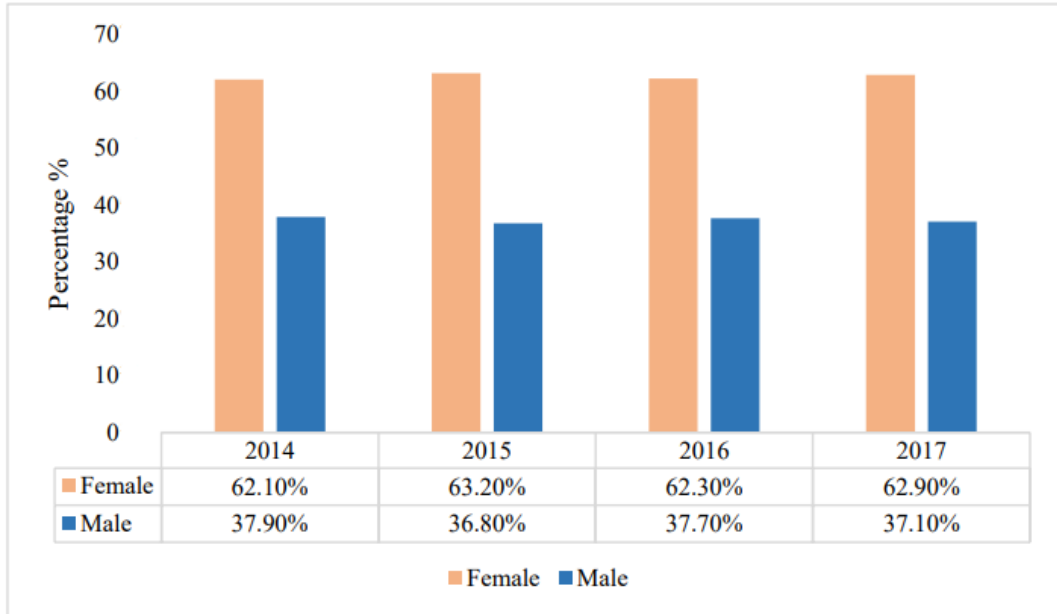


Figure 1: Female and male percentages of university enrolment of undergraduates in the recent past

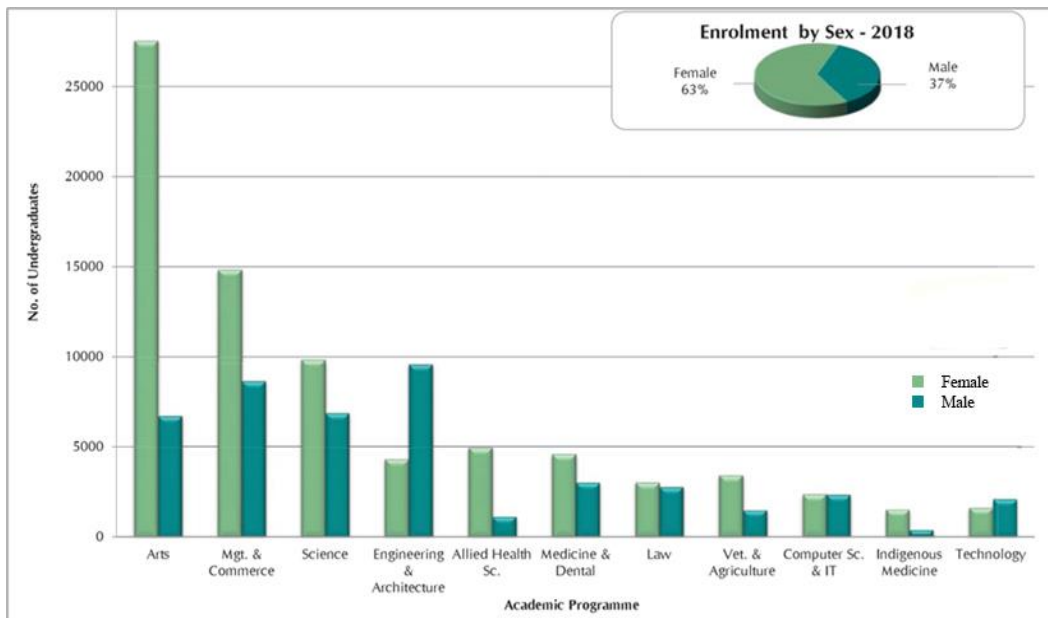


Figure 2: Male: female ratio of university enrolment of undergraduates in different streams (University Grant Commission, Sri Lanka, 2018)

