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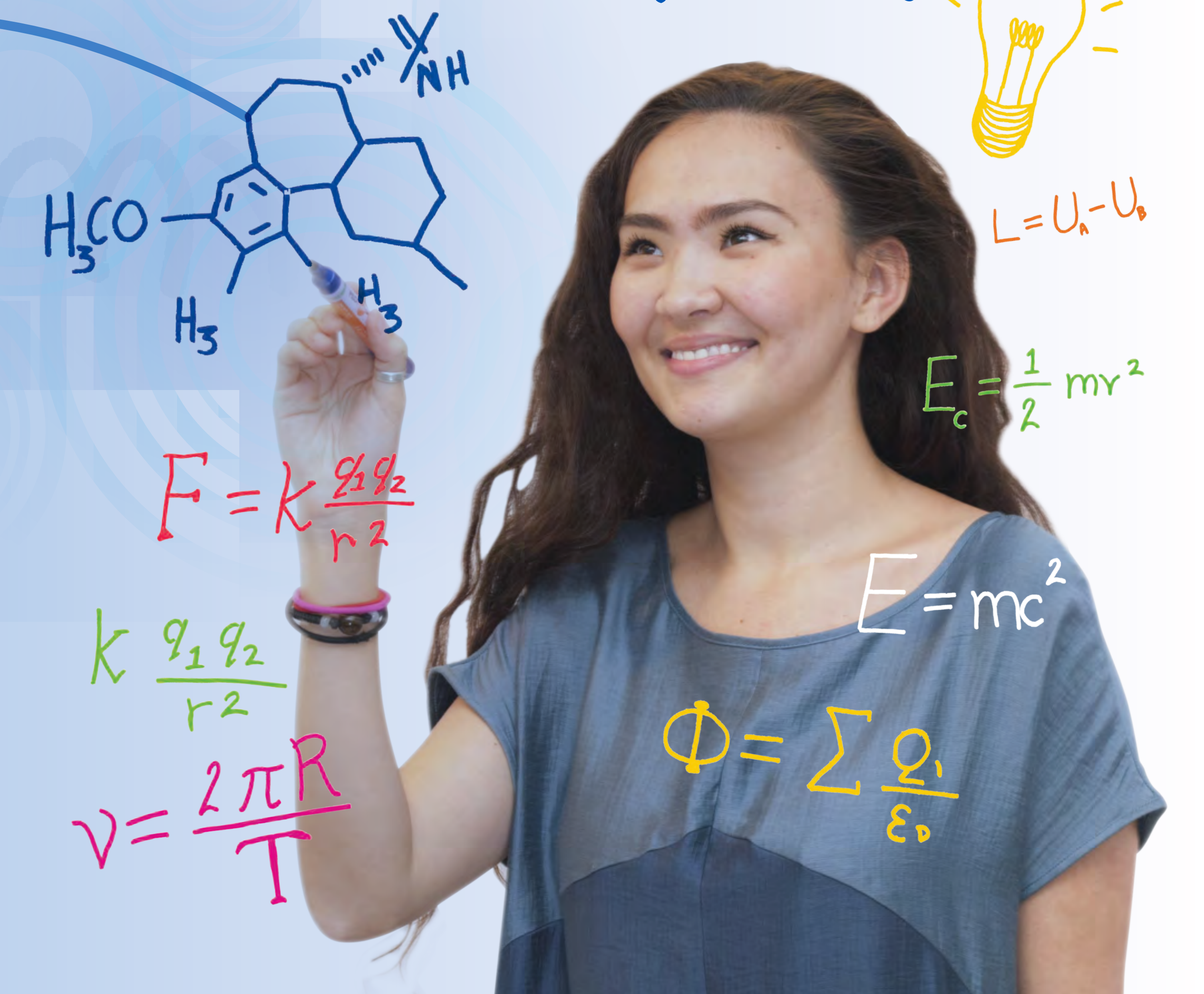
A Complex Formula



Girls and Women in Science, Technology, Engineering and Mathematics in Asia

A Complex Formula

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Foreword

In today's fast-paced and ever-changing world, new opportunities for growth and development occur alongside new challenges to peace and security. On the one hand, we enjoy the benefits of technological advancement in communication, travel and innovation. On the other, we bear witness to the growing threat of climate change, global health epidemics, migration, mounting poverty and increased income inequality. Our world today requires of us to find solutions to exploit opportunities for sustainable and inclusive growth and mitigate these simultaneous threats. But when we look into the fields of Science, Technology, Engineering and Mathematics (STEM), we must increase our capacities to cope with these persisting challenges, and for that we need to increase women's participation in STEM fields.

To help encourage more girls and women to pursue careers in STEM, UNESCO has been working to promote their integration in STEM fields through its work in education. In particular, UNESCO has driven the For Women in Science Programme which today represents 16 years of collaboration with the L'Oréal Corporate Foundation. It is an initiative which recognizes and celebrates the achievements of female science researchers in addressing the opportunities and challenges taking place in our world today.

To support our efforts, this report, *A Complex Formula: Girls and Women in Science, Technology, Engineering and Mathematics in Asia*, asks the fundamental question: what may influence the choices of girls and women to pursue STEM fields of study and occupations?

Through analysis of female participation in these fields, learning achievement and educational, psychosocial and economic influences, it answers three important questions with regard to girls and women in STEM: Where do we stand? What led us here? Where to from here? This report, which focuses on seven country studies in Cambodia, Indonesia, Malaysia, Mongolia, Nepal, the Republic of Korea and Viet Nam, is a significant report for us here in Asia, one which provides the foundation for further study and policy formulation in this region and beyond. Ultimately, the report tells us that ***early and targeted intervention through education can greatly facilitate girls' and women's increased participation in STEM fields***.

While we continue to promote STEM fields among girls and women, we commend this report for exploring the deeper influences and uncovering new solutions for attracting more girls and women into STEM. It is our wish that all women pursue freely their career ambitions with confidence, without fear of prejudice, with joy and with a thirst for new knowledge. May this report help build the greater foundation for this here in our region. Finally, we would also like to express our heartfelt thanks to the many students, teachers and all others who contributed to this study, who through their stories have enriched this report.

Gwang-Jo Kim
Director
UNESCO Bangkok

Myung-Sun Lee
President
KWDI

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This regional synthesis report was prepared by a team led by Ramya Vivekanandan Rodrigues of UNESCO Bangkok. The report was written by Aliénor Salmon with inputs from the UNESCO Bangkok review team, including Gwang-Chol Chang, Ramya Vivekanandan Rodrigues, Tserennadmid Nyamkhuu and Antony Tam. The report was edited by Rachel McCarthy and technical assistance was provided by Ratchakorn Kulsawet, while Akané Nozaki and Warren Field are gratefully acknowledged for their support with publication preparation and graphic design respectively.

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Acronyms

APEC
Asia-Pacific Economic Cooperation

ASEAN
Association of Southeast Asian Nations

BCG
Boston Consulting Group

DoHE
Directorate of Higher Education (Indonesia and Nepal)

EFA
Education for All

GENIA
Gender in Education Network in Asia-Pacific

GPI
Gender Parity Index

GPN
National Average Grade (Malaysia)

GSO
General Statistics Office (Viet Nam)

IBO
International Biology Olympiad

ICT
Information and Communication Technologies

IIEP
International Institute for Educational Planning

ILO
International Labour Organization

IMO
International Mathematical Olympiad

IOI
International Olympiad in Informatics

KEDI
Korean Educational Development Institute

KICE
Korea Institute for Curriculum and Evaluation

KWDI
Korean Women's Development Institute

MDGs
Millennium Development Goals

MEDS
Ministry of Education and Science (Mongolia)

MoE
Ministry of Education (Malaysia)

MoEC
Ministry of Education and Culture (Indonesia)

MoEYS
Ministry of Education, Youth and Sport (Cambodia)

MoHE
Ministry of Higher Education (Malaysia)

MoHR
Ministry of Human Resources (Malaysia)

MoNE
Ministry of National Education (Indonesia)

MoSTI
Ministry of Science, Technology and Innovation (Malaysia)

MSIP
Ministry of Science, ICT and Future Planning (Republic of Korea)

NAEA
National Assessment of Educational Achievement (Republic of Korea)

NGOs
Non-Governmental Organizations

NIS
National Institute of Statistics (Cambodia)

OECD
Organisation for Economic Co-operation and Development

PISA
Programme for International Student Assessment

PMR
Lower Secondary Assessment (Malaysia)

PT3
Form 3 Assessment (Malaysia)

SEAMEO
Southeast Asian Ministers of Education Organization

SPM
Malaysia Certificate of Education (Malaysia)

STEM
Science, Technology, Engineering and Mathematics

TIMSS
Trends in International Mathematics and Science Study

UGC
University Grants Commission (Nepal)

UNESCO
United Nations Educational, Scientific and Cultural Organization

UNDP
United Nations Development Programme

UNGEI
United Nations Girls' Education Initiative

UPSR
Primary Achievement Test (Malaysia)

WISET
Center for Women in Science, Technology (Republic of Korea)

“ ***I was first interested in science*** *when I started primary school. What touched me was the wonder of living creatures. Growing up in the countryside, I saw tadpoles become frogs and watched the metamorphosis of caterpillars into butterflies – all these beautiful creatures that took flight before my eyes. It was these early adventures that led me to study biology and still inspire my love of experimentation.*

At school, I was drawn to science subjects because they allowed me to think and experiment independently. Sometimes teachers and parents have a certain mindset that STEM-related subjects are not necessary for girls, and they do not encourage them to work hard. But even when girls are self-motivated, they have a tendency to give up easily and admit self-defeat if they are not satisfied with their achievement. When I was in upper secondary school, my homeroom teacher was a teacher of physics. He talked about the attractiveness of ‘scientific fun’ and his attitude and words fuelled my passion. My parents also encouraged me to do well in all classes and when I decided to study science at university, they were very supportive, however my grandparents were not happy at all.

In Japan, there are very few women studying science, or in academic societies, so that took some time for me to get used to. But once people recognized my presence, they began to give me the impression that they were listening to what I said, even though I was the only woman. This made me feel at ease in openly discussing things. Before that, I always hesitated to put my words forward as I felt anxious and isolated in a male-dominated environment. To get recognition, I focused on the business *results of my work, which was research and so I worked hard to publish as many papers as I could. I also feel that I had unique experiences as a woman, for instance I could talk openly to high-ranking men from academic societies or universities, since they did not usually consider women as competition. However, female researchers often work in administration and management which are not directly related to our field of expertise, and having more women involved would change the atmosphere of discussions to become more fruitful and successful. This is why we need to hire and promote more women in Science, Technology, Engineering and Mathematics (STEM) in all societies.*

There are still a number of issues in getting women into STEM, but we need to remember that STEM fields are incredibly vast. We can exclude life sciences including biological sciences and see that the fields with the least women are more often mathematics, physics, engineering, informatics, and chemistry. We need more role models, and more female teachers in STEM-related subjects at the secondary level. Girls need to develop an attitude to be self-motivated and learn independently, and it also depends a lot on improving students' and parents' attitudes to be more familiar with STEM fields to overcome the fear of their daughters obtaining a job in the future. ”

Kayo Inaba

University of Kyoto, Japan
Asia-Pacific Laureate of the 2014 L'Oréal-UNESCO
For Women in Science Awards

Executive Summary

"When I first wondered why the sky is blue, or rather, when I started asking questions – those are my earliest memories of my passion for science. Everything was a wonder then!" – Jingmei Li

2014 UNESCO-L'Oréal International Fellowship Winner, Singapore.

Our world today faces a multitude of increasingly interlinked challenges. Climate change, global health epidemics, demographic changes, pressures from rapid technological advances and unprecedented inequality are but some of our most pressing concerns. In this context, the technical knowhow and capability to uncover new solutions to overcome these challenges requires advanced skills in Science, Technology, Engineering and Mathematics (STEM).

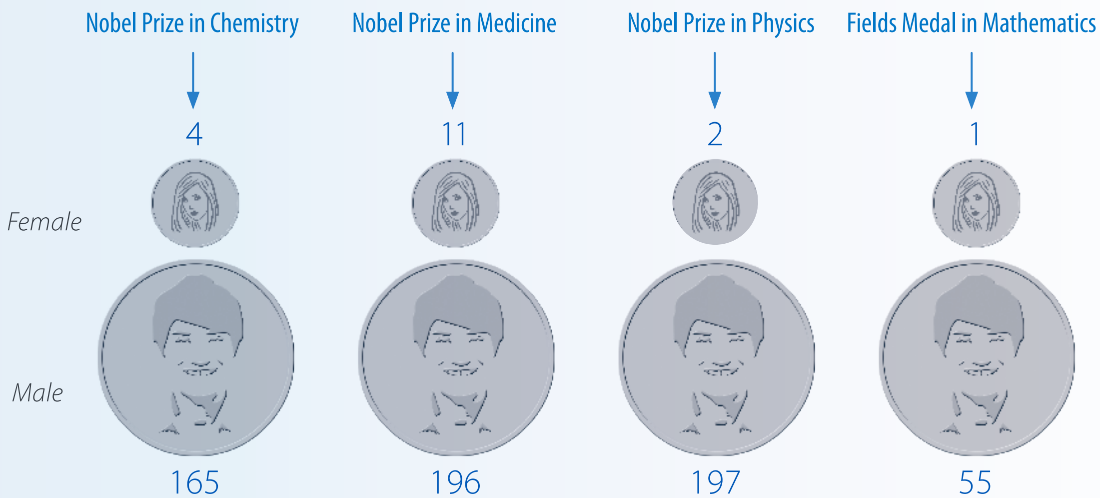
Despite this, there exists a serious labour shortage in STEM fields, particularly among women. Indeed, in the Asia-Pacific, a global survey indicates that as of 2014, the region faces 'talent shortage' of 45 per cent, with the most in-demand categories mainly comprising STEM-related occupations (ManpowerGroup, 2014). It is also estimated that globally, women represent less than 30 per cent of researchers in science, technology and innovation (UIS, 2014a).

This is reflected in the most prestigious awards in STEM fields – including the Nobel Prize in Chemistry, Medicine and Physics, as well as the Fields Medal in Mathematics – where awards to women are few and far between (see **Figure 1**). With a global labour shortage in STEM fields, and with women representing approximately half the world population, one may consider the magnitude of untapped potential and talent at a time in which STEM fields are all the more important.

As we arrive at the target date for achievement of the Education for All (EFA) Goals and the Millennium Development Goals (MDGs) in 2015, it is important that the post-2015 development agenda reflects a number of areas related to the context of this study, such as learning achievement and more broadly the quality of education, as well as the importance of STEM sectors in their contribution to economic and social development. While there has been remarkable progress in achieving gender equality both in terms of access to and achievement in education (IIEP, 2012), a lack of gender parity from the secondary level onwards persists in many countries of the world (UNESCO 2014a).

These are no easy questions given the diversity of Asia and the differing obstacles to attracting more girls and women to STEM fields across different countries. Nonetheless, the dearth of research and understanding and the significant need for increasing numbers of women in STEM, justifies a thorough investigation into

Figure 1 *Number of female and male Nobel Laureates and Fields Medallists in STEM-related fields*



Source: Nobelprize.org, 2014; IMU, 2014

this area. This report thus aims to address the lack of information in the area of gender, learning achievement and progression to study and work in STEM fields in Asia, as well as enhance knowledge and inform policy among education stakeholders and policymakers. Combining existing data with the views and perspectives of young people in the region, this report focuses on seven countries in Asia – Cambodia, Indonesia, Malaysia, Mongolia, Nepal, the Republic of Korea and Viet Nam, while drawing upon relevant examples from other countries of the region.

Ultimately, this report reveals that gender differences in STEM fields do not start in the labour market, nor even in higher education – they begin in student performance as young as 15 years old. In countries where the gender gap in student performance at the secondary education level is at the expense of girls, women tend to be underrepresented in STEM fields of study in higher education and in the labour market. Girls also tend to do relatively better in science as opposed to mathematics at the secondary level, which may explain why females prefer to choose science-related fields of study in higher education and occupations, such as biology, chemistry and medicine as opposed to more mathematics-oriented fields such as physics and engineering. Although these differences are impacted by wider sociocultural and labour market preconceptions, education has a significant role to play to address this problem: 1) by stimulating interest among female students in STEM-related subjects, 2) by ensuring that educators are equipped to take more gender-responsive approaches and encourage female students to pursue STEM fields, and 3) by taking policy measures that are conducive to increasing the number of women in these fields. Stimulating, encouraging and supporting fair and equal opportunities for girls and boys to perform in STEM-related subjects at school, therefore, would equate to more girls and women in STEM fields of study in higher education and the world of work.

In reaching this conclusion, this regional synthesis report asks three fundamental questions with regard to girls and women in STEM – Where do we stand? What led us here? Where to from here?

Where do we stand?

While differences across country contexts are undeniable, a number of major challenges can be identified when it comes to the participation of girls and women in STEM fields across Asia. In some countries, access to higher education for young women remains a challenge in itself. This was especially true for Cambodia, for instance. In others, a higher proportion of females may be enrolled, yet remain the minority in specific disciplines within STEM such as physics, mathematics and engineering such as in Malaysia, Mongolia and the Republic of Korea. Despite increasing access to higher education for girls, this does not always translate to participation in STEM fields of study. Globally, data shows that despite increased parity in enrolment at the Bachelor's[1] level (or equivalent) in higher education, in STEM disciplines male students outnumber female students in 91 per cent of countries with available data (UNESCO, 2010b, p. 5). Findings from the OECD also argue that young women are far less likely to opt for STEM fields of study at the Bachelor's level, and this only declines further from the Master's level and above (OECD, 2011, p. 2).

This also raises important questions as to the possible linkages between participation in higher education and student performance at the upper secondary level with regard to STEM-related subjects such as mathematics and science. Looking at this age range, the gender gap in student performance in the results of both international and national assessments also shows variances by country, while among the highest performing students, such as those participating in International Olympiads for instance, very few females were identified across all countries.

Turning to the seven country case studies, three major findings were identified with regard to female participation in higher education and gender differences in learning achievement in mathematics and science:

Female participation in STEM fields in higher education varies by country, with females often concentrated in certain disciplines, and their participation falling as the level of education increases.

First looking at the proportion of female graduates in science programmes in tertiary education in Asia, data shows that as of 2011, this stood at 59 per cent in Malaysia as opposed to just 11 per cent in Cambodia as of 2008 (UIS, 2014c). Looking more closely at national data within STEM disciplines among the seven countries, a higher proportion of females are found in certain disciplines such as pharmacy, medicine and biology yet remain underrepresented in others such as computer science, physics and engineering. For instance in Malaysia, which among the seven countries showed the highest proportion of female graduates in science programmes, 72 per cent of students enrolled in pharmacy were female, as opposed to just 36 per cent of students in engineering as of 2012 (MoHE, 2013). As of 2013 in Mongolia, 73 per cent of students enrolled in biology were female as opposed to 30 per cent in computer science and just 24 per cent in engineering (MEDS, 2013). With a similar situation identified among other countries, this indicates that further analysis

1 The levels of higher education cited in this publication reflect the 2011 International Standard Classification of Education (ISCED) as developed by the UNESCO Institute of Statistics.

may be required to better understand the low participation of women in specific STEM disciplines such as computer science, physics and engineering. Among those women who are enrolled in STEM fields however, data shows that the proportion of female students tends to fall as the level of education increases beyond Bachelor's level or equivalent within and beyond STEM fields of study. As of 2011 in the Republic of Korea for instance, while the proportion of females enrolled at Bachelor's level stood at 52 per cent in science and 19.5 per cent in engineering, at doctoral level female enrolment was 38 per cent in science and just 12 per cent in engineering (WISET, 2014).

Learning achievement among females and males in mathematics and science is mixed. Yet females are significantly underrepresented among the highest levels of achievement.

In international assessments such as the Programme for International Student Assessment (PISA) for instance, results show that overall females appear to be increasingly catching up to males in STEM-related subjects, particularly in science. At the same time a more noticeable difference in achievement is observed in mathematics – either in favour of boys or in favour of girls – showing very different patterns with regard to the gender gap in achievement both among the highest and lowest performing countries. According to PISA 2012 results for instance, boys outscored girls in mathematics by 18 points in both Japan and the Republic of Korea – two countries that rank among the highest performing, whereas girls outscored boys by 8 points in Malaysia and by 14 points in Thailand – two countries which perform below the OECD average (OECD, 2014).

According to a study analyzing PISA results over ten years, it appears that the most prominent gender gaps occur at the highest levels of performance with boys outperforming girls markedly (Stoet and Geary, 2013). When it comes to student participation in prestigious competitions in STEM-related fields such as the International Olympiads for instance, data shows that in the year 2014, female medallists, and more generally female contestants, were significantly underrepresented. For instance, the percentage of female contestants stood at just 4 per cent for informatics, 5 per cent for mathematics and 6 per cent for physics, yet it reached an average of 28 per cent in biology among countries in the region, the latter reflecting the findings on female enrolment within STEM disciplines in higher education (IBO, 2014; IOI, 2014; IMO, 2014; IPhO, 2014). Even among delegations from countries where learning achievement in mathematics and science is largely in favour of female students, this was not reflected. In delegations from Malaysia and Thailand for instance, there were no female contestants in the International Olympiads in informatics or physics (IOI, 2014; IPhO, 2014).

There are linkages between gender differences in learning achievement and female participation in STEM fields of study in higher education.