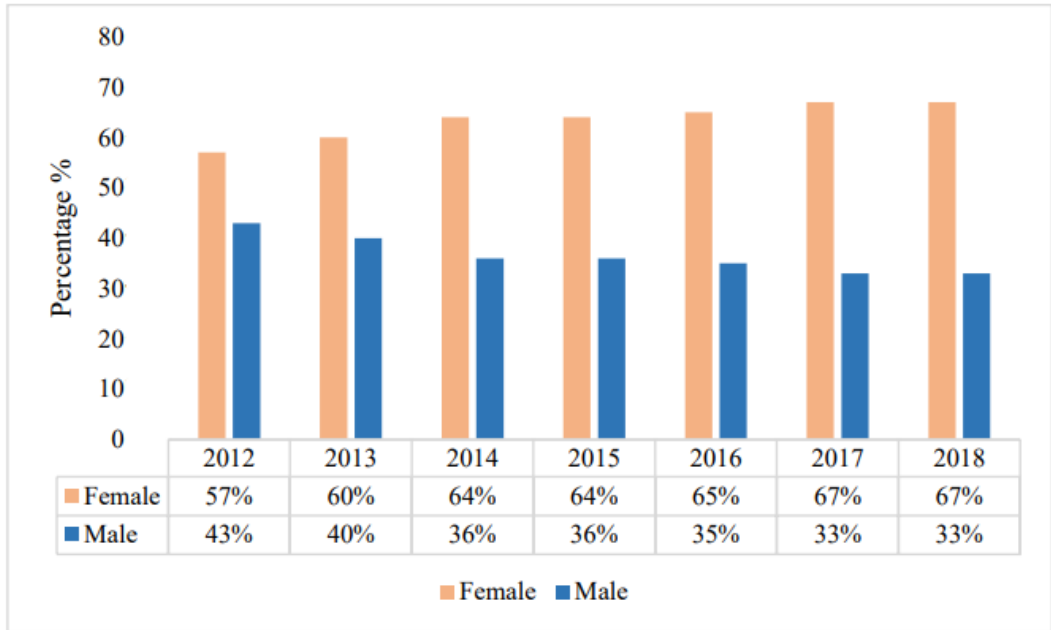


Figure 3: Female and male percentages of university graduates (2012-2018)

2.2 Female Representation in STEM-related Postgraduate Degree Programs

Statistics of postgraduate students were also analyzed to identify the gender representation among graduates, who continue studies after graduation. As per the statistics from 2012 to 2018, 22-31% of the students enroll at state universities of Sri Lanka are for postgraduate degree programs, while the rest are for bachelor degrees (University Grant Commission, Sri Lanka, 2012 - 2018). 83-87% of them enroll for master degree programs or postgraduate diploma programs. Enrolment for MD, MPhil and PhD were 5-7%, 6-10% and 2-3% respectively (University Grant Commission, Sri Lanka., 2012 - 2018). Among the postgraduate students, 44-48% are females. When master degree programs or postgraduate diploma programs are considered, 45-48% among them are females. Female representation in MD and MPhil programs are 44% and 45% respectively. Among doctoral candidates, female representation was lesser with about 40%.

2.3 Female Representation in STEM-related Careers

This section presents statistics of female representation in the STEM-related careers. Professions of engineer, scientist and university academic were studied, by using the available statistics or the survey results. Female scientists are underrepresented in all the fields (Figure 5), as per the statistics from 2010-2015 (Technology and Innovation Statistical Handbook 2013 - 2015). Accordingly, females represented 37-47% of the scientists' community in the recent past. Among the university academics

with no doctoral qualifications, 51.5% are females (Figure 5). The situation is different when the university academics with a doctoral degree are considered. Only 38% of them are females, as at 2018.