Based on the analysis in this report, linkages can be identified between gender differences in learning achievement in mathematics and science and the proportion of females entering STEM fields of study in higher education. For instance in countries where the gender gap in achievement is in favour of boys, it appears that a comparatively lower proportion of females are enrolling or graduating in STEM fields of study as opposed to countries where the gender gap in achievement is in favour of girls. At the same time, data on female participation in STEM fields in higher education, even among countries that show a higher degree of participation, shows that they tend to be concentrated in specific disciplines within STEM. This implies that a number of wider influences may be at play beyond learning achievement and enrolment issues.

How did we get here?

Educational impacts

At the policy level, specific gender-sensitive or STEM-related policy frameworks on education are difficult to identify, and where they exist, it is difficult to see how far these have been implemented. Looking more broadly at how educational aspects may influence interest in STEM among female students, the following findings have been identified:

There are fewer female teachers in STEM-related subjects and at higher levels of education.

At the school level, there are a limited number of female teachers in mathematics and science subjects, which limits the number of role models for female students in learning these subjects. Out of 20 classes observed in Nepal as part of this research, eight out of ten teachers were male in science classes, and nine out of ten teachers were male in mathematics. Even in countries that have seen the increased feminization of the teaching profession, the proportion of female teachers tends to drop, across all fields of study, as the level of education increases. In the Republic of Korea for instance, data from 2013 shows that while the proportion of female teachers stood at 99.2 per cent at the pre-primary level and 78.2 per cent at the primary level, they made up 46.7 per cent of teachers at the upper secondary level and just 34.1 per cent in higher education, and we may only assume that these rates would be lower in STEM-related subjects.

Gender-responsive teacher training in STEM-related subjects is lacking.

The findings also indicate that there is a lack of teacher training policies to properly prepare teachers in STEM-related subjects through gender-responsive teaching strategies. This was reflected in the findings based on the data collected from classroom observations for the purpose of this study. While broadly there appeared to be equal treatment of both female and male students by teachers in mathematics and science classes, different patterns were identified in some cases. For instance in Indonesia, female students were shown to be more engaged and to participate more actively in asking questions that their male peers. In Cambodia however, it was found that while female students tended to give more correct answers, they demonstrated higher levels of reluctance, shakiness and anxiety in answering questions, with some female students even waiting until the class was over to ask specific questions to their teachers. In Viet Nam, while male students seemed less confident in presenting in front of the classroom, the number of interactions between teachers and male students were far higher than with female students, averaging at 65 per cent for mathematics and 61 per cent for science. This indicates that gender-responsive teacher training in these subjects could help address the different needs and behaviours of female and male students.

Resources and equipment can stimulate interest among girls in learning STEM-related subjects.

Looking more closely at teaching strategies, there is a need for gender-responsive teacher training with regard to STEM. In addition, availability of resources and equipment for the teaching of

STEM-related subjects cannot be underestimated in enhancing students' ability to access practical 'hands-on' and creative activities. According to findings from a study in Cambodia, the provision and use of science labs can not only have a positive impact on student participation and interest, but could also help overcome preconceived notions of girls' inability to perform well in science (Kelley et al., 2013). Arguably, the increased resources for experiments, which offer the opportunity for students to apply their knowledge in practice, could help stimulate interest among female students to potentially pursue these disciplines in further study.

Teaching and learning materials still permeate gender stereotypes.

The content of teaching and learning materials, particularly textbooks, continues to permeate gender stereotypes in the ways in which they portray the roles of females and males with regard to STEM-related subjects. In Indonesia, while the content of the 2013 curriculum in mathematics and science is considered gender-sensitive, the learning materials used in its implementation could be considered quite the opposite (Sani, 2014). An extract from a Grade 7 science textbook for instance shows students learning science, all of them being male. In another example from a Cambodian Grade 9 science textbook, an illustration on the central nervous system and the different functions of the brain depicts males as thinking and exercising as opposed to females who are depicted as smelling flowers and tasting food. Indirectly, it could be inferred that this illustration communicates subtle messages regarding the most basic human functions (Szmodies and Eng, 2014).

More girls are receiving private tutoring, especially in STEM-related subjects.

The gender dimension of private tutoring in mathematics and science also provides some interesting insights into the relationship with learning achievement in a region with persisting competition in education, a phenomenon partially driven by examinations at school and systems levels (Bray and Kwo, 2014). According to the questionnaire results in the seven countries, a higher proportion of female students are receiving private tutoring across all subjects in all of the seven countries, with the exception of Cambodia and Viet Nam where female and male students appear to receive private tutoring in near-equal numbers. A similar pattern is observed when looking specifically at STEM-related subjects and in some cases shows an even higher proportion of female students. Of all students surveyed in the Republic of Korea for instance, only female students reported receiving private tutoring in physics. The overall higher number of female students receiving private tutoring could perhaps indicate that girls need more support, or that girls feel greater anxiety with regard to their performance in these subjects.

Gender-responsive career counselling, scholarship and mentoring opportunities remain limited.

Turning to career counselling, scholarship and mentoring opportunities, it appears that there are limited gender-responsive initiatives to attract more female students into STEM fields in most countries. In countries where scholarships to pursue STEM fields of study do exist, they may not always take female students into consideration. For instance in Indonesia, the proportion of students who received scholarships for further study in STEM fields was slightly higher for male students at 8.65 per cent as opposed to 7.76 per cent for female students (Statistics Indonesia, 2013). In the Republic of Korea, however, some scholarships for students to pursue STEM disciplines include quotas in order to increase opportunities for female students (MSIP, 2014b). Greater opportunities for gender-sensitive career counselling in schools, scholarships as well as mentoring opportunities for young female professionals would arguably help not only attract but also retain more females in STEM fields.

Psychosocial Influences

Psychosocial aspects can significantly impact upon female participation in STEM fields. The importance of these influences in shaping student attitudes, achievement and eventually participation in STEM fields has been increasingly recognized through a growing body of research. In particular, studies point to the need to recognize the vulnerability of female students to the threat of negative stereotypes and the importance of students developing a 'growth mindset' where capability or talent is developed over time – it is not predetermined at birth (Hill, Corbett, and St Rose, 2013). Related to the wider issue of negative stereotype threat, the gender dimension of student interest and attitudes towards mathematics and science may not only affect learning achievement in these subjects but also choices for further study and careers. According to a 2011 OECD report on gender equality in education, employment and entrepreneurship, it appears that gender differences in these choices could be more influenced by psychosocial aspects such as motivation, confidence and perseverance than by one's ability or performance (OECD, 2011, p. 2). This study considered these influences, particularly through the collection of primary data in the seven countries, which brought about a number of key findings:

There are gender differences in subject preferences and perceived performance.

Based on the results from the student questionnaire conducted as part of this study, it appears that while female and male students often choose mathematics and science among their most enjoyed subjects, mathematics is more likely to appear among the most enjoyed for males, and science subjects are more likely to appear among the most enjoyed subjects for females. At the same time, mathematics is also more likely to appear among the lowest perceived performance and science among the highest perceived performance subjects for female students. This indicates that male students appear to prefer mathematics whereas females appear to prefer science, which to a certain extent may be consistent with the patterns observed in the gender differences in achievement in international assessments.

Females may experience higher rates of anxiety around mathematics and science subjects.

Looking at student attitudes towards mathematics and science subjects in terms of interest, perceived importance, confidence, anxiety, as well as motivation and perseverance, different findings arose among the seven countries. The questionnaire results showed that females may experience higher rates of anxiety around mathematics and science subjects. This appeared to be consistent across all countries where the gender gap in participation and learning achievement was either in favour girls or boys in mathematics and science. This suggests that even when females perform better in mathematics and science, they may experience higher anxiety towards these subjects than their male counterparts.

The importance of parental and teacher encouragement cannot be underestimated.

Parental and teacher encouragement with regard to mathematics and science can impact student attitudes towards these subjects, and could provide an important area for further investigation. Based on the questionnaire results, female and male students equally perceived encouragement from their parents and teachers as important. Analysis from Cambodia also shows that based on the results of the questionnaire, correlations exist between the perceived importance of parental encouragement towards mathematics and science and the student's perceived importance of those subjects. Parental and teacher encouragement, therefore, could be fundamental for all students in addressing environmental and psychosocial influences which have so far limited the participation of women in STEM fields.

Labour market effects

Women's participation in STEM fields within the labour market, and more broadly the status of women in the workplace also play a significant role. A number of factors however, continue to limit women's participation in these fields. With this in mind, the major findings from this study include:

Lower female participation in STEM fields equates to fewer female role models for girls.

The lower participation of women in STEM fields means that there is a lack of female role models in STEM, which can further affect young women's choices for further study and their future careers in STEM fields. An OECD study argues that this is one of the greatest barriers to attracting women and girls into occupations that may traditionally be viewed as predominantly male (OECD, 2011, p. 28). Increased exposure to female role models could potentially help alleviate the negative stereotypes faced by female students with regard to these fields (Hill, Corbett, and St Rose, 2013, p. 41). Estimates show that women make up just 30 per cent of science researchers globally (UIS, 2014a), and the OECD argues that the lack of professional role models for young women in STEM professions could be a factor influencing lower levels of participation (OECD, 2011, p. 28). There also appears to be a mismatch within STEM fields that females are choosing to pursue as opposed to those for which there is demand. For instance in Mongolia, female STEM professionals may find themselves unemployed due to lack of demand in certain STEM fields, while at the same time the country is facing a high demand for engineers due to its booming mining sector (Khishigbuyan, 2014). In other countries such as the Republic of Korea, data shows that female graduates in STEM fields are also less likely to be employed than their male counterparts.

Female participation in the labour market and wages remain unequal.

Economic and development indicators across the seven countries under review, including female participation in the labour market and wage differences between women and men are still unequal across all fields of work. Even in cases where the female labour participation rate is high, unequal wages persist. For instance in the case of Nepal, where the female labour participation rate stands at 80 per cent, wage differences are calculated at 0.62 on a scale from zero to one, with one representing equality (World Bank, 2013; World Economic Forum, 2014). By contrast, in Malaysia where the labour participation rate is the lowest at 44 per cent, the equality in wages is the highest among the seven countries at 0.80 (Ibid).

Women are concentrated in specific occupations within STEM.

> "We need more role models, and more female teachers in STEM-related subjects at secondary level. Girls need to develop an attitude to be self-motivated and learn independently, and it also depends a lot on improving students' and parents' attitudes to be more familiar with STEM fields to overcome the fear of their daughters obtaining a job in the future" – Kayo Inaba
>
> Asia-Pacific Laureate of the 2014 L'Oréal-UNESCO For Women in Science Awards, Japan

Looking at participation within STEM fields, women appear to be concentrated in specific occupations – a similar pattern to enrolment of female students in STEM by field of study in higher education. Here, a higher proportion of women work in professions related to medicine or biology as opposed to a low proportion of women working in physics or engineering, which relates to the proportion of female students enrolled in these respective fields of study in higher education. In Malaysia for instance, 72.9 per cent of pharmacists are female as opposed to just 10.6 per cent of professional engineers (DoHE, 2014). In Indonesia, the Gender Parity Index (GPI)[2] among senior STEM researchers receiving grants in the year 2013 was 1.8 in biology and just 0.1 in physics (Directorate of Research and Community Services, 2014).

Women are concentrated at lower levels and ranks within STEM occupations.

Women are also concentrated at lower levels and ranks within STEM occupations, where they are less likely to reach higher level positions. In the case of the Republic of Korea for instance, women are more likely to be in non-regular or temporary work, which can greatly affect their prospects for promotion to higher level positions. At the same time, it appears that limited support offered to women working in STEM fields may affect retention as well as progression in these fields due to the difficulties faced in maintaining a balance between family responsibilities and professional life – a balance which could also be shared by male scientists.

Gender differences in learning achievement and the number of female researchers in STEM fields are likely related.

When looking at women's participation in STEM fields, it appears that there may be a link between learning achievement in mathematics and science and the proportion of female researchers in science, technology and innovation. Countries which have a higher proportion of female researchers, for instance

2 The gender parity index (GPI) is the most common measure of gender parity in access to education for female and male students where the figure 1 would constitute perfect gender parity, whereas a figure below 1 would show access in favour of male students and above one in favour of female students.

in Malaysia (49 per cent) and Thailand (51 per cent), girls tend to outscore boys in these subjects in international assessments (UIS, 2014d). In countries where a lower proportion of researchers are female such as the Republic of Korea (17 per cent) and Japan (14 per cent), boys tend to outscore girls in mathematics and science (Ibid).

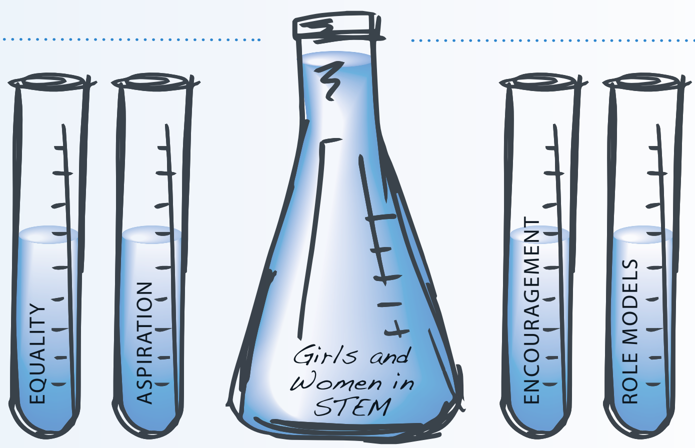
Where to from here?

As these findings illustrate, women are poorly represented in STEM fields of study and occupations in most, if not all countries under analysis. This trend is not surprising, given the dearth of female representation in STEM worldwide and the concerning statistics regarding female 'talent shortage' in STEM related fields of occupations. Findings here have also demonstrated the multivariate factors and influences contributing to the lack of engagement of women in STEM: educational, psychosocial and economic, and their compounding nature; these factors undoubtedly intersect to inform and shape attitudes as part of an ongoing feedback loop.

This is not to suggest that these factors are irreversible and the greater engagement of women in STEM study and occupation is somehow out of reach. On the contrary, the identification of these multivariate factors allows one to critically assess how their impacts may be carefully unwound. The following provides a summary of the key recommendations governments and policymakers of Asia may consider in addressing this important shortage:

- Further data **disaggregated by sex** is needed to conduct in-depth analysis at country level and help provide a clearer picture of women and girls' participation within STEM, which will inform policies and programmes for increased participation of women in STEM-related education and employment sectors such as engineering and physics.
- **Gender-responsive action from governments**, through education and labour market policies, enforcement of gender-related laws, as well as specific initiatives for advocacy and awareness raising, is needed to attract more women and girls into STEM fields.
- In order to ensure the effective implementation of policies related to education, gender and/or STEM, **coordination between ministries** should be strengthened. This may involve joint programmes across various government sectors such as ministries of education, women's affairs or gender equality, science, technology and innovation, as well as labour.

Figure 2 *How can we get more girls and women into STEM?*



- **Curricula and learning materials** should undergo further rigorous review from a gender perspective to ensure that they do not perpetuate gender stereotypes. This would ideally involve a representative group of stakeholders with male and female experts in order to ensure different perspectives.
- **Teacher education and policies on recruitment** must ensure a fair representation of both male and female teachers in all subjects, including mathematics and science, at all levels of education and especially in higher levels of education where students look to their teachers as role models as they begin to shape career perspectives and choices.
- Teacher education, be they pre- and in-service programmes, should be transformed to ensure that teachers are trained in **gender-responsive teaching strategies** so that female and male students can develop their full potential in STEM-related subjects.
- Appropriate funding for **equipment and resources** should be allocated in order to stimulate student interest in mathematics and science, particularly among female students. Allowing students to practically apply their learning in real-life situations as well as creative and hands-on experiments will not only contribute to enhancing the quality of learning but also increasing student interest in learning these subjects.
- Structured and formalized **gender-responsive career counselling** programmes should be considered in order for both female and male students to have support and objective guidance as they begin to shape their career choices.
- **Scholarship programmes** targeted at women and girls in STEM would also contribute to increased opportunities for young women to pursue further study and eventually careers in STEM fields.
- Promoting more **female role models in STEM** fields, whether female teachers in mathematics and science at the secondary level, female students and faculty members in higher education, and more broadly more women working in STEM fields, is an important strategy to attract women and girls into STEM fields.
- Finally, adequate **support programmes and initiatives for female STEM professionals** would help to address some of the factors which can cause them to discontinue their careers, including family responsibilities. This will also help them be equipped with the most up-to-date knowledge and skills in fields which experience fast-paced change and innovation.

Conclusion

This study has looked to address the significant gap in literature on girls and women in STEM in Asia by analyzing a number of factors with regard to their participation and achievement in STEM fields through case studies in seven Asian countries. While the findings demonstrate a serious gender gap with far too few women engaged in STEM fields of study and occupations, this report also points the way for greater action to help address these gaps and ensure women are not sidelined from further study and pursuing a career in fields, in which they could contribute with equal talent, enjoyment and passion. Indeed, if women are to stand alongside men as equal contributors in the building of just, peaceful and prosperous societies, they must be ensured the equal opportunity to learn in all areas, including STEM fields. Addressing the fundamental educational, psychosocial and economic influences that have traditionally inhibited their participation in these fields requires careful analysis, policy action and advocacy to help ensure greater gender equality in STEM, and for young women to have the equal opportunity to pursue further study and careers in any field they wish to pursue in Asia and beyond.

1 Introduction

"It is harder to crack a prejudice than an atom" – Albert Einstein

Gender disparities in learning achievement, particularly in mathematics and science, have been subject to intense policy debates in the field of education (Griffin and Nguyen, 2011). Although the latest results from international assessments such as the Programme for International Student Assessment (PISA) show that boys continue to outperform girls on average, this gap varies by country and tends to be narrow, especially in science (OECD, 2014). While girls are increasingly perceived as 'catching up' to boys in terms of performance in these subjects at the secondary education level, this does not always lead to the furtherance of these subjects or related fields of study at the level of higher education and eventually to flow on career choices in Science, Technology, Engineering and Mathematics fields (STEM).[3] At the same time, as demand continues to rise for professionals in STEM (ManpowerGroup, 2014), these remain fields in which women are largely underrepresented, making up less than 30 per cent of researchers globally (UIS, 2014a).

Studies indicate that while there may be gender equality in achievement at the primary and lower secondary school level with regard to STEM-related subjects, the proportion of female students opting for these subjects rapidly declines at every stage of upper secondary and higher education, as does the proportion of women choosing to pursue careers in STEM fields and advancing to the highest positions (Hill et al., 2013). Based on the findings from a study conducted in 14 countries[4] (BCG, 2014, p.1), it is estimated that on average, female students in upper secondary have a 35 per cent probability of enrolling in STEM, an 18 per cent chance of graduating with a Bachelor's degree in a science-related field, an 8 per cent probability of graduating with a Master's degree in science, and a 2 per cent probability of becoming a Doctor in science. By contrast, the probabilities for males are 77, 37, 18, and 6 per cent respectively.

In terms of the most prestigious awards in STEM fields, only a small proportion have been awarded to women. Looking at the Nobel Prize for instance, out of 199 laurates in Physics, 169 in Chemistry and 207 in Medicine, there were only two female laureates in physics, four in chemistry and 11 in medicine between 1901 and 2014 (Nobelprize.org, 2014). The Fields Medal, which was initiated in 1936 and is considered the most prestigious prize in mathematics, was only obtained for the first time by a woman, Maryam Mirzakhani from

3 Note that a precise definition or categorization of disciplines or occupations within STEM may differ from country to country. For the purpose of this study, STEM refers to a broad definition including natural sciences, computer science and engineering as well as medical science.

4 This citation refers to findings based on 14 countries analyzed: Argentina, Brazil, China, Egypt, France, Germany, India, Indonesia, Japan, Morocco, South Africa, Spain, United Kingdom and the United States.

Iran, in 2014 out of a total of 56 medallists (IMU, 2014). At the same time, data on student delegations participating in STEM-related International Olympiads[5] also shows that female students have been and continue to be largely absent, and even more so among medallists (Ellison and Swanson, 2010; Jones, 2006).

While overall access and participation in STEM fields of study may reflect one aspect of the gender gap, STEM fields are vast, with stark differences in levels of participation in fields such as biology or medicine, as opposed to other fields where they remain far less represented such as chemistry, physics and engineering, among others (Hill, Corbett, and St Rose, 2013). This raises important questions with regard to the factors which may affect young women and men's interest and performance in mathematics and science subjects, their prospects of progressing to study STEM fields in higher education, and eventually in pursuing a career in STEM.

As we arrive at the target date for achievement of the Education for All (EFA) Goals and the Millennium Development Goals (MDGs) in 2015, it is important that the post-2015 development agenda reflects a number of areas related to the context of this study, such as learning achievement and more broadly the quality of education, as well as the importance of STEM sectors in their contribution to economic and social development. There has undeniably been remarkable progress in achieveing gender equality both in terms of access to and advancement in education (IIEP, 2012). As of 2011, however, globally only 60 per cent of countries had achieved gender parity in primary education, and a mere 38 per cent of countries had achieved parity in secondary education (UNESCO, 2014a). In Asia, a number of contrasting characteristics can be identified. In some countries reviewed in this report, such as Malaysia and Mongolia, a reversed 'gender gap' can be observed as enrolment rates at secondary and higher education are now higher for girls than for boys (UNGEI, 2012). Other countries in the region, however, show that a substantial gender gap remains with girls making up just 41 per cent of students enrolled in secondary education in Pakistan and just 34 per cent in Afghanistan as of 2011 (UNESCO, 2014b).

Looking more closely at performance in mathematics and science through a 'gender lense', this stark contrast can also be identified in the results of international assessments. In the Republic of Korea for instance, both 2012 PISA results as well as 2011 results in the Trends in International Mathematics and Science Study (TIMSS) show that boys outscore girls in mathematics and science, whereas in Thailand girls outscore boys in mathematics and science (OECD, 2014). Perhaps relatedly, the proportion of female researchers in science stands at 51 per cent in Thailand as opposed to 17 per cent in the Republic of Korea (UIS, 2014a). At the same time, a global annual talent survey conducted by ManpowerGroup indicates that as of 2014, the Asia-Pacific has a regional talent shortage of 45 per cent,[6] reaching 81 per cent in Japan alone, and with the most in demand categories comprising mostly STEM-related jobs with engineering in first place (ManpowerGroup, 2014).

This report seeks to explore the various factors that influence female and male student performance, interests, and perspectives on study and career choice in STEM fields, by:

5 International Olympiads are held each year in various fields, where each participating country usually sends a delegation of 4-6 highest achieving upper secondary students

6 A talent shortage refers to a shortage of labour in terms of specific skills and abilities.

1. Examining: a) the participation of female and male students in STEM fields of study in higher education, b) the performance of female and male students in mathematics and science in international and national assessments, and c) the proportion of women and men working in STEM fields;
2. Exploring the educational, psychosocial and labour market influences on girls' learning achievement and progression to STEM in higher education, and;
3. Analyzing the ways in which education can contribute to ensuring equal opportunity for female and male students in STEM to help inform education policy.

With a global labour shortage in STEM fields and with women representing approximately half the world population, one may consider the magnitude of untapped potential and talent and the influential factors preventing girls from pursuing careers in STEM where they could potentially thrive, and for which they may exert genuine passion, given the right support and encouragement. To address this issue, one of UNESCO's flagship programmes for the promotion of women in science can be found in the 16-year collaboration between UNESCO and the L'Oréal Corporate Foundation through the 'For Women in Science Programme'. Every year, this programme seeks to provide recognition to women who have contributed to scientific excellence in their commitment and passion through the L'Oréal-UNESCO For Women in Science Awards which are awarded to one laureate per continent. In addition, the UNESCO-L'Oréal International Fellowships are granted to 15 promising young female scientists. Serving as crucial role models for young women across the globe, stories from the 2014 Laureate as well as from one International Fellow from Asia are included in this report.

While there is a growing body of research stemming mainly from North America and Europe, there is limited research on gender and STEM in Asia. Given the region's diverse landscape in women's participation and female students' performance in education, this report aims to address the knowledge gap in the area of gender, learning achievement and progression to STEM in Asia, as well as enhance knowledge and inform education stakeholders and policymakers. Combining a range of existing data with the views and perspectives of young people in the region, this report primarily focuses on seven countries in Asia – Cambodia, Indonesia, Malaysia, Mongolia, Nepal, the Republic of Korea and Viet Nam, while drawing upon relevant examples from other countries in the region. This report is the second in a series of studies undertaken as part of a three-year research project conducted by the UNESCO Asia and Pacific Regional Bureau for Education (UNESCO Bangkok), in partnership with the Korean Women's Development Institute (KWDI). It draws on the findings of the first study entitled *Gender, Jobs and Education. Prospects and Realities in the Asia-Pacific* published in January 2014, which examined the gender dimension of career interests, perspectives and choices in the Asia-Pacific region.

Report Structure

This report first outlines the research methodology designed for this study in Chapter Two. It then briefly presents the sociocultural background of the seven countries under review, before focusing on access and participation in STEM in higher education in Chapter Three. Chapter Four explores the issue of learning achievement and performance in mathematics and science in international assessments, results of the 2014 International Olympiads in STEM-related fields, as well as the results of national assessments where available. Education policy, teaching and learning conditions, private tutoring, career counselling as well as scholarship and mentoring opportunities are then analyzed in Chapter Five. Chapter Six considers psychosocial influences, including student attitudes, self-belief, motivation and aspiration towards mathematics and science subjects. Labour market effects, including the proportion of female professionals in STEM fields both by occupation as well as by type of employment are then examined in Chapter Seven. Finally, Chapter Eight reflects findings presented in the previous chapters in order to provide policy suggestions, while Chapter Nine provides a conclusion to this report.

2 Research Framework

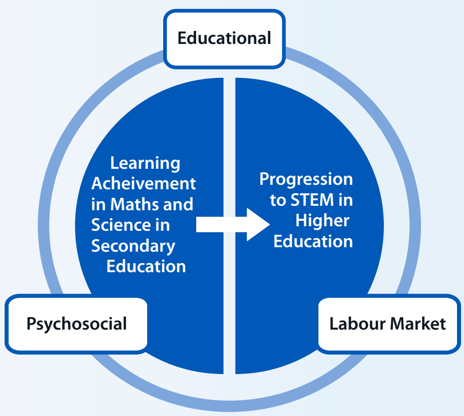
This report presents the research findings of a desk study prepared by UNESCO Bangkok which examined the current global and regional situation of girls and women in STEM, in addition to in-country research. Seven countries were reviewed across various sub-regions of Asia – Cambodia, Indonesia, Malaysia, Mongolia, Nepal, the Republic of Korea and Viet Nam. The report also draws upon relevant findings from other countries in the region and beyond. The selection of countries reflect those proposed for review by the Korean Women's Development Institute (KWDI) including Cambodia, Indonesia and Viet Nam, as well as four other countries, Malaysia, Mongolia, Nepal and the Republic of Korea, included by UNESCO for a wider regional review. Overall, the selection of these seven countries was made in order to:

1. Reflect countries with different income levels, for instance high income (Republic of Korea), upper middle income (Malaysia), lower middle income (Indonesia, Mongolia and Viet Nam), and low income countries (Cambodia and Nepal);
2. Reflect different geographical distributions and various sub-regions of Asia, for example, Central Asia (Mongolia), East Asia (Republic of Korea), South Asia (Nepal), and Southeast Asia (Cambodia, Indonesia, Malaysia and Viet Nam);
3. Examine more generally different cultural backgrounds and perspectives. In addition, countries from Asia that currently participate in international assessments such as PISA and TIMSS are referred to in Chapter Four of this report, which of the seven countries reviewed, include Indonesia, Malaysia, Viet Nam, and the Republic of Korea. Across these seven countries, different social and cultural contexts, contrasting issues with regard to gender, learning achievement and the varying proportions of women in STEM fields are reflected.

Analytical Framework:

The analytical framework for this study informed both regional and in-country research. This is displayed in **Figure 3** where learning achievement in mathematics and science, as well as student progression to study STEM fields of study in higher education, are influenced by three main dimensions – educational, psycho-social and labour market influences.

Figure 3 *Analytical framework: the gender dimension of learning achievement and progression to STEM*



In-country research was carried out by national researchers to provide a detailed analysis based on the analytical framework provided (Figure 3) and three main research methods:

1 Desk studies;

2 Student questionnaire; and

3 Classroom observations.

Country reports adopted the following outline:

1. Country **background**, focusing on participation in education by sex at the secondary level and in STEM fields of study at higher education as well as in technical and vocational education.
2. Analysis of **learning achievement** by sex, based on the results of international assessments for countries participating in PISA and TIMSS, as well as existing structures and results of assessment in mathematics and science at the national level.
3. **Psychosocial factors**, including sociocultural norms and attitudes towards girls' education, particularly in mathematics and science, women working in STEM fields, as well as parental attitudes.
4. A current picture of the **labour market**, including the proportion of women working in STEM fields, career progression and existing government or private sector employability schemes to encourage more students to work in STEM.
5. **Educational factors**, in terms of education policies and programmes on girls' education and initiatives promoting girls' learning in mathematics and science; the school environment with regard to teacher attitudes, analysis of teaching and learning materials, and activities intended to enhance learning in these subjects; career orientation, including the role of teachers and the school, as well as existing career counselling and scholarship programmes.
6. **Reflections and analysis**, with the aim of analyzing the possible links between the different factors explored in previous chapters while keeping in mind the country context.
7. **National level policy recommendations**, in order to identify overarching regional as well as country-specific issues.

Methodology

The research methodology consisted of both qualitative and quantitative methods based on secondary and primary data mainly comprising:

1 Literature review of national policy documents, national data, existing research and relevant publications;

2 Questionnaire administered to 15-year-old female and male secondary students in both urban and rural areas; and

3 Classroom observations conducted in both mathematics and science classes between Grades 7-9.

In all seven countries, the data collection took place between June and September 2014. Data disaggregated by sex was collected where available. National researchers were also provided with detailed research guidelines including research methods and analysis tools, which were designed by the research team at UNESCO Bangkok, and then adapted by national researchers to suit the local context.

These included guidance on sample selection, ensuring that both female and male students were equally represented, as well as urban and rural areas within different cities, provinces and districts across the seven countries. Locations were then selected in each country based on these guidelines and are displayed in **Table 1**.

Table 1 *Urban and rural research locations by country*

Country	Urban	Rural
Cambodia	Phnom Penh, Kampong Chhnang, Preah Sihanouk.	Kampong Chhnang, Kampong Speu, Kandal.
Indonesia	Jakarta, Medan, Palembang, Makassar, Samarinda.	Pangkalan susu, Perdagangan, Indralaya, Stabat, Babalan, Tebing Tinggi, Lumbung, Percut.
Malaysia	Kuala Lumpur, Petaling Jaya, Seri Petaling.	Alor Setar, Kulim, Jitra.
Mongolia	Ulaanbaatar (Sukhbaatar, Bayangol, Nalaikh districts).	Selenge, Sukhbaatar (aimag centre and Munkhkaan soum), Dornod, Tuv aimags (provinces).
Nepal	Kathmandu, Kavrepalanchowk, Chitwan.	Kathmandu, Kavrepalanchowk, Chitwan.
Republic of Korea	Seoul and Gyunggi provinces.	Gyunggi and Chungchung Namdo provinces.
Viet Nam	Dong Da, Hoang Mai, and Hai Ba Trung (Ha Noi province); Ngo Quyen, Hai An (Hai Phong province).	Kien Thuy, Tien Lang, An Lao, Vinh Bao, Thuy Nguyen (Hai Phong province).

Desk Study

The regional desk study, which was conducted by the research team at UNESCO Bangkok, involved the review of a broad range of literature including analysis of global, regional and country-specific policy documents and reports, as well as relevant social, economic or psychology studies. National researchers also conducted a desk study at the country level to further explore national data obtained from national statistics offices and relevant national ministries such as ministries of education, labour, social affairs, ministries working on women and gender equality, as well as policy documents including national education policies, teacher policies and training materials, curricula, and studies on classroom practices related to the theme of this study. The country level desk study also included documents in national languages that reflect the country context and social perceptions, as well as pertinent data which may be currently unpublished and was collected through either informal or formal interviews with relevant stakeholders.

The purpose of the desk study, both at the regional and country level, was to analyze all documents from a gender perspective focusing on learning achievement and transition to STEM in higher education. Within this context, the specific purpose of the desk study is as follows:

- Outline the regional and country contexts, in particular sociocultural factors impacting on gender and STEM;
- Assess the regional and country situation through national statistics and indicators that relate to gender and education, the labour market, learning achievement, and STEM in higher education;
- Identify any potential sociocultural, psychosocial, educational and labour market factors related to gender and STEM from existing studies, and;
- Explore what actions governments and other stakeholders such as non-governmental organizations (NGOs) and the private sector are taking with regard to gender, learning achievement and STEM.

Student Questionnaire

A student questionnaire was developed by the research team at UNESCO Bangkok in order to obtain the views and perspectives of 15-year-old[7] female and male students with regard to mathematics and science, as well as perspectives on future study and career plans. The questionnaire (**Annex 1**) was designed to cover attitudes, perceived importance and performance in mathematics and science, as well as motivation, perseverance and confidence of students with regard to these subjects.[8] The questionnaire was then translated into local languages by national researchers, and adapted as necessary, for instance in listing curricular subjects that are specific to that country. The minimum sample size was suggested by UNESCO based on the feasibility of data collection given time and resources. For the questionnaire this consisted of 100 students per country, comprising 50 female and 50 male students, each including 25 students each from urban and rural areas. In some cases this sample varied slightly, such as in Cambodia (total of 100 students, 53 female and 47 male students) and in the Republic of Korea (total of 90 students, 45 male and 45 female). The suggested school and student samples provided to countries are outlined in **Table 2**.

A simple questionnaire analysis sheet was provided in order to ensure the usability and comparability of the questionnaire results across the different countries. This sheet enabled national researchers to record responses to questions by sex and by urban/rural location, while additional analysis was included within country reports. Responses to open questions were also recorded by national researchers by analyzing the frequency of responses by sex and summarizing those most commonly given.

Table 2 *School and student sample per country*

		Urban	Rural	Total
School sample (total of 10 public schools)		5 *(1 school from each district)*	5 *(1 school from each district or administrative unit)*	10
Classroom sample (total of 10 classrooms)		5 *(1 classroom from each school)*	5 *(1 classroom from each school)*	10
Student sample (total of 100 students in 8-9th grade (or equivalent for students that are 15 years old)	Female	25 *(5 female students from each classroom)*	25 *(5 female students from each classroom)*	50
	Male	25 *(5 male students from each classroom)*	25 *(5 male students from each classroom)*	50

7 Students 15 years of age were chosen for the survey because this: a) corresponds to the age at which international assessments are taken; b) reflects the age at which students in most countries are at a crossroads with regard to the end of basic education; and c) reflects different expectations in forming choices on further study and careers for 15 year old girls and boys in different sociocultural contexts.

8 Some of the questions in this questionnaire have been adapted from the OECD's PISA 2012 survey, which can be found at: http://www.oecd.org/pisa/pisaproducts/PISA%202012%20framework%20e-book_final.pdf

Table 3 School and classroom sample for classroom observations

Classroom observations				
Grades	8-9th grade (or equivalent for students that are 15 years old)			
Schools	Urban		Rural	
	4 (1 school from each district)		4 (1 school from each district)	
Subjects	Mathematics	Science	Mathematics	Science
	2	2	2	2
Total classes	**8 classes in 8 different schools**			

Classroom Observations

Classroom observations were also conducted in order to provide insight into the interactions among students and between the teacher and students, as well as the classroom environment. The schools selected for these observations, all of which were co-educational schools, were largely the same as those selected for the questionnaire, and in some cases included additional schools depending on local factors. The sample for classroom observations consisted of a total of eight classes per country, comprising four urban and four rural, of which two mathematics and two science classes were included, as outlined in **Table 3**. There were two exceptions: in the case of Malaysia four classroom observations were conducted, and in the case of Nepal, 20 classes were observed. Across the seven countries, a total of 64 classes were observed for this study.

National researchers were provided with specific instructions in conducting classroom observations and provided with a classroom observation sheet to be completed (**Annex 2**). This observation sheet was developed based on gender-responsive school observation tools provided in the Gender in Education Network in Asia-Pacific (GENIA) toolkit, in order to identify gender bias and issues in the classroom environment, as well as in teaching and learning processes (UNESCO, 2009, p. 5). Specific areas for observation were also outlined and the sheet used to record findings in each class observed. The overall focus of classroom observations for this study is outlined as follows:

a. Student and teacher behaviour and attitudes;
b. Interactions both among students and between students and their teachers; and
c. Mathematics and science classroom environments.

Within the research guidelines, national researchers were instructed to explain the main theme of the study to schools, teachers and students, while not mentioning the gender dimension, in order to ensure the objectivity of the data. The observer was then asked to sit at the back of the classroom so as to have a good view of the entire class, record observations on student and teacher behaviour and their interactions, as well as drawing a classroom map to label important points in terms of seating, movement and equipment. Researchers attended the entire lesson for all classroom observations to ensure consistency, and were required to observe from a distance rather than interact in the classroom in order not to skew the data.

In two countries, national researchers collected additional primary data through interviews and group discussions in order to supplement existing findings. In Indonesia for instance, semi-structured interviews were carried out with a total of ten respondents, including five teachers and five female STEM professionals working in diverse fields (e.g. physics, pharmacy, and electronics). These interviews were conducted over a period of 90 minutes, and focused on teaching, learning and working conditions in STEM, based on guiding questions (see **Annex 3**). In Nepal, group discussions were conducted in each of the sample schools involving both the school head teacher and mathematics and science teachers in a total group comprising five respondents. Questions explored in these group discussions were also derived from the original research questions as presented in the research framework.

Limitations

Due to limited resources, time and location-specific factors, primary data collection was limited to small samples in a number of provinces in each of the seven countries under review. Therefore, this regional synthesis report aims to provide only examples in these country case studies and others in the region based on the data that was collected for this study. It cannot, therefore, claim to reflect regional trends or be fully representative of the population of the seven countries or of the entire region. In addition, while all countries followed the research guidelines as far as possible, the sample size varied slightly above or below the recommended figure. While in general, most countries showed a high response rate, in other countries the response rate was lower for some questions. In terms of questionnaire analysis, countries used various methods for data analysis depending on local resources and thus provided differing levels of analysis. Because of this, it was not always easy to draw correlations from responses. In addition, some countries may have experienced complications in carrying out the data collection which may have affected the results. For instance in the Republic of Korea, the majority of teachers initially contacted to conduct the student questionnaire and classroom observations declined to participate, meaning that those who eventually participated in this research were those that allowed open access. This could potentially have positively skewed the results of the data collection in terms of teacher preparation for class, teacher interaction with students, and teacher influence on student attitudes. At the same time, analysis of previous experiences indicates that the reason why teachers at the secondary level may hesitate to open their classrooms to the public is due to the fear that their performance would be assessed (Yun, 2012).

In addition, findings on parental and teacher influences on student attitudes in learning mathematics and science were based on student responses to the questionnaire as opposed to teacher or parent responses. However, in some cases such as Cambodia, the results of the questionnaire and classroom observations were shown to be consistent with findings from previous studies on related topics in the country. With regard to secondary data analysis, a lack of available data meant that comparability could not always be ensured among countries. Therefore, the latest available data in some countries included in this report may not be up to date in comparison to others. Nonetheless, this regional synthesis report presents the findings of an exploratory study, which despite these limitations, does not diminish the value of the overall findings, analysis and conclusions.

Part A

Girls and Women in STEM: Where do we stand?

3 Level of Participation in Higher Education

Social and cultural norms towards women can greatly influence their opportunities in access and participation in STEM. According to a regional report by the World Bank (2012), social norms, especially with regard to the perceived role of women as caregivers, can impact their chosen fields of study and careers. For instance, the higher rate of women choosing to pursue professions such as teaching may be due to the perception that such professions allow more flexibility to balance family and work responsibilities (World Bank, 2012, p. 36). A multitude of social and cultural factors, whether through the family, community and wider society can also influence the choices of young women and have been identified as one major cause behind the lower proportion of women in STEM fields. In fact, academics have often described the low proportion of women in science as caused by "subtle messages in the media and society" (BBC, 2011). Before exploring the seven country cases in more detail, **Table 4** presents an overview of female participation in higher education both across fields of study as well as within science programmes.

Table 4 *Participation in higher education across all fields and female participation in science programmes*

	Gross Enrolment Ratio (GER)			Gender Parity Index (GPI)	Proportion of female students in science programmes (%)
	Total	Female	Male		
Cambodia $^{-1}$	15.83	12.01	19.59	0.6135	13.9 $^{-3}$
Indonesia $^{-1}$	31.51	32.05	30.98	1.0347	-
Malaysia $^{-2}$	35.97	39.08	32.70	1.19531	48.19
Mongolia $^{-1}$	61.10	72.38	50.03	1.44695	40.2
Nepal $^{-2}$	14.49	11.42	17.93	0.63685	26.17
Republic of Korea $^{-1}$	98.38	83.55	111.48	0.74951	30.63
Viet Nam $^{-2}$	24.60 $^{-1}$	24.63	24.24	1.01619	-

Notes: Data as of year -1 = 2012, -2 = 2011, -3 = 2004 for all fields by country unless indicated. Proportion of female students in science programmes not available for Indonesia and Viet Nam.

The levels of higher education cited in this publication reflect the 2011 International Standard Classification of Education (ISCED) as developed by the UNESCO Institute of Statistics.

Source: UIS, 2014b

In examining the gender dimension of access to and participation in STEM, particularly in higher education, it is important to briefly consider the sociocultural context of the seven countries reviewed, before providing an overview of participation in STEM fields of study in higher education as well as examples in technical and vocational education at the tertiary education level. Together, these areas will be explored in this chapter as contextual background not only with regard to the region and countries under review, but also as background to the subsequent chapters in this report.

A. Sociocultural background

Norms and attitudes towards girls' education, the role of women in the workplace and in particular the role of girls and women in STEM can have a drastic impact on their access to and participation in these fields. According to Shapiro and Williams (2012), 'gender-related stereotype threat', which can be transmitted by parents, teachers and the wider society from the youngest ages, affects not only a girl's attitude towards mathematics and science and performance in these subjects, but also a woman's interest and performance in STEM in their studies and careers (Shapiro and Williams, 2012). Each country has its own unique story, with different historical, cultural and social influences which may lead to different attitudes towards women in the workplace, particularly with regard to STEM. These are briefly examined in the following cases based on the reports produced in the seven countries reviewed.