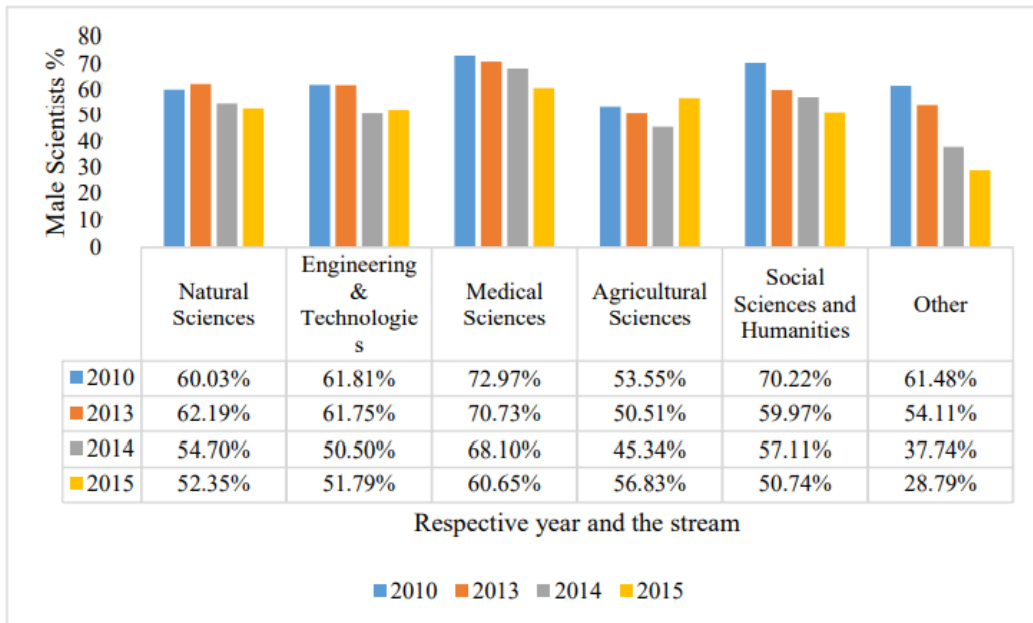


Figure 4: Male scientists’ percentages in different streams

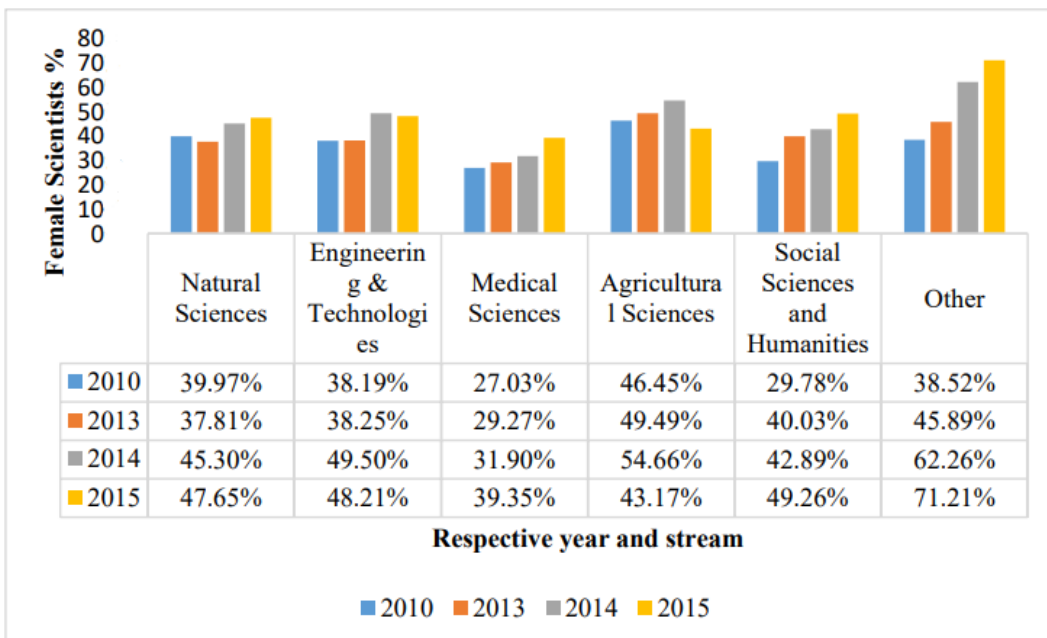


Figure 5: Female scientists’ percentage in different streams

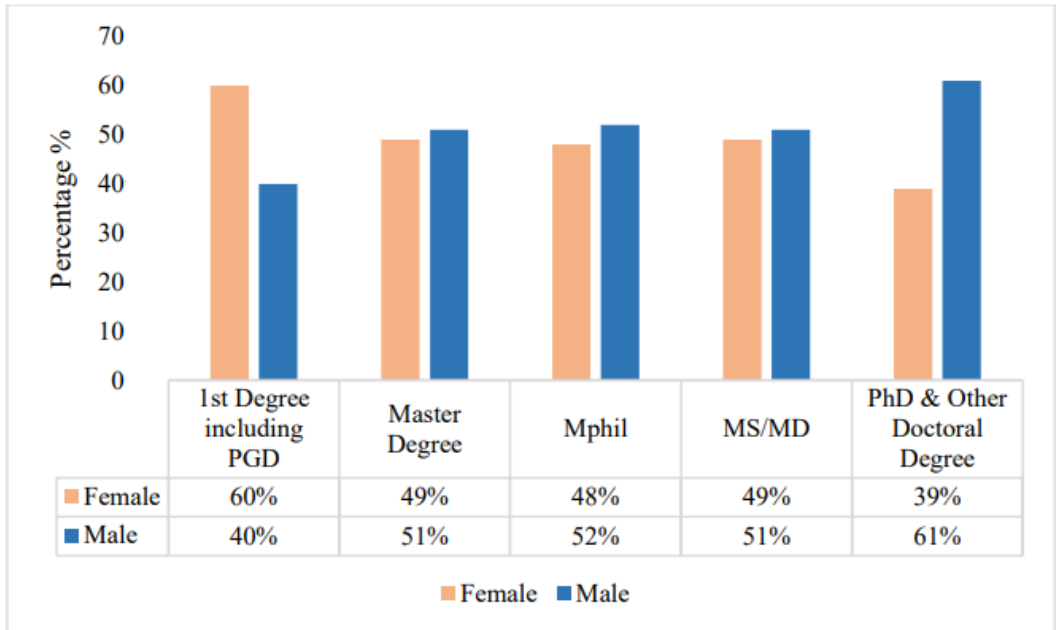


Figure 6: Female and male percentage of university academics

The first ever island-wide survey conducted to collect information of the female engineers living and working in Sri Lanka was carried out in 2017, and 435 women engineers responded voluntarily (Fernando, *et al.*, 2018a; Fernando, *et al.*, 2018b). The sample comprised of engineers working in the industry and academia, postgraduate students and entrepreneurs. According to the survey, 42% of the female engineers have postgraduate qualifications. Women Engineers’ perception of engineering as a profession was checked and 91% of women engineers think that engineering is a man’s world. 71% of women engineers would like to see a proportion of women need to be 40-50% in order to be considered gender-balanced, but 74% of the responders reported that the ratio of women: men in engineering is not balanced in engineering industries. Survey results conclude that devoting long hours for family commitments demonstrably affects the career progression of women engineers. Further, 71% of the responders believe that women engineers have to face more opposition than men in leadership positions. Further, 77% think that some men are not comfortable reporting to women.