Cambodia

Cambodia's education system evolved from a historically male-centred system whereby Theravada Buddhism was taught to young men through religious instruction, to a modernized and compulsory education system established in 1924, which presented the first opportunity for female students to enrol in formal schooling (Szmodies and Eng, 2014). Following the genocide war between 1975-79, approximately 75 per cent of teachers at all levels of education were killed, as well as 96 per cent of university students and 67 per cent of students in primary and secondary education; leaving 90 per cent of education infrastructure entirely destroyed (Ayers, 2000; Clayton, 1998). It was not until the 1990s that improving political stability allowed for the education system to reorganize (Chandler, 2008).

Traditional Khmer social norms and the country's historically hierarchical society continue to affect gender attitudes and the ways in which women and girls are perceived within society, whereby value is placed on men as the knowledgeable and powerful adult in the household, and with mothers instructing their children to show the highest reverence to their fathers, and perceiving male children as a valuable resource and investment for potential wealth and for society (Smith-Hefner, 1993; Gorman and Kheng, 1999). This also stems from traditional poems including chbab srey which is known to inform the traditional code of conduct for women and which has been perceived as negatively reinforcing the lower social status of women in society (UNIFEM, 2009). In recent years, however, Cambodia's transition to a more developed economy as well as its full integration into ASEAN has helped to change gendered attitudes, especially with regard to education and employment (Szmodies and Eng, 2014). While there remain significantly low levels of education among older women, the increase in educational opportunities for girls and young women has been perceived partly as a result of a transforming view regarding the importance of education for women (Filmer and Schady, 2006).

Indonesia

The Government of Indonesia has made significant efforts to reach gender parity in education, and has aimed to strive for equal opportunities for both female and male students (Sani, 2014). This has been largely due to the prominent focus on gender equality in the Ministry of Education and Culture's[9] (MoEC) education strategies, which include mention of equal access for all to education from early childhood up until higher education (MoNE, 2010). At the same time, the country report argues that social norms and attitudes, particularly in rural areas and lower socioeconomic groups, still inform the perception that the role of women is in the home, which – compounded with the issue of early marriage – may affect young women's opportunities to pursue further studies (Sani, 2014). In addition, the country report suggests that additional circumstances, such as a woman in a more senior professional position than her husband, or a woman having a child under the age of three years old, may discourage the continuance of their career due to societal expectations. In addition, some companies implement rules whereby marriage among employees is prohibited, in most cases causing female employees to resign, as opposed to male employees, in order to marry. Nonetheless, social perceptions towards women and girls are continuously changing with increasing support from government and from society for women in paid employment to support the family income. While women working in STEM fields may be perceived as 'tough' in their ability to 'work like men' and 'put in the effort', the increasing number of women working in STEM as will be observed in Chapter Seven is undeniable (Ibid).

9 In October 2011, the name of the Ministry of National Education (MoNE) was changed to the Ministry of Education and Culture (MoEC).

Malaysia

In the case of Malaysia, gender equality has improved substantially over the years, both as a result of increasing numbers of women participating in the labour market, and because of marked government efforts to achieve this. While in the past there were few opportunities for women to be educated, a prevailing norm promoted since national independence in 1957 has been that of equality in education as well as in employment (Mahdzir et al., 2014). Indeed, the Malaysian Government has recognized that significant progress in economic and social development since Malaysia's independence was achieved largely because of increased female participation (UN, 2011). This is reflected in the number of women employed, which increased by 95 per cent between the years 1990 and 2012, or from 2,374,300 to 4,689,700 across all fields (MoHR, 2012). Recognizing the importance of STEM fields for innovation in the country's development and growth, the Government committed to specific policy initiatives that seek to fuel interest in STEM disciplines, as will be explored in Chapter Five. While challenges remain, academics in other countries have looked to Malaysia as an example of women's participation in STEM fields. According to Schechter (2010), Malaysian women may have redefined gender roles in technology, as a country where women make up 50-60 per cent of employees in the computer industry with many working in management roles (Schechter, 2010). At the same time, this may have been influenced by perceptions rooted in sociocultural norms, in that professions in the computer industry constitute 'indoor' professions that are suitable to women as opposed to 'outdoor' professions (Ibid). At the same time, lower access, participation and learning achievement of male students across all subjects suggests that they are potentially emerging as a disadvantaged group as discussed in subsequent chapters in Part B of this report.

Mongolia

The role of women in Mongolia could also be considered as an exception in Asia. Looking at traditional roles within Mongolia's nomadic culture, both men and women contribute equally to the household, for instance sharing tasks and duties in animal rearing and migrating each season in order to secure the family livelihood. It could be argued that a similar pattern is observed as the country has undergone a transition from a planned economy to a market economy, with women actively participating in education and in the workforce. In particular, the influence of the socialist system for almost 70 years until 1990 meant that women were encouraged to work, with childcare and other support provided by the State to allow for their participation in the workforce (UNESCO and KWDI, 2013). Today's education indicators however, show an emerging trend of gender inequality in favour of girls, with boys often dropping out of school at higher rates than girls as the level of education increases. While women comprise a majority of university graduates in Mongolia at 65 per cent, a significant wage gap remains as women earn between 19-30 per cent less than their male counterparts in higher ranking professions such as management and engineering (ADB, 2011). At the same time, women are often perceived as better suited to working in other professions such as teaching and medicine, though not necessarily as engineers (Khishigbuyan, 2014).

Nepal

In Nepal, a number of factors such as religion, socioeconomic status of the family, early marriage in the case of girls and a preference for sons are all considered to contribute to gender disparities within the family and society as well as in educational institutions. According to Bista (2004), "Gender-based inequality and discrimination in education are a reality rather than an accident. They are part of the deep-rooted socio-cultural norms and patriarchal society." The dimensions of gender disparity are seen through participation in education, learning conditions, funding, under-representation of women in decision-making and leadership positions, a lack of gender neutrality in educational policies, acts and programmes, discrimination against girls through education materials and examinations, and finally, the lack of gender mainstreaming skills and commitment (Ibid, p. 23). A particular issue is observed in parental choices in regard to the type of school they decide to send their children to. Data from the Ministry of Education for the 2010/2011 academic year indicates that enrolment rates for girls are higher in 'community' state schools, whereas enrolment for boys is higher in 'institutional' private schools (MoE, 2011).[10] At the same time, expanding educational institutions in rural areas may have positively influenced sociocultural norms in view of gender equality, particularly among the most disadvantaged. While traditionally, education was made a priority for boys, particularly in rural and remote areas, the impact of mass media, gender-sensitive policies and laws, as well as increased awareness and expansion of formal and non-formal education has resulted in reduced gender discrimination (Kafle, 2014).

Republic of Korea

In the Republic of Korea, education indicators often point towards increased equality among female and male students in terms of participation. Indeed, trends over the last 13 years show continuously high enrolment rates for both female and male students, particularly between primary, lower secondary and upper secondary education with no sizeable gender differences, as well as a relatively high level

10 In the case of Nepal, only community schools were included in the sample for data collection for the purpose of this study.

in higher education which includes 69.4 per cent of all males enrolled and 67.9 per cent of all females (Statistics Korea, 2014). Some have argued that sociocultural norms and attitudes towards women may be rooted in Confucian tradition which places lower value on the status of women in society and could be linked to the low level of representation of women in political positions (Resos, 2014). These cultural factors are also considered to influence the choices of women in study and careers as early as at the upper secondary level where female students are perceived as more likely to pursue social science streams as opposed to natural science streams (Lee, 2010, p. 237). While in past decades women were commonly seen to pursue non-STEM-related fields of study, there have been rapid changes in recent times whereby women are opting for STEM fields, particularly in light of the digital revolution (UNESCO, 2010a, p. 4).

Viet Nam

In Viet Nam, gender equality has received a great deal of attention in recent years, in particular through government policies and initiatives that seek to raise awareness in promoting equal opportunities in education and at work. As identified in the first report in this series, perceptions of 'gender characteristics' as well as the traditional division of labour by sex have influenced attitudes with regard to what professions are perceived as suitable for women including those related to 'gentle' and 'delicate' traits in light industry, health, education and social work (UNESCO and KWDI, 2013, p. 9). Despite remaining challenges, there have been great efforts to reduce the gender gap, for instance through a number of policies and resolutions that work to provide more opportunities for women to participate in the development of the country, review of educational programmes and textbooks from a gender perspective, as well as gender-sensitive teacher training (Do, 2014). Indeed, data that will be explored throughout this report shows that in recent years, the participation of female students in education at primary and lower secondary levels has reached higher levels than that of their male counterparts. According to the Population and Housing Census 2009 for instance, the net enrolment rate of female students at lower secondary levels was 83 per cent as opposed to 80.4 per cent for male students (Central Population and Housing Census Steering Committee, 2009).

Given these different sociocultural backgrounds, some commonalities and variations arise with regard to the overall status of women in society, and in particular when it comes to STEM. Female participation in higher education across all fields of study, and more generally girls' educational opportunity, varies greatly among the seven countries. In Cambodia for instance, opportunities for all students, and in particular female students, to pursue higher education remain limited. On the other hand, a high level of female participation can be observed in other countries such as Malaysia, Mongolia and the Republic of Korea. Looking at sociocultural norms and traditions, perceptions and attitudes of women and their role in society have continued to be influential in countries such as Cambodia, Nepal and the Republic of Korea, yet with perceptions rapidly changing in recent years. Of countries that have experienced such changes, it could be argued that there has been a long-term policy focus on gender-equality, for instance in Indonesia, Malaysia and in more recent times, the Republic of Korea and Viet Nam.

B. Access and participation in STEM fields of study in higher education

Having noted the country context and sociocultural background of these countries, it is important to consider how these may be reflected in the participation of female and male students in STEM fields of study in higher education. This section is comprised of two parts and will first provide an overview at the regional level based on the desk study, before a more focused analysis on the seven country case studies.

Regional overview

Despite increasing access to education for girls in higher education, this may not necessarily reflect participation specifically in STEM fields of study in higher education. Globally, data shows that despite increased parity in enrolment at the Bachelor's[11] level (or equivalent) in higher education, in STEM disciplines male students outnumber female students in 91 per cent of countries with available data (UNESCO, 2010b, p. 5). Findings from the OECD also argue that young women are far less likely to opt for STEM fields of study at the Bachelor's level, and this only declines further from the Master's level and above (OECD, 2011, p. 2). In addition, the study also shows that in OECD countries there is a significant gender difference with regard to fields of study chosen, with an average of 71 per cent of graduates in the humanities and health fields being female, as opposed to an average of 75 per cent of graduates in mathematics and engineering being male (Ibid, p. 25). Within Asia, a substantial gap was identified in Japan with regard to tertiary degrees in engineering, manufacturing and construction, where only 11 per cent of graduates were female, compared to just over 50 per cent of female graduates in Indonesia as of 2008 (Ibid). The following case study on China and Japan presented in **Box 1**, which is based on a study by the Boston Consulting Group, further illustrates the decline in the proportion of women in science fields as the level of education increases.

Among countries in Asia, different levels of participation can be identified with regard to female enrolment in STEM fields of study in higher education. Based on available data by country, the proportion of female graduates in science programmes in higher education is presented in **Figure 4.** Here, countries such as Malaysia and Mongolia show a relatively higher proportion of female graduates at 42 and 43 per cent respectively, compared to others such as Japan at just 14 per cent and Cambodia

Box 1 *Proportion of women in science fields by academic level in China and Japan (%)*

A study by the Boston Consulting Group further explores this growing gender gap in science starting from upper secondary level up until high-level academic positions with specific data available from China and Japan. In the case of these two countries, the point at which the gap occurs is identified at the Bachelor's level (BCG, 2014, p. 6).

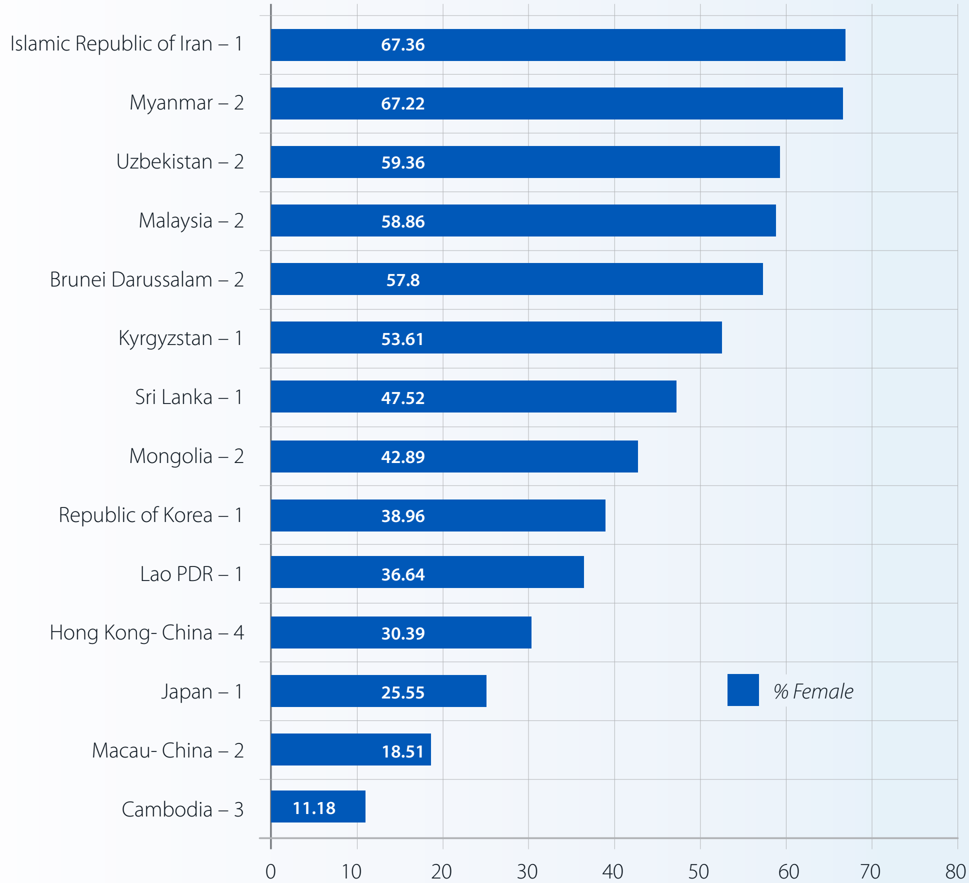
	High school	Bachelor	Master	Doctorate	Researcher Career
China	46%	28%	28%	18%	25%
Japan	51%	23%	14%	24%	14%

Note: Data for China as of 2012; data for Japan as of 2011.

Source: Adapted from BCG, 2014;

11 The levels of higher education cited in this publication reflect the 2011 International Standard Classification of Education (ISCED) as developed by the UNESCO Institute of Statistics.

Figure 4 *Proportion of female graduates in science programmes in tertiary education in Asia (%)*



Notes: This data reflects graduates of levels 5 and 6 of the 2011 International Standard Classification of Education (ISCED), which are equivalent to Diploma (level 5) and Bachelors (level 6) or equivalent.
Data as of 1= 2012; 2= 2011; 3= 2008; 4= 2006. Data not available for Indonesia, Nepal and Viet Nam.

Source: UIS, 2014c

at a mere 10 per cent (UIS, 2014c). These findings bring forward questions as to what factors may influence female students in their distinct choices for further study and careers across different countries of the region.

Country case studies

Looking more closely at enrolment in STEM fields of study within and across the seven countries revealed that while women make up a sizeable proportion of students in some disciplines, they may also remain a minority in others. For some countries, however, accessing higher education in general presents in itself a significant setback, let alone entering specific STEM fields. For instance, despite increased enrolment in higher education in **Cambodia** for more than a decade (MoEYS, 2014), overall, only 15.83 per cent of Cambodian students were enrolled in higher education across all fields as of 2012, with the latest available data for the proportion of female students standing at 13.9 per cent as of 2004 (UIS, 2014b). Indeed, despite slight increases in the last decade, the proportion of female students across all fields of study in higher education remains low with a Gender Parity Index (GPI)[12] of 0.61 as of 2012, enrolling at half the rate of their male counterparts (UIS, 2014b). Nonetheless, results from the questionnaire conducted in Cambodia indicate that parental engagement in education, specifically concerning STEM disciplines, does not differ significantly by sex, while parents and students both place more importance on mathematics education compared to science education. Based on this, choices in higher education show that a majority of Cambodian students enrol in business and accounting fields, which rely heavily on mathematics. By contrast, the sciences remain one of the least popular fields of study, which could be a result of both parental and student ideas surrounding the most profitable and prestigious career choices (HRINC, 2010).

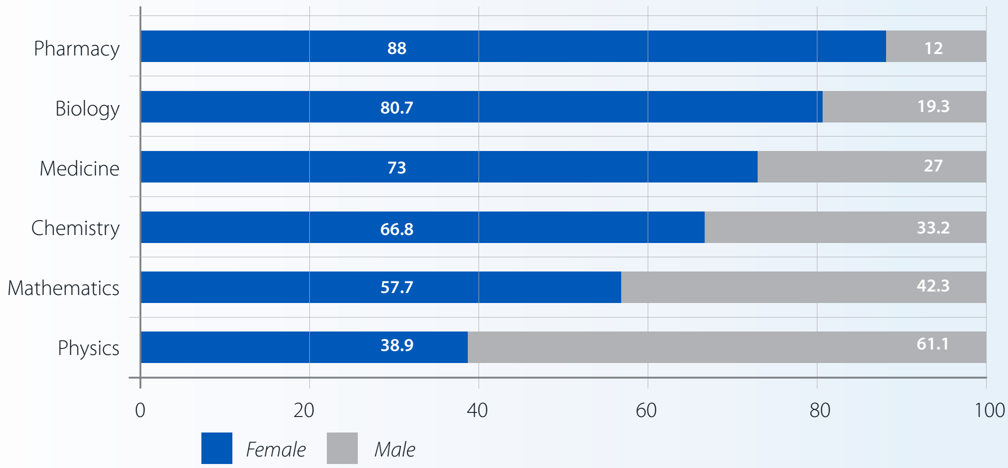
The seven country case studies provide more detailed findings in terms of female participation in higher education, particularly with regard to fields of study within STEM. These data sets will be presented by country, and while it would be ideal for subjects to follow the same categorization and classification, these may differ across countries. In **Viet Nam** for instance, opportunities for young women to enter higher education also remained limited, where large increases in participation can be observed. For instance, in comparing new entrant rates at the university level between the academic years of 2012-2013 and 2013-2014, the rate of female students increased from 30.29 per cent to 52.49 per cent, whereas it declined in male students from 69.71 per cent to 47.51 per cent (MoET, 2014). Though the latest available data by field of study is from 2006, it is possible to observe that at that time, female students were more likely to specialize in education, the humanities and arts – fields in which 41 per cent of all female students were enrolled as opposed to 26 per cent of all male students. By contrast, men were more likely to specialize in engineering, manufacturing and construction, fields which included 29 per cent of all male students enrolled in higher education as opposed to just 11 per cent of all female students (World Bank, 2011, p. 29). The data shows an even greater concentration of male students when it comes to engineering, which is consistent with findings in other countries.

In the case of **Indonesia**, a country in which women are generally well represented in higher education in comparison to other countries, variations can also be observed within STEM fields of study. Based on data from selected universities, women are concentrated in certain disciplines within STEM, and are better represented in disciplines such as pharmacy and biology, yet slightly underrepresented in others such as physics (DoHE, 2014). Nonetheless, the proportion of women in general among STEM fields in these Indonesian universities is notable as reflected in **Figure 5**.

An even higher proportion of women in STEM fields of study can be found in **Malaysia,** a country which presents an exceptional case in this study. For instance, overall, the entrance, enrolment and graduation rates of female students are higher than that of their male counterparts with female students representing approximately 63 per cent of total student enrolment across all fields of study as of 2012 (MoHE, 2013). Looking more specifically at enrolment rates in higher education by STEM disciplines, as observed in **Figure 6**, the latest available data from 2012 shows that female students outnumber

12 The gender parity index (GPI) is the most common measure of gender parity in access to education for female and male students where the figure 1 would constitute perfect gender parity, whereas a figure below 1 would show access in favour of male students and above one in favour of female students.

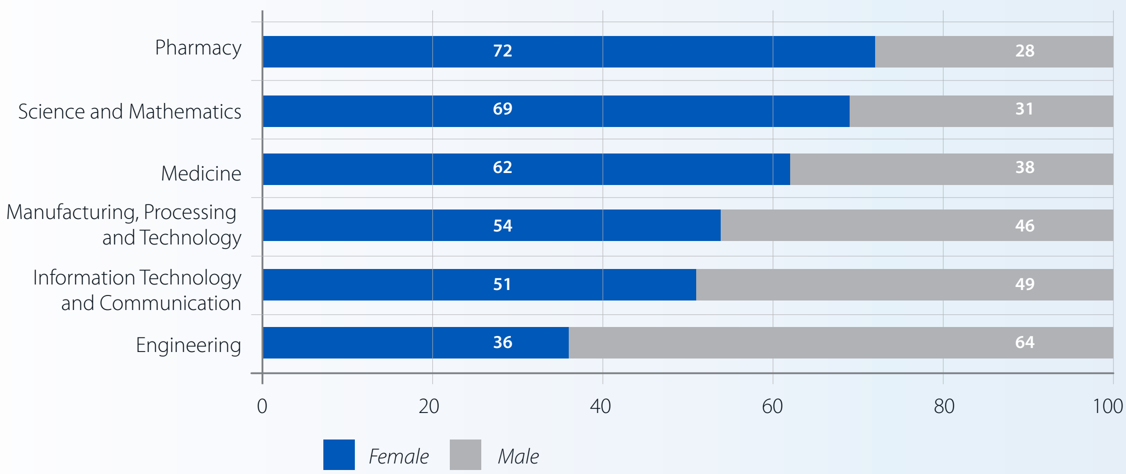
Figure 5 *Proportion of students enrolled in STEM disciplines in selected universities in Indonesia by sex (%)*



Note: All data presented in this figure is based on enrolment rates at the undergraduate level at the Bandung Institute of Technology and the University of Indonesia (Jakarta), with the exception of pharmacy, which is based on data from Gajah Mada University.

Source: DoHE, 2014; Yogyakarta Statistics, 2013.

Figure 6 *Proportion of students enrolled in STEM disciplines in higher education in Malaysia in 2012 by sex (%)*

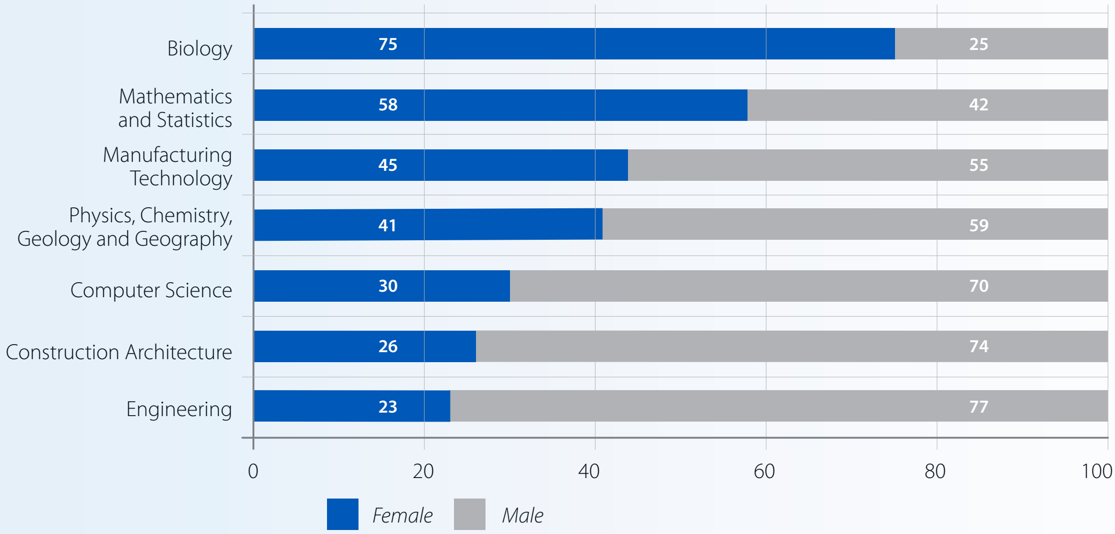


Source: Adapted from MoHE, 2013

male students in all STEM disciplines with the sole exception of engineering, where 36 per cent of students enrolled are female. While this latter finding may be consistent with findings from other countries, comparatively, female students in Malaysia remain better represented in engineering at 36 per cent than in other countries.

The concentration of female and male students in certain disciplines is also identified in the case of **Mongolia**, where despite the relatively high average of female graduates in science and technology at 43 per cent (as highlighted in **Figure 4**), female students are both over- and under-represented in certain disciplines. For example, while they made up the majority

Figure 7 *Proportion of students enrolled in STEM disciplines in higher education in Mongolia as of 2013 by sex (%)*



Note: Data for the field, *Physics, chemistry, geology and geography*, is only available in this grouped category.

Source: MEDS, 2013

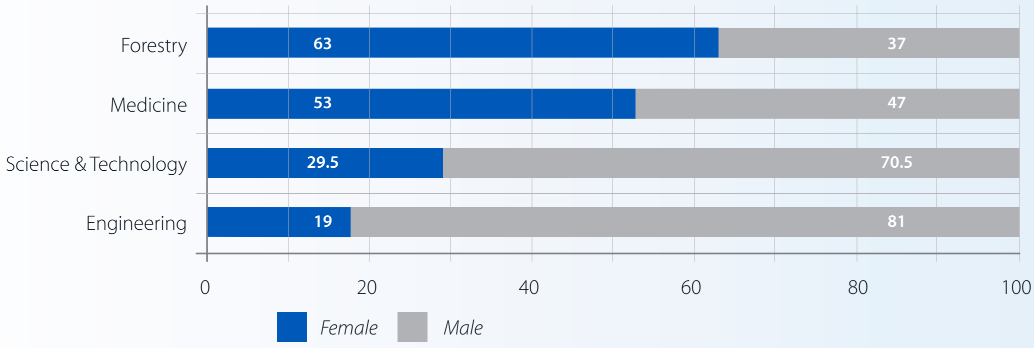
in biology and mathematics, they were a minority in others, with the lowest proportion in engineering (23 per cent), followed by construction architecture (26 per cent) and computer science (30 per cent). This data is more closely examined in **Figure 7**.

Based on the data presented in Figure 7, the level of female participation in STEM fields of study in Mongolia may be influenced by the fact that the country has seen enrolments in higher education increase across the board by almost 80 per cent between 2002 and 2013, or by a 65 per cent increase for women and almost 100 per cent increase in men (NSO, 2012). At the same time, data from 2013 shows that while 88 per cent of degrees awarded were at Bachelor's level, of which 57 per cent of graduates are female, female students continue to outnumber their male peers at all levels of higher education, particularly at the Master's level where they made up 63 per cent of graduates, as well as 57 per cent of those graduating with a Doctorate (Ibid). On the other hand, the low proportion of female students enrolled in engineering, which overall holds the largest proportion of students in any STEM field (Ibid), could present a source of employment for women in one of the most in-demand professions (Khishigbuyan, 2014).

In **Nepal,** a total of 46 per cent of students enrolled in higher education are female (UGC, 2013). As in other countries, while female students are a minority in fields of study such as engineering (19 per cent) and science and technology (29.5 per cent), they are however, a majority in other STEM-related disciplines such as medicine (53 per cent) and forestry (63 per cent), as displayed in **Figure 8**. One possible point for analysis is that nursing is often included within medicine, and is a profession often perceived as predominantly female, which could explain this higher rate; a point also applicable to other countries included in this study.

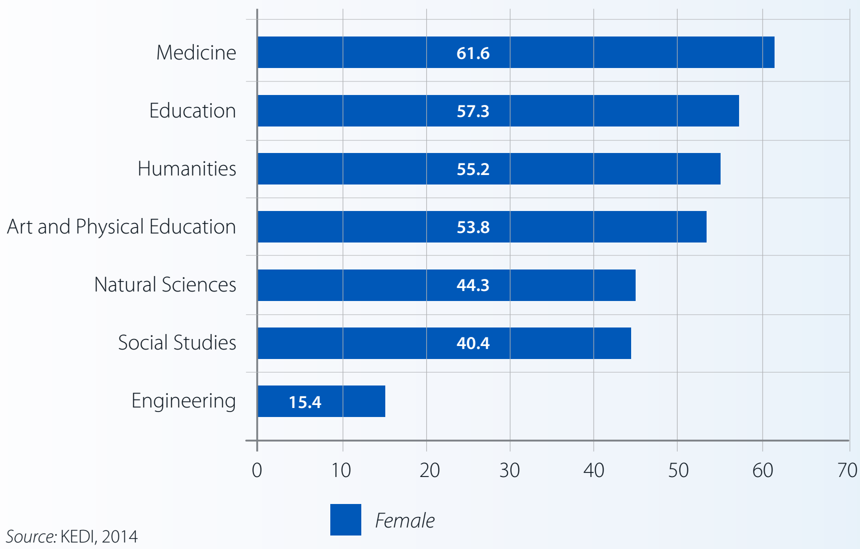
On the other hand, education indicators demonstrate that the highest numbers of

Figure 8 *Proportion of students enrolled in selected STEM disciplines in higher education in Nepal as of 2011/2012 by sex (%)*



Source: UGC, 2013

Figure 9 *Proportion of female students enrolled in selected STEM and non-STEM disciplines in higher education as of 2014 in the Republic of Korea (%)*



Source: KEDI, 2014

female students are enrolled in non-STEM fields of study (Ibid). Nonetheless, it is also interesting to note that even in non-STEM fields of study, the participation of women declines substantially as the level of education increases, suggesting that beyond the issue of enrolment, the issue of retention of women at the highest levels of education continues to be problematic. Looking at students enrolled in educj1ation, for instance, reveals that 53 per cent of Nepali students enrolled at the Bachelor's level were female. This declined to 42 per cent at the Master's level, and to just below 28 per cent at the Doctoral level or equivalent (UGC, 2013).

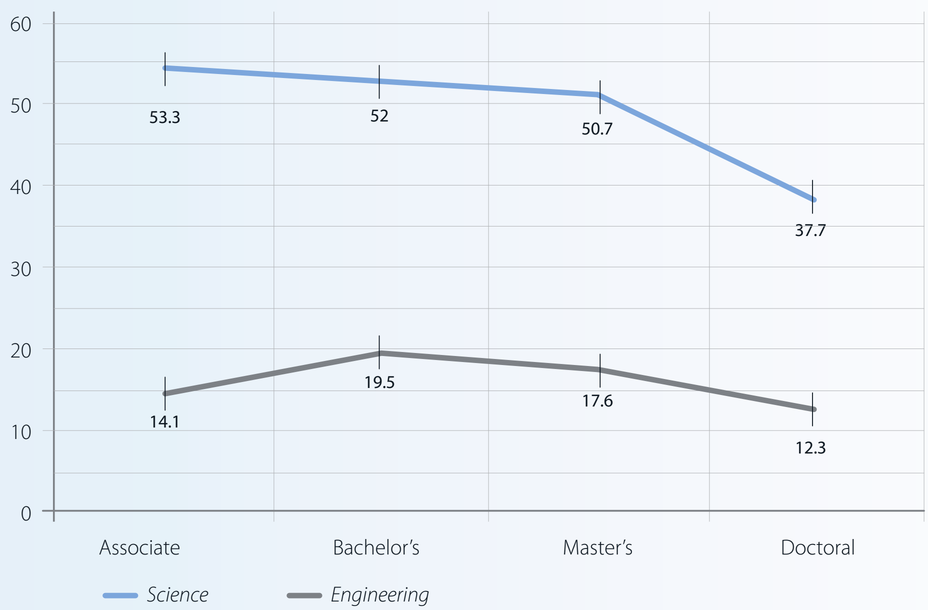
Analysis from the **Republic of Korea** also shows that considering the high rate of female students entering higher education at 67.9 per cent (Statistics Korea, 2014), the rate of female students entering STEM disciplines is not high **(see Figure 9).** This suggests that while medicine reflects high female participation at 61.6 per cent, only 15.4 per cent of those enrolled in engineering are female, an observation that appears consistent with other countries.

As in the case of Nepal, even when a notable proportion of female students are enrolled in higher education, this proportion tends to drop as the level of education increases. Arguably, this is even more prominent in the case of enrolment in STEM fields of study. Indeed, data from the Republic of Korea shows that 28.3 per cent of all students enrolled in science and engineering in higher education are female, and as displayed in **Figure 10**, not only is there a higher proportion of female students enrolled in science as opposed to engineering, but the proportion of female students in these two fields gradually reduces as the level of education increases.

The data presented in Figure 10 shows the extent to which female enrolment declines by level of education in the Republic of Korea, in both engineering as well as science. Indeed, looking at the proportion of female students enrolled in engineering at the Bachelor's level for instance, enrolment decreases at Master's level, and decreases even further at the Doctoral level.

While the previous section focused on university education with an academic focus, STEM fields of study are also taught in different streams of post-secondary education, for instance in vocationally-oriented institutions. Findings on the proportion of female students enrolled in such institutions also highlight varying participation by discipline across countries. **Cambodia**, for instance, has one of the smallest shares of students enrolled with approximately 6 per cent of Cambodians between the ages of 20–24 having attended

Figure 10 *Percentage of female students enrolled in science and engineering in higher education by level, Republic of Korea as of 2011*



Note: Associate degree programmes refer to 2-3 year colleges, whereas Bachelor's degree programmes refer to those offered by general 4-year universities.

Source: Adapted from WISET, 2014

vocationally-oriented institutions at both upper secondary and tertiary levels (World Bank, 2010). Of those graduating from vocational institutions (of 40 public schools and 170 schools run by NGOs) in the academic year of 2005-6, 37.5 per cent were female (Ibid).

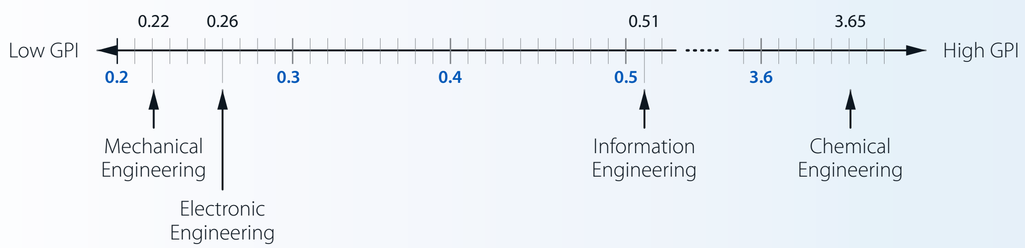
In **Indonesia**, a broader choice of occupation-specific training appears to be available, with the notable participation of women. As was found earlier in this chapter, both high and low proportions of women by discipline are also present, and to some extent even more visible than in higher education as was displayed in **Figure 5**. Indeed, enrolment rates in vocational programmes in selected institutions show a stark contrast between the low participation of female students in disciplines such as mechanical engineering where they make up just 5 per cent, compared to the very high participation of female students in chemical engineering where they make up more than 78 per cent. The GPI for these programmes is detailed in **Figure 11**.

According to the analysis presented in the country report for Indonesia, the lower level of female enrolment for mechanical engineering may be due to perceptions that work in this field may not be suitable for women. Informal interviews conducted in Indonesia as part of this study with female STEM professionals showed that such fields tend to be regarded as male domains requiring "physical exertion" and working in "unattractive environments", despite the fact that technical and vocational programmes are openly accessible to women (Sani, 2014).

In **Viet Nam**, increased training and incentives for women to enter vocational institutions could potentially serve as an entry point into STEM fields in order to face changing labour market demands. According to Kabeer et al. (2005), vocational training currently available in the country is arguably subject to gender stereotyping, and may also fail to prepare women to pursue a wider range of labour market opportunities (Kabeer, Van anh, and Manh Loi, 2005). With this in mind, the country report argues that successful initiatives already developed in other countries, whereby training institutes work in partnership with private sector firms, could help encourage young Vietnamese women to enter these sectors of the labour market, and perhaps also enter non-traditional fields (Do, 2014).

Reflecting on the findings presented in this chapter, it could be argued that the sociocultural context may influence access to

Figure 11 *Average Gender Parity Index (GPI) in selected STEM-related technical and vocational programmes in selected institutions in Indonesia*



Notes: The figure 1 would constitute perfect gender parity, whereas a figure below 1 shows an advantage to males and above one in favour of females. In the absence of national level data, this figure shows the average GPI for these study programmes based on enrolment data from the following institutions: Gajah Mada University, Bandung State Polytechnic, Medan State Polytechnic, Jakarta State Polytechnic, Pontianak State Polytechnic, Ujung Pandang States Polytechnic, Samarinda State Polytechnic and Bandung Manufacturing Polytechnic.

Source: DoHE, 2014; Yogyakarta Statistics, 2013 and participation in STEM for female and male students as a result of norms and attitudes towards women and men in society, as well as the professions for which they are perceived as best suited. The main reflections from this chapter can be summarized as follows:

- In the case of Cambodia and until recently Viet Nam, **access to higher education** in general has been in itself a challenge for women. In other countries such as Malaysia and Mongolia, overall a higher proportion of female students are enrolled in higher education than their male counterparts.
- Within STEM fields of study, females tend to be concentrated in **certain disciplines such as pharmacy, medicine and biology** yet remain underrepresented in others such as engineering and physics. This indicates that further data analysis may be required on women's participation in specific STEM disciplines such as engineering and physics.
- Data from Nepal and the Republic of Korea on enrolment by level of education shows that **the proportion of female students falls as the level of education increases beyond Bachelor's level or equivalent** within and beyond STEM fields of study.
- The sociocultural context cannot ultimately be viewed as the sole determining factor in the level of participation of women in STEM fields; **specific policy actions** would be required to help promote their increased participation.
- This raises important questions as to what factors may **influence choices for further stud**y and the proportion of female students enrolled in STEM in higher education. These potential factors are examined in the subsequent chapters of this report.

4 Learning Achievement in Secondary Education

In order to better understand the varied degree of participation of women in STEM fields of study at the higher education level, this chapter will focus on the gender dimension of learning achievement at the secondary level. While some have identified a gap in favour of male students with regard to mathematics and science, findings indicate that this may not necessarily be the case and that variations may occur by country. Indeed in some countries, a reversed gender gap can also be identified in favour of female students in these subjects. This chapter will first analyze the results and status of international assessments in participating Asia-Pacific countries such as PISA which assesses 15-year-old students in reading, mathematics, science and optional areas in both OECD and non-OECD countries, as well as TIMSS which assesses Grade 4 and Grade 8 students in mathematics and science in a range of countries. It will then review the results of International Olympiads in STEM-related fields, where country delegations are composed of the highest achieving students in these fields, and finally results of national assessments, where available, among the seven countries under review.

A. International Assessments

The results of international assessments such as PISA 2012 and TIMSS 2011 both show that the gender gap in learning achievement varies from country to country. Of the seven countries reviewed, Indonesia, Malaysia and the Republic of Korea participate in both assessments, with Viet Nam participating in PISA for the first time in 2012. At the same time, there may be a relationship between student performance in a given subject and student enrolment in higher education in that field of study. According to a study conducted by Stoet and Geary (2013) that analyzed ten years of PISA data, there is in fact a link between the gender gap in high performing 15-year-olds in mathematics and the proportion of women enrolled in mathematics programmes in higher education (Stoet and Geary, 2013, p. 7). While in some countries such as Japan and the Republic of Korea, male students continue to outperform their female counterparts particularly in mathematics, in others such as Malaysia and Thailand, female students outperform their male counterparts at similar rates, especially in TIMSS. **Tables 5 and 6** present these latest results by sex for participating countries and jurisdictions in the Asia-Pacific region for PISA 2012 and TIMSS 2011 respectively.

Since PISA and TIMSS were never calibrated on one single scale,[13] conclusions cannot be drawn in comparing countries' results in these two assessments. However, there could potentially be some important points for further analysis based on their methodological differences. In this sense, female and male students, or in the broader sense national education systems, may be better geared towards knowledge acquisition over

Table 5 *PISA 2012 results for participating countries and jurisdictions in the Asia-Pacific*

	Mathematics			Science		
Country/Jurisdiction	Average Score		Difference	Average Score		Difference
	Female	Male		Female	Male	
Australia	498	510	+12	519	524	+5
Hong Kong- China	553	568	+15	551	558	+7
Indonesia	373	377	+4	383	380	-3
Japan	527	545	+18	541	552	+11
Kazakhstan	432	432	0	429	420	-9
Macau- China	537	540	+3	521	520	-1
Malaysia	424	416	-8	425	414	-11
New Zealand	492	507	+15	513	518	+5
Republic of Korea	544	562	+18	536	539	+3
Shanghai- China	610	616	+6	578	583	+5
Singapore	575	571	-4	552	551	-1
Thailand	433	419	-14	452	433	-19
Turkey	444	452	+8	469	458	-11
Viet Nam	507	517	+10	528	529	+1

Note: + indicates a score difference in favour of boys, and – indicates a score in favour of girls.
Source: OECD, 2014

13 In analyzing the gender differences in both PISA and TIMSS as outlined in Tables 5 and 6, it is important to note that the overall scores from these two international assessments are not comparable since they follow different methodologies. While PISA is a competency-based assessment examining how far students are able to apply their knowledge and skills within the context (OECD, 2014), TIMSS is a curriculum-based assessment which helps to assess if students have learnt what they have been taught (IEA, 2012c).

Table 6 *TIMSS 2011 results in Grade 8 for participating countries and jurisdictions in the Asia-Pacific*

	Mathematics			Science		
Country/Jurisdiction	Average Score		Difference	Average Score		Difference
	Female	Male		Female	Male	
Australia	500	509	+9	511	527	+16
Hong Kong- China	588	583	-5	536	534	-2
Indonesia	392	379	-13	409	402	-7
Iran	411	418	+7	477	472	-5
Japan	566	574	+8	554	562	+8
Kazakhstan	486	488	+2	434	419	-15
Republic of Korea	610	616	+6	558	563	+5
Malaysia	449	430	-19	434	430	-4
New Zealand	478	496	+18	501	522	+21
Singapore	615	607	-8	589	591	+2
Thailand	435	417	-18	458	443	-15
Turkey	457	448	-9	491	475	-16

Note: + indicates a score difference in favour of boys, and – indicates a score in favour of girls.