Research conducted in STEM-related fields are reported. As per the findings of a research conducted in Europe, men are more likely to stay in STEM, while women leave the study area after completing the study. As a result, women are underrepresented in the leadership positions.

Female scientists tend to drop out of research earlier than men with similar qualifications because they are paid less, promoted less and win fewer grants (Nimmegern, 2016). A research conducted in United States of America found that at different stages of life, social and physiological factors create barriers women to enter the STEM-related careers (Nilanjana and Jane, 2014).

As the statistical analysis or survey results about female representation in the fields of engineering, academia and scientist presented above do not cover the scope STEM sufficiently, a survey was conducted. Women in Sri Lanka, who have a bachelor degree in a STEM-related field, but unemployed currently or earlier for a certain period of time was the target group in the survey. The primary objective of this survey was to identify the reasons for underrepresentation of women in STEM Careers, in employees' point of view.

One hundred and fifty female graduates qualified with a STEM-related bachelor degree were reached to collect information voluntarily and confidentially. Data were collected online via a questionnaire, for which the responses had to be given in writing. Personal data as well as information related family, education and work experiences were collected via multiple choice questions. Further, their experiences, views and suggestions were collected by giving open questions.

The age of the responders varies from 25-55 years (Figure 7) and the sample includes females with not only BSc qualifications, but also masters and PhDs (Figure 7). Based on the University of awarding the first degree, the sample represents state universities namely University of Colombo, University of Sri Jayewardenepura, University of Moratuwa, University of Peradeniya, University of Ruhuna, University of Kelaniya, Wayamba University of Sri Lanka, Uva Wellassa University of Sri Lanka, Rajarata University of Sri Lanka and Eastern University of Sri Lanka. Further, there were responders from other higher education institutes, namely London Metropolitan University (ESOFT), NSBM Green University, Sri Lanka Institute of Information Technology (SLIIT), University of Westminster (IIT), Edith Cowan University, University college of Dublin (NIBM).

3. Results and Discussion

The sample is diverse in terms of the age, educational qualifications and field of specialization. About 40% of the sample represents married females, while the rest are unmarried. Further, 20% of the responders in the sample have children. The sample well represents all four STEM fields and performance at the first degree according to the online survey (Figure 7).