Source: IEA, 2012a; IEA, 2012b

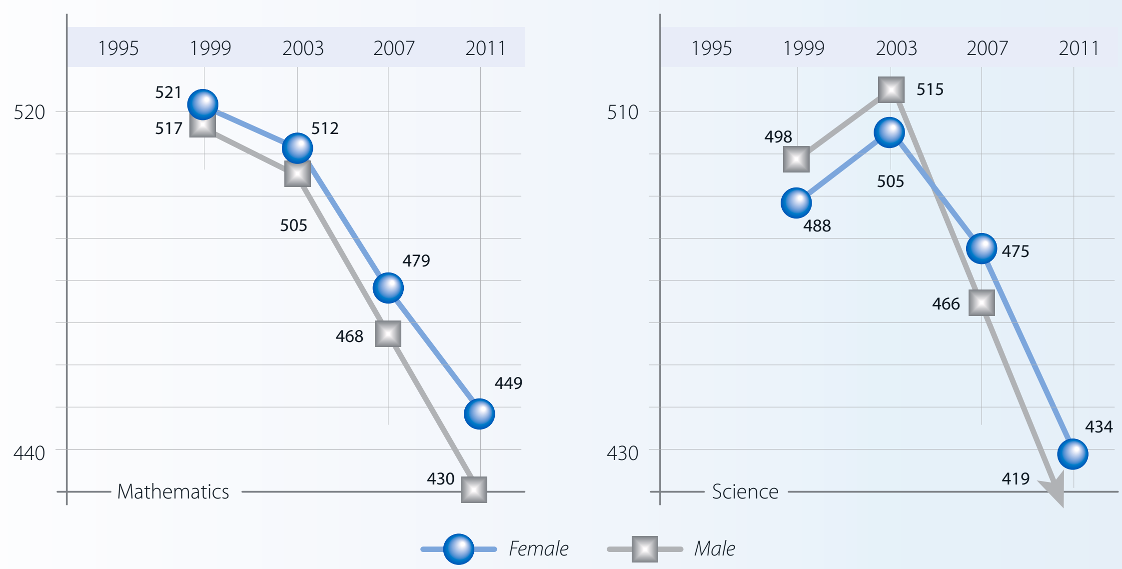
knowledge application, yet further exploration to confirm these differences is required.

Looking more closely at the overall results with regard to the gender gap in achievement, one consideration may be the gap in achievement itself while the other may be the actual score. In countries with a higher gender gap in favour of males, such as the Republic of Korea, female students scored higher in PISA 2012 and TIMSS 2011 than females in other countries. Indeed, studies have shown that the gender gap in favour of boys tends to be greater in more economically developed countries as well as among the highest–performing students (Stoet and Geary, 2013), which to some extent is consistent with the results presented in **Tables 5 and 6**. According to these results, OECD countries such as Australia, Japan, New Zealand and the Republic of Korea show a substantial gender gap in achievement in favour of male students and also higher average scores, whereas the opposite is found in non-OECD countries, in particular in Southeast Asian countries such as Thailand and Malaysia. In these countries, there is a substantial gender gap in favour of girls, yet lower average scores. Viet Nam, however, presents an exception. Having first participated in PISA in 2012, Viet Nam scored above the OECD average, outperforming some OECD countries such as Australia and New Zealand in mathematics and science (see Table 5), while at the same time, a ten point score difference was identified in favour of boys in mathematics. Looking beyond the countries reviewed, the cases of Hong Kong- China and Singapore provide an example of those with high levels of achievement in mathematics and science, yet with a smaller gender gap in performance (with the exception of Hong Kong- China for mathematics in PISA 2012 results). For instance in TIMSS 2011, girls in Hong Kong- China outscored boys by just five points in mathematics and two points in science, whereas in Singapore, girls outscored boys in mathematics by eight points and boys outscored girls by just two points in science. These country examples could provide interesting case studies for further analysis, particularly in terms of what factors may have contributed to both high student performance in these subjects as well as a lower gender gap in achievement.

Among the seven countries, two cases with contrasting trends over time will be examined in further detail: Malaysia and the Republic of Korea. Malaysia demonstrates a 'reversed gender gap' whereby a sizeable difference in achievement in mathematics and science is found in favour of girls – by eight points in mathematics and 11 points in science in PISA 2012, and by 19 points in mathematics and four points in science in TIMSS 2011. Despite a narrowing gender gap in performance in the Republic of Korea, boys continue to outscore their female counterparts – by 18 points in mathematics and three points in science for PISA 2012, and by six points in mathematics and five points in science in TIMSS 2011.

In the case of **Malaysia**, results of international assessments such as PISA and TIMSS are often seen as an opportunity to benchmark the education system against international standards, with some stakeholders utilizing these results in order to monitor the impact of structural, curricular, and instructional reforms implemented on achievement (Mahdzir et al., 2014). Looking at Malaysia's first participation in TIMSS Grade 8 back in 1999, student performance in mathematics and science was initially above the average among participating countries. However, this average score has gradually dropped by almost 70 points in mathematics and more than 80 points in science over the span of eight years by the year 2011. As a consequence, only 40 per cent of Malaysian students have a level of achievement that is above the international average in mathematics, causing national concern among

Figure 12 *Trends in mathematics and science achievement in TIMSS Grade 8 by sex in Malaysia*



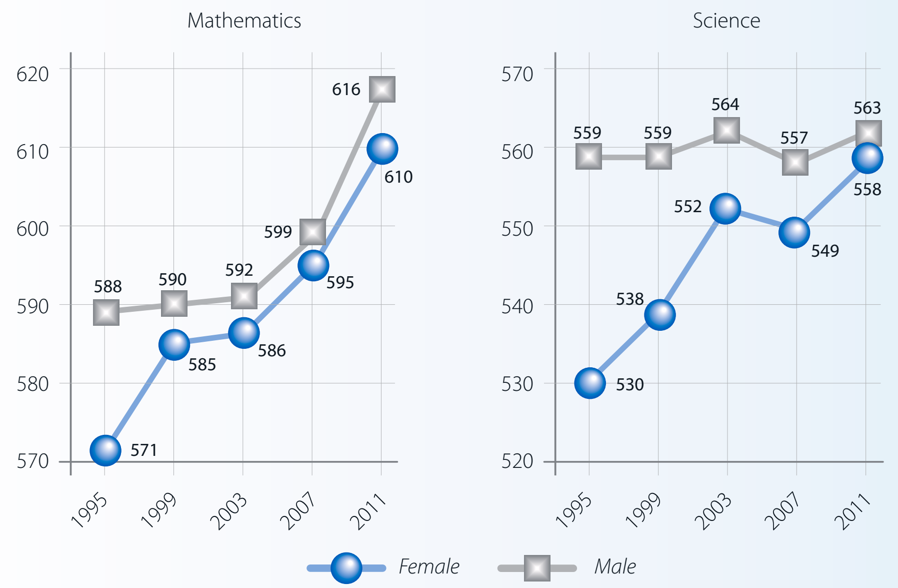
Source: Adapted from IEA, 2012a; IEA, 2012b education stakeholders (Ibid). While female students have consistently outscored their male counterparts in mathematics, trends in science performance show that initially, male students scored higher until the year 2003, with female students scoring higher from 2007 onwards. Nonetheless, since Malaysia's first participation in TIMSS in 1999, the decline in performance follows a similar trend among both female and male students as illustrated in **Figure 12.**

Overall, trends in TIMSS results in Malaysia between 1999 and 2003 show a growing gender gap in performance in favour of girls. For instance, while in 1999 girls outscored boys by four points in mathematics and 10 points in science, in 2011 they outscored boys by 19 points in mathematics and 15 points in science. Perspectives on the general decline in Malaysia's performance in TIMSS suggest that it may stem from a number of factors beyond gender, namely a potential language barrier, sampling methodology, unfamiliarity with lengthy questions and application of problems as well as interpretation and reflection in the case of PISA, unfamiliarity with 'higher order thinking' skills, variance in standards in terms of curriculum content and focus on application and reasoning (MoE, 2013a; MoE, 2013b). More specifically, the decline in performance has been linked to the introduction of English for the teaching of mathematics and science (ETeMS) in 2003 (Mahdzir et al., 2014). Studies commissioned by the Ministry of Education showed that students and teachers (from rural areas in particular) had greater difficulty understanding the teaching of these subjects through English (Ibid). The staggered reversal of this policy in 2009 saw the teaching of mathematics and science in Bahasa reintroduced from Grade 1 in 2011. This reversal may cause further difficulties for students to adapt to different terminologies (Ibid).

By contrast, trends in TIMSS Grade 8 in the **Republic of Korea**, which has participated since 1995, show that the gender gap in achievement narrowed considerably in mathematics (2007) as well as in science (2011) as displayed in **Figure 13**.

While in mathematics the gender gap in achievement reduced to near parity by 2007 and in science by 2011, the results from TIMSS Grade 8 in both subjects show a steady increase in scores over time for both subjects. They also show that the gap in performance between female and male students is gradually narrowing. In 1999, boys outscored girls by 17 points in mathematics and by 29 points in science. By 2011, this had changed significantly with boys outscoring girls by just six points in mathematics and five points in science. The increase in student achievement over time in the Republic of Korea has been perceived as the result of sociocultural influences and policy interventions. For example, the importance of education has been reinforced by strong family support, as well as education reforms which have been seen to increase structural efficiency and the quality of the education system. (Lee, 2014). Others have argued that this is due to the pragmatic approach to learning and the importance given to examinations, while at the same time, the favourable characteristics of Korean language in describing the number system (Park, 2014). Looking back to the case of Malaysia, studies have indicated that the language of instruction can in fact have an impact on academic achievement in mathematics, often citing East Asian languages in particular as better suited to mathematical concepts than English (Wall Street Journal, 2014). This could perhaps explain the overall decline in achievement in Malaysia and the increase in achievement in the Republic of Korea among both female and male students. Both of these cases also suggest that other influential factors, including changes in education policy in Malaysia, could have played an important role in not only affecting changes

Figure 13 *Trends in mathematics and science achievement in TIMSS Grade 8 by sex in the Republic of Korea*



Source: Adapted from IEA, 2012a; IEA, 2012b

in scores, but also in how these may affect differences in achievement between female and male students.

B. International Olympiads in STEM-related fields

Some countries and jurisdictions from the Asia-Pacific region[14] also participate in International Olympiads in STEM-related fields such as mathematics, physics, chemistry, biology and informatics. These Olympiads are usually held annually and consist of international competitions whereby participating countries send a delegation of four to six of their highest achieving upper secondary students in that particular field. As was observed in the previous section on international assessments, studies have argued that the most prominent gender gaps occur among the highest performing students (Stoet and Geary, 2013), with the results of International Olympiads providing a particularly interesting case for further exploration. Indeed, a gender analysis of the 2014 results of relevant International Olympiads for Asia-Pacific countries, which was conducted by the research team at UNESCO Bangkok, revealed significant gender gaps and covered the following: International Biology Olympiad (IBO), International Olympiad in Informatics (IOI), International Mathematical Olympiad (IMO), and the International Physics Olympiad (IPhO).[15] Overall, what these results show is that by total delegation (including both medallists and non-medallists) female contestants are largely absent or underrepresented, which may be due to the lower proportion of girls at the highest levels of achievement. For instance,

14 See Annex 4 for the full list of participating countries from the Asia-Pacific region for International Olympiads in mathematics, physics, chemistry, biology and informatics.

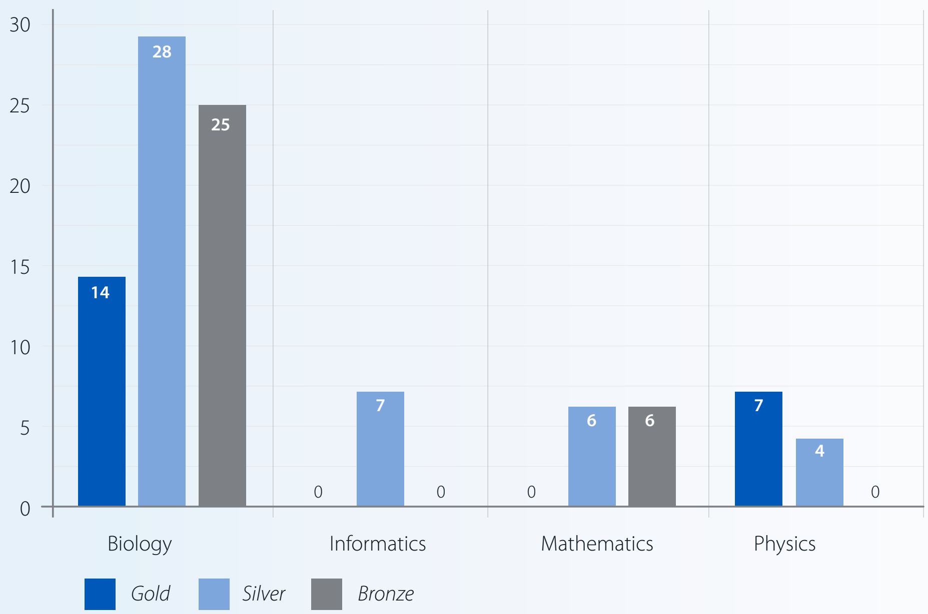
15 Unfortunately, the gender of contestants for the International Chemistry Olympiad (IChO) could not be determined.

the percentage of female contestants stood at just 4 per cent for informatics, 5 per cent for mathematics and 6 per cent for physics, yet it reached an average of 28 per cent in biology among countries in the region, the latter reflecting the findings in the previous chapter on access and participation by STEM discipline. Looking more closely at the proportion of female medallists in these Olympiads, these figures are shown to be even lower, as displayed in **Figure 14.**

The higher proportion of female medallists for biology as opposed to the remarkably smaller proportion in informatics, mathematics and physics, appears to be consistent with female participation by field of study in STEM at the higher education level, as seen in Chapter Three. Here, a higher proportion of female students tend to be enrolled in biology as opposed to mathematics or physics. At the same time, there may also be a possible link to the smaller or in some cases reversed gender gap in science performance in international assessments as opposed to mathematics. Nonetheless, in countries with a substantial gender difference in achievement in favour of female students, such as Malaysia and Thailand, data indicates that this does not necessarily correlate with the number of female contestants in these country delegations. For instance, in the Informatics and Physics 2014 Olympiads, both country delegations consisted of four male contestants (IOI, 2014; IPhO, 2014). Of these two countries, only Thailand participated in the areas of biology and mathematics in 2014. For Thailand, there was just one female of a total delegation of four for biology, and in mathematics all six contestants were male (IBO, 2014; IMO, 2014).

Another possible assumption from the results of these 2014 International Olympiads could be

Figure 14 *Proportion of female medallists in STEM-related International Olympiads in 2014 among participating Asia-Pacific countries and jurisdictions (%)*



Note: Overall proportion calculated based on participating countries from the Asia-Pacific region (see Annex 4).

Source: Compiled from IBO, 2014; IOI, 2014; IMO, 2014; IPhO, 2014.

found in the proportion of female contestants as part of the total delegation compared with the proportion of female medallists (See Annex 4 for full statistical tables by Olympiad and by country). In informatics for instance, female contestants represent 4 per cent of the total delegation among participating Asia-Pacific countries and on average 2 per cent of medallists, while in mathematics only 5 per cent of the total delegation was female with an average of 4 per cent female medallists. Looking in closer detail at the results of International Olympiads by country, it appears that in cases where female contestants are present among country delegations, they have a tendency to be awarded as medallists. For instance in physics, both Indonesia and Viet Nam each had one female contestant of a total delegation of five contestants, and in both cases, the female contestant was awarded with a gold medal (IPhO, 2014). In mathematics, Hong Kong- China, Indonesia, Iran and Viet Nam each had one female contestant of a total delegation of six contestants, with the female contestants from Hong Kong- China and Viet Nam being awarded with a silver medal and the contestants from Indonesia and Iran being awarded with a bronze medal (IMO, 2014). In biology, where a relatively higher number of female contestants were represented across all countries, a similar situation can be observed and in particular in countries that received the most medals overall. For instance, the Republic of Korea and Singapore each had one female contestant as part of a total delegation of four contestants, with both winning a gold medal (IBO, 2014). While these assumptions may not be statistically verifiable given the small sample sizes of country delegations as well as possible selection bias, this data may imply that when female contestants are highly represented, they are likely to perform well.

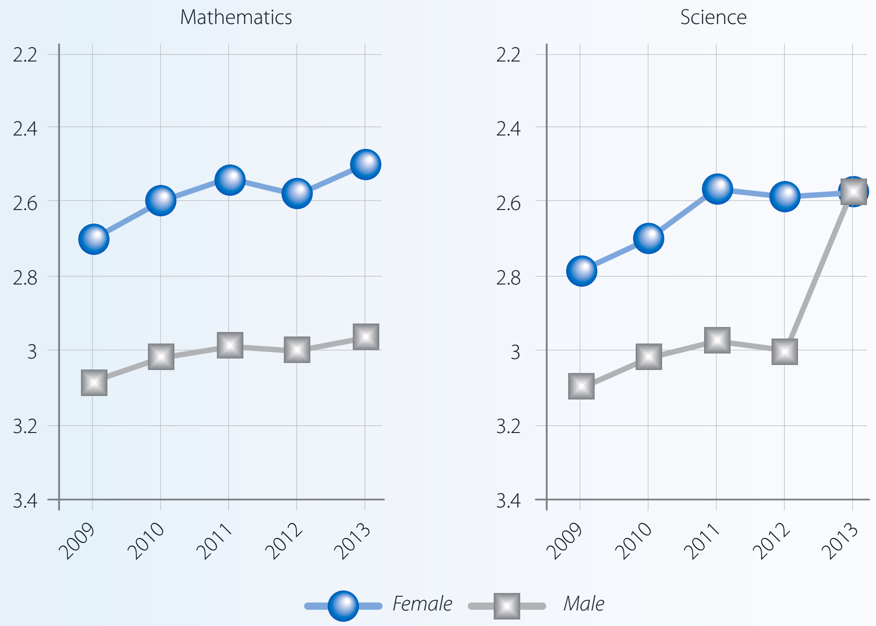
Arguably, International Olympiads not only provide recognition to high-achieving female students in these fields, but they also provide an opportunity to promote young female role models in their countries and beyond. The low level of female contestants and medallists shows that other factors may be at play in encouraging women to excel in STEM fields, especially in countries where a narrow gender gap was observed in participation in higher education and in the results of international assessments in mathematics and science.

C. National Assessments

The results of international assessments, as well as those of International Olympiads representing the highest levels of student achievement, provide clear and comparable information across countries. It is important, however, to examine the results of national assessments in mathematics and science (whether high-stakes examinations or low-stake assessments) where available among the seven countries under review. While the results of international assessments may not necessarily be comparable with the results of national assessments, the latter can still reveal an interesting dimension of the performance of female and male students in mathematics and science subjects. Based on available data disaggregated by sex from three of the seven countries – Malaysia, the Republic of Korea and Viet Nam – this section aims to explore how these subjects are assessed in these countries as well as explore the gender dimension of the results of national assessments.

Detailed information on the modes of national examinations in **Malaysia** shows that until 2013, mathematics and science had been assessed through centralized national examinations which were set by the Malaysian Examinations Syndicate at three levels: The Primary Achievement Test (UPSR) which is taken in the last year of primary at the age of 12, the Lower Secondary Assessment (PMR) taken at 15

Figure 15 *Trends in achievement among 15-year-old students in the Malaysian Lower Secondary Assessment (PMR)*



Note: This score is based on the national average grade (GPN) from grades A-E per subject, 1 being the highest and 5 being the lowest, with 1 being equivalent to A and 5 equivalent to E.

Source: MoE, 2013a

years old, the Malaysia Certificate of Education (SPM) taken at 17 years old and the Malaysian Higher School Certificate, also known as 'form six' (STPM) which is taken by students as a pre-university examination (Mahdzir et al., 2014). From August 2014 onwards, the PMR is replaced with a school based assessment system together with the centralized Form 3 Assessment (PT3), which could present opportunities to adapt to a student's individual learning styles and to perhaps better adapt to the different learning styles of female and male students.

For mathematics and science subjects, however, testing instruments tend to maintain their paper and pencil form (Ibid). Students are tested under the UPSR through multiple choice questions, a combination of multiple choice questions and coursework beyond the exam at PMR level, and both multiple choice and non-multiple choice questions via paper format at the SPM level. With regard to learning achievement in mathematics and science, data from the PMR assessment which is taken by 15-year-old students may show consistency with the results of international assessments specifically with regard to the higher performance of female students. In addition, trends in these results indicate that the gender gap in achievement has been sustained over the last four years. In the case of science however, the gender gap appears to have been closed in the year 2013, as male achievement increased. This is reflected in the national average grade in the PMR as displayed in **Figure 15**, which is carried out in national schools[16] and makes up approximately

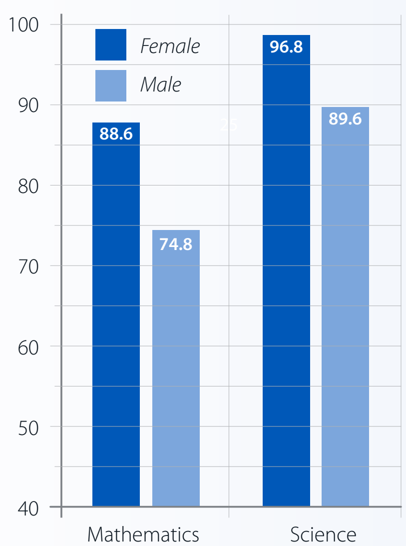
16 National schools refer to government-funded schools where the medium of instruction is Bahasa, as opposed to national-type schools which are government-funded schools where the medium of instruction is either Chinese or Tamil language (UNESCO IBE, 2004).

80 per cent of the total school population. Here, performance is indicated for both female and male students in mathematics and science, using the National Average Grade (GPN) which ranges from 1 (highest possible score) to 5 (lowest possible score).

Looking at the pass rate of the SPM in 2013, a high stakes examination taken by 17 year old students, the proportion of female students passing the exam also appears to be significantly higher than the proportion of male students, especially in mathematics as displayed in **Figure 16.**

Based on the data from Figures 15 and 16, a noticeable gender gap can be observed in favour of female students. While a higher proportion of students overall pass science compared to mathematics, 96.8 per cent of female students pass as opposed to 89.6 per cent of male students in science. In mathematics, the gap in achievement is even higher with 88.6 per cent of female students passing as opposed to just 74.8 per cent of male students. To a certain extent, these gaps are similar to those identified in international assessments, for instance in TIMSS 2011 results where female students scored an average of 19 points higher than male students in mathematics and four points higher in science.

Figure 16 *Proportion of students passing the Malaysia Certificate of Education (SPM) in mathematics and science in 2013 by sex (%)*



Source: MoE, 2013a

By contrast, in the **Republic of the Korea**, the higher scores among male students in international assessments are not necessarily reflected in national assessments at the lower secondary level, yet emerge at the upper secondary level. For instance, results from the Grade 9 (14-15 years old) National Assessment of Educational Achievement (NAEA), between the years 2010 and 2013, have consistently shown near-equal scores between female and male students in mathematics and science, with often slightly higher scores for female students. Based on these results, the difference in scores could be considered statistically insignificant, with female students scoring 190.95 in mathematics and 197.55 in science, as opposed to male students scoring 190.19 in mathematics and 195.05 in science respectively out of a maximum score of 300 (Lee, Jo, and Lee, 2014; Lee et al., 2014). While gender differences in learning achievement may not be evident at the primary level, they become visible at the lower secondary level, and are then clearly identified at the upper secondary level (Choi and Kim, 2014). Indeed, results from the Grade 11 NAEA from 2012 show that the proportion of male students among the highest achievers was 5.4 per cent higher than the proportion of female students, a trend which has been identified every year (Kim, et al., 2012). With this in mind, the lower proportion of female students in the highest levels of achievement in mathematics and science may indicate that specific strategies are required to reach high performing female students, considered as those with potential to pursue a career in these subjects, as well as provide additional support to those female students concentrated in intermediate and basic levels of achievement.

In the case of **Viet Nam**, differences in the gender gap are also observed with female students outscoring their male counterparts in national assessments as opposed to PISA 2012 where male students outscored female students by ten points in mathematics and by just one point in science as was observed earlier in this chapter. In 2009, a survey was conducted on achievement in mathematics and physics among Grade 9 students at the national level in order to supervise and evaluate learning outcomes of students as well as to inform adjustments in education policy (Do, 2014). According to the results of this survey, an 8.4 point difference in mathematics and an 8 point difference in physics were found in favour of female students, which appears to suggest a different pattern to those observed in the results of PISA 2012. While in the case of Viet Nam, the gender gap appears to differ between international and national assessments, to some extent the difference in performance in favour of female students is reflected in both international and national assessments in Malaysia, and in favour of male students in international and national assessments at upper secondary level for the Republic of Korea.

This chapter has sought to explore the gender dimension of learning achievement in mathematics and science in three main areas: results of international assessments such as PISA and TIMSS, results of International Olympiads in STEM-related fields, and results of national assessments in countries with available data. The main findings can be outlined as follows:

- Linkages between these three areas may not be statistically verifiable, yet they do provide useful insight into **gender differences in learning achievement**.
- While data from **international assessments** indicates that on average significant gender gaps remain in favour of male students in mathematics, they also show that female students are increasingly catching up in science. At the same time, while some countries show a substantial gap in favour of male students such as Japan and the Republic of Korea, other countries such as Malaysia and Thailand show a substantial gap in favour of female students with very different patterns among countries in Asia.
- **Female medallists** and contestants were very few and far between in the 2014 International Olympiads, even in those countries where female students scored higher in international assessments and even in biology where they tend to be more greatly represented in higher education.
- Finally, the results of **national assessments** also show a similar situation with regard to gender differences in achievement, especially in the cases of Malaysia and the Republic of Korea. In Malaysia for instance, both the results of national and international assessments show higher scores in both mathematics and science among female students. In the Republic of Korea however, where boys outscore girls in international assessments, higher scores are identified in female students at the lower secondary level, yet are higher in male students at the upper secondary level in national assessments. By contrast, Viet Nam shows minor point differences between female and male students in favour of females in mathematics and physics in national assessments, yet in the results of international assessments males scored slightly higher, especially in mathematics.
- While the data presented in this chapter provides a picture on the gender dimension of achievement, it is now important to further explore the **wider factors** that could potentially influence the differences in achievement between female and male students, and ultimately, their participation in STEM fields.

Part B

Girls and Women in STEM: What led us here?

5 Educational Impacts

In order to better understand the wider influences on student performance in mathematics and science, their attitudes towards these subjects as well as their career perspectives, it is important to consider a number of educational impacts. Based on the seven country case studies, this chapter will first explore education policies and programmes with regard to gender equality and STEM, followed by teaching and learning conditions, including the proportion of female teachers in mathematics and science, findings from classroom observations and analysis of teaching strategies and learning materials from a gender perspective. Private tutoring will then be examined based on results from the student questionnaire, followed by career counselling in terms of available services and support in schools and the results from the student questionnaire on perceptions of further study and career choices, as well as scholarship and mentoring opportunities.

A. Education policy

While some countries have implemented national policies on gender equality in education, and others perhaps specifically with regard to STEM, it remains unclear how far various ministries are working together to develop a specific policy framework on STEM education for girls and women. In **Cambodia** for instance, in working towards economic development in view of the forthcoming 2015 ASEAN Economic Community, the National Strategic Development Plan (2014-2018) has created a policy agenda that identifies the role of the education system as key to providing students with specialized skills in science, technology and research through improving the school environment (MoEYS, 2014). In particular, it outlines the need for better access to schools labs, computer training and preparation for potential participation in PISA and TIMSS assessments as well as scholarship opportunities for female students to enter STEM fields of study in order to meet these policy objectives.

In **Indonesia**, while no policy framework on gender, education and STEM was identified, there have been a number of efforts through various ministerial regulations to integrate gender mainstreaming and promote gender sensitivity in education (Sani, 2014). In the year 2000 for instance, the Presidential Instruction No. 9/2000 called for gender to be mainstreamed across all development programmes and all government levels, including the Ministry of National Education (MoNE) through ministerial regulation No. 84/2008 (MoEC, 2014). Gender mainstreaming was implemented in education from 2002 with the aim of reaching all districts and cities in the country by the year 2015, with provinces continuously working to implement a number of capacity development initiatives on gender mainstreaming (Ibid). In **Viet Nam**, the publication of the Viet Nam Country Assessment in 2006 led to a number of government initiatives including the Law on Gender Equality which was introduced (2006), the Law on Domestic Violence Prevention and Control (2007), and the National Strategy on Gender Equality (2010). The implementation of these policies, however, has been viewed by some as slow, partly due to lack of capacity across different ministries (Do, 2014).

In the case of **Mongolia,** the first Law on the Promotion of Gender Equality was adopted by the Mongolian Parliament in February 2011, and includes provisions on equal opportunities to education for both women and men, fair admission requirements in higher education in terms of gender equality, as well as reflecting gender equality issues in the curriculum from pre-primary to higher education levels (Khishigbuyan, 2014). In **Nepal**, two specific policies for gender and education were introduced in 2007, including the Gender Mainstreaming Strategy and the Girls' Education Strategy for Gender Equity and Development (UNESCO and KWDI, 2013).

Malaysia has also worked to launch a number of relevant STEM-related education policies over the years, in particular due to concern over the declining interest in science streams among all students, as well as increased underperformance among male students in mathematics and science. As far back as 1967, Malaysia's Planning Committee of Higher Education first introduced the 60:40 Policy in recognition of the importance of STEM education to align with the human resources needs of the country. This policy aims to promote a ratio of 60 science stream students to 40 arts stream students at upper secondary level with the objective of producing sufficient quality science graduates by the year 2020. In reality, the declining interest in science streams has led to some estimates of this ratio standing at 20:80 as of 2012 (MoSTI, 2012, p. 6), while data from 2009-2013 identifies the figure to have stood at an average of 37:63 (MoE, 2013b). Other initiatives, such as the decision to replace the Lower Secondary Assessment (PMR) with school-based assessment from 2014 (as examined in Chapter Four), indicate a step towards seeking more holistic and flexible assessment methodologies that can adapt to the needs of female and male students, and more widely to students of different characteristics, backgrounds and learning needs. Although no specific initiatives or policies exist thus far, the higher number of female students enrolled in science streams as well as STEM disciplines in higher education, as well as the sustained higher performance of female students in all subjects including mathematics and science, could present a reversed situation and eventually become a concern with regard to male students and marginalization in education policy (Mahdzir et al., 2014).

In the **Republic of Korea**, however, a number of policy measures and initiatives specifically related to education, gender and STEM have been initiated in order to address the issue of women in STEM fields. Over the last 14 years, initiatives such as the Women into Science and Engineering (WISE), gender inclusive curricula, fellowship opportunities for female students in science and engineering, job training opportunities aiming to overcome traditional gender roles, as well as the 2002 Act on 'Fostering and Supporting Women Scientists and Technicians' are all examples of this (Choi and Kim, 2014). In addition, the Center for Women in Science, Engineering and Technology (WISET) was established, which will be further explored later in this chapter in the section on career orientation. Other examples of specific gender policies may be found in other countries. For instance in Thailand, the successful Development and Promotion of Science and Technology Talents Project (DPST) appears to have almost equal numbers of male and female graduates since its inception, aiming to nurture friendship among project participants, exposure to role models, the organization of field trips, and the encouraging 'learning for learning's sake', meaning that students are encouraged to have a positive attitude towards mathematics and science regardless of whether they excel in the subject or not (APEC, 2010, p. 11). Arguably, such policies and programmes, and in particular the initiatives in the Republic of Korea and Thailand, are a positive step in providing support for learning in mathematics and science, as well as in stimulating interest in STEM fields among students.

B. Teaching and learning conditions

The school environment – in terms of how gender-sensitive and supportive the environment is for both female and male students – also presents a crucial area for analysis in terms of how female and male students may be influenced in learning in mathematics and science. This section is therefore structured to explore teacher sex, for instance with regard to the proportion of female teachers who are often the first role models that female students encounter in these fields, the relationships and interactions between teachers and students, teaching strategies and teaching and learning materials including textbooks.

Female teachers

Female teachers can serve as one of the first female role models that girls are exposed to (UNESCO, 2014a, p. 43). Despite the feminization of the teaching profession in lower levels of education and in lower positions in many countries in Asia, when looking more specifically at mathematics and science, it is common for teachers to be predominantly male and also as the level of education increases in most countries. Looking at the proportion of female teachers in these subjects in **Nepal** based on 20 classes observed as part of this research, eight out of ten teachers were male in science classes, and nine out of ten teachers were male in mathematics classes. The opposite situation can be seen in **Mongolia**, which traditionally has a highly feminized teaching workforce, with national level data showing that on average approximately 90 per cent of teachers in chemistry and biology, as well as 75 per cent of teachers in information and communication technologies (ICT), mathematics and physics are female (NSO, 2012). While the high concentration of female teachers at the primary and lower secondary level was also identified across all subjects in the **Republic of Korea**, this was shown to decline as the level of education increased as displayed in **Table 7.**

Table 7 *Proportion of female teachers by level of education in the Republic of Korea as of 2013 (%)*

	Pre-Primary	Primary	Lower Secondary	Upper Secondary	Higher Education
% Female teachers	99.2	78.2	68.8	46.7	34.1

Source: MoE, 2014

In the Republic of Korea, the majority of teachers at the pre-primary level are female at 99.2 per cent, a proportion which gradually decreases to 46.7 per cent at the upper secondary level and to just 34.1 per cent in higher education. It could be inferred that subject-specific data would show a similar situation, and perhaps even lower proportions for mathematics and science, especially at higher levels of education.

Relationships between students and teachers

In terms of relationships and interactions between students, as well as between teachers and their students, the results from the classroom observations conducted across the seven countries for this study seem to indicate equal treatment and equal levels of participation of female and male students in mathematics and science classes. However, different patterns were identified in some classes. For instance in **Indonesia**, analysis of classroom observations shows that female students seem more engaged, participate more actively and ask more questions in these subjects than their male peers. In **Cambodia**, however, there were overall equal levels of activeness, teacher support and sharing of opinions in class between male and female students, yet with some important differences. While female students tended to give more correct answers to questions than their male counterparts, they demonstrated higher levels of reluctance, shakiness and anxiety in answering questions, with some female students even waiting until the class was over to ask specific questions to their teachers, whereas male students were perceived as braver and more confident, despite their answers more often being incorrect.

In terms of grouping of students during team activities, observations in **Mongolia** found that in all except one class observed, teachers assigned equally mixed groups comprising both female and male students. In **Nepal**, a contrasting situation was identified in urban and rural locations with regard to the level of participation and support in the classroom. While boys were observed to be significantly more active and confident and received more teacher support in urban areas, quite the opposite was found in rural areas, where girls were observed as having more teacher support, as well as higher level of participation and confidence in both mathematics and science classes. The same findings arose from classroom observations conducted in **Viet Nam** where male students seemed less confident in presenting in front of the classroom in rural areas than their female counterparts. At the same time, important differences were observed with regard to the number of opportunities given to female and male students to interact with their teachers or respond to questions, especially in mathematics as demonstrated in **Table 8**.

These observations in Table 8, which are based on eight classroom observations conducted in mathematics and science classes as well as in both urban and rural areas, suggest that perhaps there is more frequent interaction between teachers and their male students as opposed to female students. For instance in mathematics, the number of interactions observed with teachers for male students stood at 65 per cent as opposed to 35 per cent for female students. In science, a similar pattern was observed with 61 per cent of student-teacher interactions being for male students as opposed to 39 per cent for female students.

Teaching strategies

Looking in more detail at teaching strategies and effectiveness in these subjects, studies show that teacher training and preparation, student access to practical 'hands-on' and

Table 8 *Interactions between students and teachers in upper secondary mathematics and science classes by sex based on classroom observations in Viet Nam*

	Mathematics						Science					
	Urban		Rural		**Total**		Urban		Rural		**Total**	
	No.	%	No.	%	**No.**	**%**	No.	%	No.	%	**No.**	**%**
Female	8	32	5	42	**13**	**35**	4	18	16	55	**20**	**39**
Male	17	68	7	58	**24**	**65**	18	82	13	45	**31**	**61**

Source: Do, 2014

creative activities, and increased use of student-centred methods using cooperative learning can strengthen students' positive attitudes towards science (Haladyna, Olsen, and Shaughnessy, 1982; Myers and Fouts, 1992). Studies also argue that for girls in particular, interest and performance in STEM-related subjects increase substantially through an interactive learning environment that allows for team-based learning and hands-on activities (Christie, 2005; Sanders, 2005). With regard to gender-responsive teacher training and generally in the teaching of science in **Cambodia** for instance, few opportunities for teacher education and more broadly capacity development in this area has meant that there is little room for teachers to fully integrate gender equality through their teaching strategies. Findings from a school supported by an NGO showed the extent to which such training could potentially have a positive impact on girls' learning achievement in science. For instance, in a school in Siem Reap province supported by the NGO Caring for Cambodia where teacher training and resources for conducting science experiments were provided, the national exam pass rate for female students was the highest of all 19 schools in that province. This demonstrates the importance of necessary equipment and resources in teaching science, but also of gender-responsive training for teachers.

In addition, findings from another study conducted in Cambodia have shown that provision and use of science labs can not only have a positive impact on student participation and interest, but could also help overcome preconceived notions of girls' inability to perform well in science (Kelley et al., 2013). The lack of adequate facilities was also observed in **Mongolia**, where lack of funding has meant that teachers lack resources and equipment in order to carry out experiments in science classes, and with some schools relying on outdated equipment from the socialist era, especially in rural areas. Arguably, the increased resources for experiments, which offer the opportunity for students to apply their knowledge in practice, could help stimulate interest among female students to potentially pursue these disciplines in further study. More broadly across the seven countries, the importance of gender-responsive teacher education with regard to both mathematics and science was raised as important in order to address the different learning needs of female and male students.

Teaching and learning materials

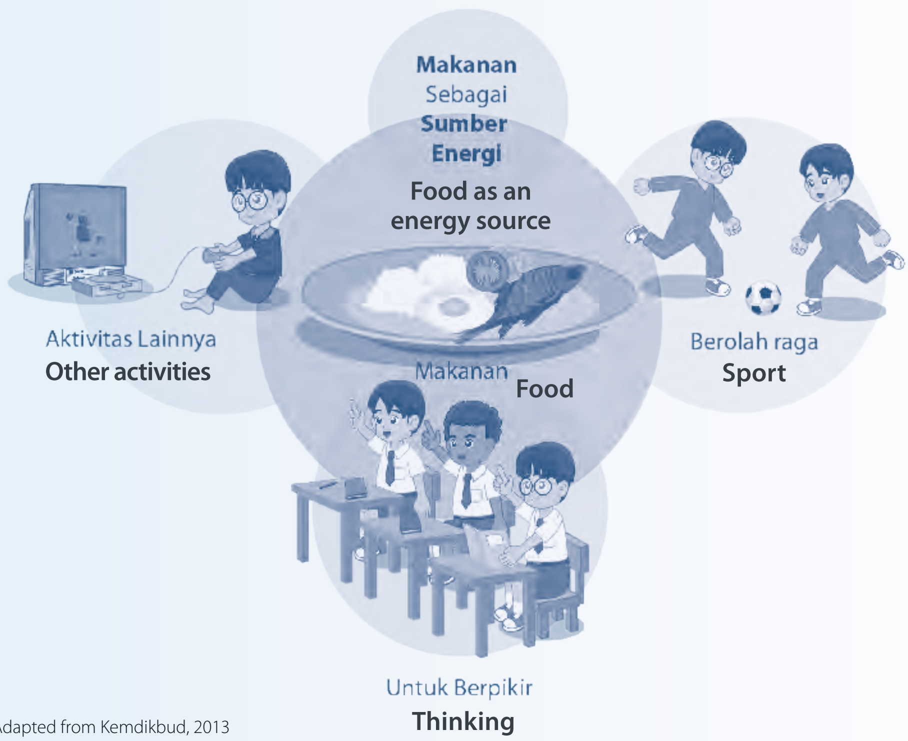
Another important factor within teaching and learning conditions is that of textbooks and learning materials and in particular, the ways in which they portray the roles of females and males. Indeed, analysis of textbooks among the seven countries reviewed indicates that in some cases, textbooks and curricular teaching and learning materials continue to permeate gender stereotypes. For instance in the case of **Indonesia**, while the 2013 curriculum content in mathematics and science is considered gender-sensitive, the learning materials used in its implementation could be considered as quite the opposite (Sani, 2014). As shown in **Figure 17**, images used in the Grade 7 science textbook, developed by the MoEC and implemented in all schools nationwide at this level, mostly portray students as male.

In the case of **Cambodia**, another illustration is taken from a Grade 9 science textbook under the lesson plan on the central nervous system, presenting another example of how textbooks may be perpetuating subtle gender stereotyping as displayed in **Figure 18** (MoEYS, 2012).

In explaining brain function, it could be argued that this illustration depicts males as thinking and exercising as opposed to females who are depicted as smelling flowers and tasting food. Indirectly, it could be inferred that this illustration communicates subtle messages regarding the most basic human functions (Szmodies and Eng, 2014).

But this concern is not limited to the cases of Indonesia and Cambodia. Other countries such as the Republic of Korea, Nepal and Viet Nam have also sought to raise the need for a gender-sensitive review of learning materials. In the Republic of Korea for instance, the dominance of male characters in textbooks, which tends to increase as the level of education advances, could arguably reinforce gender stereotypes with regard to certain types of professions, especially if they are represented by one gender (Choi and Kim, 2014). In turn, this could

Figure 17 *Representation of students in Grade 7 science textbooks in Indonesia*



Source: Adapted from Kemdikbud, 2013

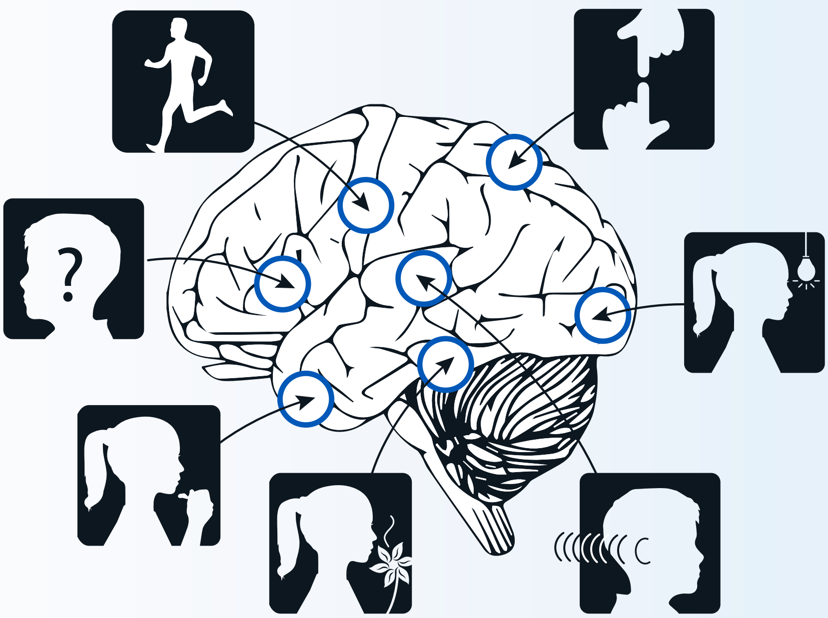
potentially contribute to fuelling negative attitudes or perceptions of mathematics and science subjects as well as affecting levels of achievement of female students.