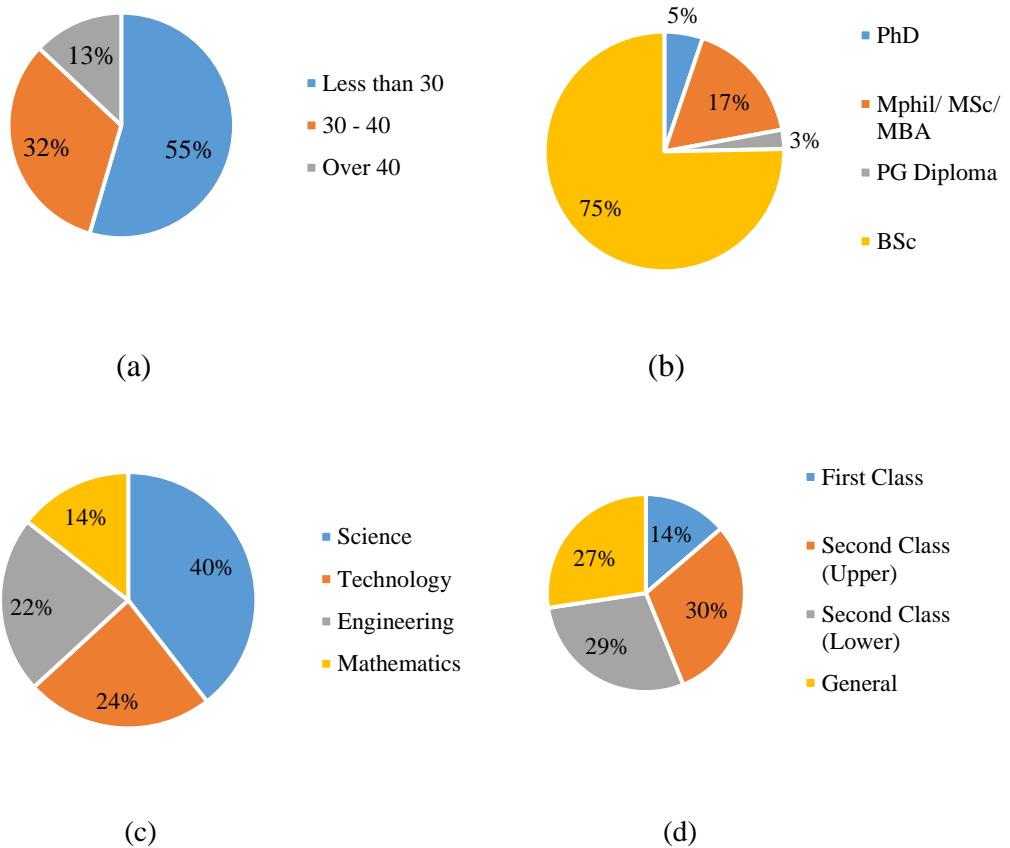


Figure 7: Analysis of responders' information. (a) Age (b) Highest educational qualification (c) The relevant STEM field (d) Performance at the first degree.

Out of the participants who responded voluntarily, 55% are currently unemployed, while the rest were unemployed for at least a six months period in the past after graduation. Only 5.5% of the responders commented that they are unemployed by choice, while all the others prefer to be employed.

Out of the responders who were unemployed for a certain period of time, only 40% were unemployed for more than 6 months soon after graduation. The majority left from the job after being employed for a certain time period and were unemployed for at least a 6 months period.

The reasons for unemployment were also investigated in the perspective of unemployed women. The major reason as per the comments given by 52% of the responders was family commitments, followed by low salary and travelling problems as highlighted by 44% and 36% of the responders respectively. The other reasons were inflexible working hours, high workload and problems they faced at the workplace, as experienced by less than 30% of the responders. As the mother has to

take the responsibility of household activities and childcare in the Sri Lanka perception, a considerable number of females had to leave from the jobs giving priority to their family, as indicated by the responders. Though employees in government, semi-government and academic sectors are paid with no gender discrimination due to transparency of pay scales, the situation at private sector is sometimes gender biased as they experienced. Travelling problem may be common to both males and females due to the under developed public transportation system in Sri Lanka. Working hours of almost all government and semi-government institutions are fixed, while some private organizations allow flexible working hours, as found.

The responders have given numerous suggestions to create a conducive work environment for females. The highest demand was flexible working hours as suggested by more than half of the responders, followed by equal opportunities stressed by 45%. Females may get a better chance of balancing family and work if working hours will be flexible. Equal opportunities may encourage competent women to climb the ladder and reach career goals. Further, 39% of the responders stressed the importance of having no gender discrimination at the work place. It may also encourage retention of STEM women, as they experienced. Providing facilities such as transport and day care were also proposed to create a conducive work environment for females. Moreover, juniors can be trained to adapt through proper mentoring by women in leadership positions.

4. Conclusions

As per the statistics of UGC, Sri Lanka, female undergraduates are underrepresented in the subject streams of engineering, architecture and technology, while female representation in all the other subject streams is at least 50%. In contrast, females are underrepresented in all the fields at postgraduate studies. In the STEM-related careers of engineer, university academic and scientist, females are underrepresented. Family commitments is the major reason for STEM females' unemployment as commented by 52% of the responders, followed by low salary commented by 44% of the sample. As per the results of a survey conducted under this research, travelling problems, inflexible working hours and high workload are the other significant influential factors for the unemployment of females in STEM-related careers. More than half of the responders, suggested flexible working hours to encourage female employees. Another major effective way suggested by the responders is giving equal opportunities encouraging competent women to climb the ladder and reach career goals. Eliminating gender discrimination at the work place and providing facilities such as transport and day care were also proposed by a considerable number of responders to create a conducive work environment for females.

5. Acknowledgement

The authors acknowledge the females who participated as responders in the survey.

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