In **Nepal**, a study commissioned by DFID and the Royal Norwegian Embassy looked at a sample of school textbooks to analyze how gender roles and relations are depicted. The review found that while on the whole, males and females are represented in a balanced manner and most of the textbooks reviewed are free from harmful gender stereotypes, a few textbooks still feature stereotypical presentations of men and women's roles (Terry and Thapa, 2012). The findings are broadly in line with previous reports which have noted the progress made in incorporating contents on gender sensitivity and removing negative gender stereotypes from textbooks in Nepalese schools. In **Viet Nam**, similar cases were observed in a textbook analysis conducted by UNESCO between 2009 and 2010, which also showed cases of under-representation of women and girls, but also subtle biases in the ways in which they are portrayed. For instance, girls and women are presented as kind and caring, often in professions such as weaving, nursing or teaching, whereas boys and men in mathematics textbooks are portrayed as strong and able to use modern technology (UNESCO Ha Noi, UNESCO IBE and MOET, 2010; Do, 2014).

C. The gender dimension of private tutoring in mathematics and science

With persisting competition in education in Asia, which has in part been driven by benchmarking through international assessments, the gender dimension of supplementary and fee-paying private tutoring can provide some interesting insights into the relationship with learning achievement. According to Bray and Kwo (2014), this emerging phenomenon in the region and

Figure 18 *Grade 9 science textbook Illustration on the central nervous system in Cambodia*



Source: MoEYS, 2012

Table 9 *Proportion of students reporting having received private tutoring across all subjects in the 2013/2014 academic year (%)*

Country	% students receiving private tutoring	Of which % female	Of which % male
Cambodia	87	51	49
Indonesia	52	63	37
Malaysia	68	59	41
Mongolia	14	71	29
Nepal	73	53	47
Republic of Korea	74	54	46
Viet Nam	66	53	47

Note: In the case of Mongolia, only half of the total surveyed students responded to this question.

Source: Based on results from the student questionnaire (Annex 1)

worldwide is at least partially driven by examinations at both school and system levels (Bray and Kwo, 2014, p. 5). With regard to the gender dimension of private tutoring, the likelihood of female or male students receiving tutoring varies in favour of either gender depending on the country (Ibid, p.27).

According to the student questionnaire results in the seven countries under review, a high proportion of private tutoring is undertaken in STEM-related subjects as well as in English as a foreign language. When asked why they take private tutoring, the main responses from both female and male students across all countries were a) to increase exam scores, and b) to learn the subject better. The proportion of female and male students surveyed that reported having received private tutoring in the last academic year across all subjects is outlined in **Table 9**, as well as the proportion of female and male students within mathematics and science subjects as presented in **Table 10**.

These findings reveal a number of interesting points with regard to proportions of female and male students receiving private tutoring. In some countries such as Indonesia, Malaysia and Mongolia, the proportion of female students receiving tutoring across all subjects is substantially higher than male students. In Cambodia and Vietnam however, female and male students reported receiving private tutoring in near-equal numbers. Looking more closely at these results by subject, a similar pattern can be identified. For instance in **Cambodia**, a significant association was identified between the subjects in which students were receiving private tutoring and those perceived as their lowest performance subjects with the exception of biology which was perceived as among the highest performance subjects for both female and male students. In the **Republic of Korea**, where a near-equal proportion of female students (54 per cent) and male students (46 per cent) reported receiving private tutoring across all subjects, when looking at those reporting receiving tutoring in physics, the proportion is 100 per cent female as opposed to 59 per cent female in mathematics. Overall, the higher number of female students receiving private tutoring could perhaps indicate that girls need more support, or that girls are more anxious about their performance in these subjects. The latter would link to other

Table 10 *Proportion of female and male students reporting having received private tutoring in mathematics and science subjects in the academic year of 2013/2014 (%)*

Country	Subject	% Female	% Male
Cambodia	Biology Chemistry Mathematics Physics	45 57 50 55	55 43 50 45
Indonesia	Biology Chemistry Mathematics Physics Other	67 69 67 68 57	33 31 33 32 43
Malaysia	Mathematics Science	59 59	41 41
Mongolia	Mathematics	71	29
Nepal	Mathematics Science	52 52	48 48
Republic of Korea	Physics Mathematics Other	100 59 35	0 41 65
Viet Nam	Chemistry Mathematics Physics	50 47 50	50 53 50

Note: In the case of Mongolia, only half of the total surveyed students responded to this question.

Source: Based on results from the student questionnaire (Annex 1)

findings from the questionnaire results as will be presented in the subsequent chapter on psychosocial influences, showing that girls, contrary to analysis in previous studies, may have higher motivation and perseverance in mathematics and science subjects.

D. Career counselling

As has been examined in previous chapters, a number of determinants may shape career perspectives and choices of female and male students. Looking more closely at some aspects of both formal and informal career counselling, namely perspectives of students on future study and career plans, it appears that most students across the seven countries plan to pursue higher education, with high interest in STEM fields of study. Based on the findings of the first study in this series on career perspectives and choices as mentioned in Chapter One of this report, it appears that female and male students may have an internalized bias as to what types of occupations are better suited to women or men, as well as a higher preference among male students towards STEM occupations such as engineering and a higher preference among female students towards medicine (UNESCO and KWDI, 2013). At the same time, it also appears that appropriate and gender-responsive career counselling services and scholarship programmes may be lacking, as will be considered in this section. In

Cambodia for instance, 95 per cent of students surveyed plan to pursue further study in higher education, of which 54 per cent plan to pursue a career in a STEM-related field. In addition, a regression analysis based on these questionnaire results showed that this outcome was highly associated with subjects which students most enjoy, those in which they perceive highest performance, as well as those in which they felt they had parental and teacher support. However, the country report argues that there is a questionable level of understanding of these subjects, and in particular in the explanations of why they enjoy these subjects and wish to pursue these in the future (Szmodies and Eng, 2014). At the same time, a negative correlation was found between those receiving private tutoring in mathematics and science and those who were more likely to wish to pursue non-STEM related subjects in higher education. While no significant gender differences were observed, in rural areas, female students tended to agree more with the statement that STEM related professions were suitable for women than male students.

In **Indonesia**, linkages between career aspirations of students and participation by STEM discipline in higher education were also identified when students were asked to state their career aspirations in open questions of the questionnaire. For instance, among students who reported enjoying science and who wished to pursue a career in science, female students reported the choice of career of medical doctor, as opposed to male students who reported interest in becoming engineers. This suggests that many of the patterns identified in enrolment in higher education by discipline, as well as labour market participation by occupation within STEM, may already be shaped by the perspectives of students at 15 years old. At the same time, female students were more likely to perceive mathematics as important for their future career at 83 per cent, as opposed to just 39 per cent of male students. A similar observation is found in science where 78 per cent of female students consider the subject important for their future career, compared to 35 per cent for their male counterparts.

In **Mongolia**, both female and male students plan to study and pursue a career in the subjects that they enjoy most, yet at a higher rate for female students at 88 per cent as opposed to 70 per cent of male students. When students were asked to explain their choices through open questions, no gender difference was identified in responses, with students stating reasons such as interest and market demand, as well as to support their parents and develop their country. A high number of students also plan to pursue higher education in **Viet Nam** at 97 per cent, of which 87 per cent plan to pursue a subject which they most enjoy. Here there was no significant gender difference.

The role of career counselling in schools could arguably play a positive role in guiding female and male students in their future study and career choices, yet structured programmes remain limited across the seven countries. In **Nepal** for instance, there are no such programmes, but rather career counselling is offered informally by teachers. The most important element for teachers in giving career advice to students, however, is academic achievement, with those scoring above 90 per cent in the Grade 10 exam usually encouraged to pursue medical science or engineering regardless of their gender (UNESCO and KWDI, 2013, p. 30). By contrast, career counselling services do exist in the **Republic of Korea**. Of those available, however, some argue that most of these programmes are not gender-sensitive (Choi and Kim, 2014). According to analysis presented in the country report, this might indicate that at present, educational policymakers and administrators may not have considered gender equality issues in developing career counselling programmes. At the same time, it was found that when female students seek advice from parents and teachers, there is a tendency for them to stress the lower number of female professionals in STEM fields and the difficulties that may be faced as a result of gender should they eventually choose to pursue a career in STEM fields, which could arguably have a negative influence on their career choices and perspectives (Ibid).

E. Scholarship and mentoring opportunities

In addition to career counselling, scholarship programmes also present an encouraging initiative for students to pursue STEM fields of study in higher education, with two examples identified among the seven countries. For instance in **Indonesia**, such programmes are available, yet not specifically targeted at female students. When looking at the proportion of students who received scholarships for further study in STEM fields of study, however, the figure is slightly higher for male students at 8.65 per cent as opposed to 7.76 per cent for female students (Statistics Indonesia, 2013).

A similar finding is observed in the **Republic of Korea** where there is a lower representation of female students in programmes for students gifted in science, in particular as the level of education increases (MSIP, 2014a). Nonetheless, a number of initiatives in the country are striving to promote women's and girls' education and career prospects in STEM fields. In higher education for instance, scholarships for students to pursue STEM disciplines include quotas in order to increase opportunities for female students (MSIP, 2014b). The Centre for Women in Science, Engineering and Technology (WISET) referred to earlier in this chapter, seeks to promote educational and career programmes for women and girls to foster their interest in mathematics and science, develop their potential, and support their progression to study STEM disciplines in higher education. In addition, WISET also provides a mentoring programme whereby female students and professionals in STEM fields are paired to provide students with a female role model and mentor. This programme has continued to grow from 219 such pairs in the years of its initiation in 2002 to 3,667 pairs in 2013.

Such a mentoring programme could be a source of great support for female students as they progress through their studies and eventually move into STEM careers. Finally, the WISET award programme seeks to inspire female scientists and engineers by giving recognition to female students in upper secondary education for outstanding papers and posters in this field (WISET, 2013a). Looking more closely at job training, WISET supports female job seekers in STEM fields through information on employment trends, interview preparation, communication skills as well as training opportunities in research aimed to develop competencies such as leadership, creativity, writing and project management for undergraduate and graduate level female students. It also provides temporary job opportunities for graduate students in early stages of their careers, as well as education and training for women scientists and engineers that have taken career breaks (Ibid).

Educational factors can have a great impact on student performance and attitudes towards mathematics and science, learning achievement as well as student choices for further study and careers in STEM. Some reflections on the educational factors explored in this chapter are also follows:

- There are a number of **remaining gaps** with regard to the gender sensitivity of education or STEM-related policies, career counselling and scholarship programmes where they exist.
- While policies on gender mainstreaming were identified among the seven countries under review, it remains unclear how far **specific policy frameworks** have been implemented in recognizing both gender equality and attracting girls and women to STEM, which may indicate an area for collaboration between ministries of education, labour, science and innovation and gender equality or women's affairs.
- The lower proportion of **female teachers** in higher levels of education in mathematics and science could limit the number of role models for female students in learning these subjects.
- With regard to the **relationship between students and between teachers and students,** the questionnaire responses among the seven countries tended to show that these were generally positive for both female and male students. Yet in the case of Viet Nam, it appears that male students may be more greatly benefitting from more frequent interactions with their teachers than their female counterparts, a finding that could be further studied across a range of subjects.
- While it appears that overall countries recognize the importance of STEM fields in contributing to economic development through education policies and beyond, **specific initiatives** such as gender-sensitive curricula, teaching strategies, career counselling and scholarships that target all students, including female students, appear to be lacking in most countries. Arguably, initiatives such as those identified in the Republic of Korea could potentially help stimulate interest among female students as well as provide support to those who wish to pursue STEM fields in further study and eventually in their careers.

6 Psychosocial Influences

A growing body of research has identified that gender differences in learning achievement in mathematics and science, as well as in student choices to pursue further study and eventually a career in STEM fields, may potentially be the result of various psychosocial factors related to student attitudes towards these fields. Indeed, PISA 2012 results included an additional survey which examined the gender dimension of motivation, confidence and anxiety towards mathematics where a gender difference in these aspects was identified to the advantage of male students (OECD, 2013). This suggests that there are other influential factors that lie behind enrolment rates in STEM fields of study in higher education and levels of learning achievement in examining the attitudes of female and male students towards mathematics and science. This chapter will first examine the findings of various studies that explore these psychosocial factors before looking at the results of the student questionnaire, which was conducted for the purpose of this study, and which is structured in three main parts: a) student preferences towards different subjects as well as their perceived performance in these subjects, b) student attitudes towards mathematics and science and c) parent and teacher influences with regard to learning mathematics and science.

International research suggests that levels of confidence and perseverance, particularly in female students, could in fact be influenced by the risk of 'negative stereotype threat'. This threat can be defined as the "fear of being viewed through the lens of a negative stereotype or of doing something that would confirm that stereotype" (Hill, 2013). Academics also argue that these stereotypes are developed from the earliest ages, for instance through toys that are given to children such as dolls for females or cars for males (BBC, 2011). Another study conducted by Dweck (2008) argues that the ability of female students to develop a 'growth mindset', whereby students are taught that intelligence is not fixed but rather achieved overtime through experiencing failure and perseverance, could potentially help to reduce this gap in achievement (Dweck, 2008, p. 4). Through teaching a growth mindset, this could make them far less vulnerable to the threat of negative stereotypes, for instance from the negative stereotype that girls are 'not good' at mathematics and science. From various experiments cited in the study whereby 'growth mindset groups' (having been taught about growth mindset) and 'control groups' (taught about a fixed mindset) were followed over a length of time, results from growth mindset groups showed that female students made the biggest gains in assessments in mathematics and in some cases even greater than those of male students, whereas female students performed much lower in control groups with male students largely unaffected (Ibid, p.7). Experiments for minority groups in the United States show a similar trend with the largest gains in achievement found in African-American students who were placed in the 'growth mindset' group (Ibid). Considering the gender differences in learning achievement that were observed in the previous chapter, these findings may imply that the 'growth mindset' approach targets those who may be less confident as a result of their vulnerability to negative stereotype threat.

Related to the wider issue of negative stereotype threat, the gender dimension of student interest and attitudes towards mathematics and science may not only affect learning achievement in these subjects but also choices for further study and careers. According to a 2011 OECD report on gender equality in education, employment and entrepreneurship, it appears that gender differences in these choices could be more influenced by psychosocial factors such as motivation, confidence and perseverance than by one's ability or performance (OECD, 2011, p. 2). The report also identifies that even among female students enrolled in higher education in STEM fields of study, they are less likely to continue a career in these fields than their male counterparts (Ibid). Even among those who are enrolled in STEM fields in higher education, female students tend to be concentrated in specific disciplines such as biology or medicine as was observed in Chapter Three.

According to Gibbons (2009), "Certain STEM sub disciplines with a clearer social purpose, such as biomedical engineering and environmental engineering, have succeeded in attracting higher percentages of women than have other sub-disciplines like mechanical or electrical engineering." Indeed, it is important to consider how psychosocial factors may influence student performance, choices and attitudes within the unique Asian context where gender differences in participation and achievement vary greatly by country. The findings based on responses to the student questionnaire, conducted in the seven countries under review, also reflect these variances. At the same time, they point towards possible linkages between the attitudes of male and female students in mathematics and science, the gender gap in learning achievement, as well as the representation of female students in higher education.

A. Student subject preferences and perceived performance

In order to better understand the attitudes of female and male students towards different subjects, the questionnaire[17] asked students to select their three most and least enjoyed

17 See questions 4-5 in Annex 1.

subjects, as well as the three subjects in which they felt they performed best and worst. These were then compiled as the three most frequently occurring subjects for each category by country and by sex. Looking at subject preferences, linkages could be identified with female and male enrolment in higher education by field of study, while at the same time some interesting exceptions are displayed in **Table 11**.

Based on the overall subject preferences presented in Table 11, some observations can be found when looking specifically at mathematics and science. For instance, mathematics was chosen as one of the most enjoyed subjects by male students in six countries, but by female students in just three countries. Nonetheless, mathematics subjects only appeared as one of the least enjoyed for both male and female students in two countries – Cambodia (calculus) and Indonesia (general mathematics). Science was selected as one of most enjoyed subjects by female students in four countries and by male students in three countries, whereas it was chosen as one of the least enjoyed subjects in four countries by female and male students

Table 11 *Most and least enjoyed subjects reported by students by country and by sex*

Country	Most enjoyed subject		Least enjoyed subject	
	Female	Male	Female	Male
Cambodia	Foreign Languages Language/Literature Biology	History Algebra Language/Literature	Social Science Life Skills and Calculus (tie) Physical Education and Science (general) (tie)	Social Science Life Skills and Calculus (tie) Physical Education and Science (general) (tie)
Indonesia	Physical Education Art Music	Physical Education Art Music	Chemistry and Algebra (tie) Mathematics Physics	Mathematics Moral and Ethics Education Physics
Malaysia	Language/Literature English Life Skills	Mathematics Language/Literature Art	Moral Educatiion Science Geography	History English Science
Mongolia	Foreign Languages Mathematics Physics	Mathematics Foreign Languages Physics	Art Technology Music	Music Technology Art
Nepal	Science (general) Biology Mathematics and Computer Science (tied)	Science (general) Mathematics Algebra	Geometry Music Foreign Languages	Chemistry Design/Technology Foreign Languages
Republic of Korea	Physical Education Science Art	Physical Education Science Mathematics	Foreign Languages Moral and Ethics Education Social Science	Language/Literature Social Science Moral and Ethics Education
Viet Nam	Language/Literature Mathematics Foreign Languages	Algebra Physical Education Mathematics	Chemistry History Foreign Languages	Foreign Languages History Art

Source: Compiled from country reports

respectively. This could perhaps be due to the different ways in which science may be taught in schools across the seven countries, which presents an area for further analysis. While these findings are based on small samples and correlations with participation in STEM fields of study in higher education may not be determined at first glance, upon further analysis by country however, they do provide interesting insight as demonstrated in the cases of Cambodia, Indonesia, Mongolia and Nepal.

Based on the questionnaire results in **Cambodia**, it was found that there was no statistically significant gender difference with regard to interest in mathematics and science. However, analysis presented in the country report argues that this anomaly may simply exist due to indicators suggesting an overall lack of interest in these subjects for all students (Szmodies and Eng, 2014). Another study previously conducted in Siem Reap province of Cambodia with more than 900 students between Grades 7-12 also showed similar results with no significant gender differences in STEM interests (Kelley et al., 2013). Nonetheless, when looking at the three most and least enjoyed subjects in Cambodia, while those subjects least enjoyed appear quite similar among female and male students, only female students state biology, a STEM-related subject, as one of their most enjoyed subjects. This similarity between female and male subject preferences, as well as a possible low interest in mathematics and science, is also identified in **Indonesia** where both female and male students showed a preference for non-academic curricular subjects such as physical education, art and music, while also choosing a number of STEM-related subjects among least preferred subjects, namely chemistry, mathematics and physics. Further analysis based on open questions related to subject preferences in the questionnaire also found that students in Indonesia felt that subjects such as physical education and art were perceived as 'easier', perhaps in terms of assessment, and therefore more enjoyable, whereas mathematics and science subjects were considered too difficult to understand, full of formulae and too fast-paced in the way in which they were taught.

By contrast, **Mongolia** presents rather different results from the questionnaire, with both female and male students choosing mathematics and physics among their most enjoyed subjects, with art and music among those least enjoyed. Mathematics, and in particular physics, are two STEM-related subjects that are usually shown to have higher participation of male students in higher education as was observed in Chapter Three. While mathematics showed a higher preference among male students as selected by 46 per cent of male students as opposed to 36 per cent of female students, physics showed a slightly higher preference from female students selected by 34 per cent as opposed to 30 per cent of male students. Similar results emerged in **Nepal** where both female and male students selected STEM-related subjects such as general science and mathematics among the top three subjects that they most enjoy along with biology for female students and algebra for male students. A difference however, was observed with regard to computer science in terms of students located in urban and rural areas, ranking as the third preferred subject for both urban female and male students, yet not among the top three most enjoyed subjects in rural areas, which could perhaps be due to the lower availability of computer equipment in rural areas more generally. At the same time, other STEM-related subjects were among the three least enjoyed subjects such as geometry for female students and chemistry in the case of male students.

While this can provide insight into the subjects that students enjoy most and enjoy the least, it is important to also consider how female and male students perceive their own performance in different subjects. As part of the questionnaire, students in the seven countries were also asked to identify the three subjects in which they felt that they perform highest, as well as those in which they felt that they perform lowest with the most frequent responses by country and by sex displayed in **Table 12**.

At first glance, the findings in Table 12 reveal that science was more often perceived among students' highest performing subjects, and mathematics was more often perceived as among students' lowest performing subjects. For instance, mathematics was perceived by female students in three countries and by male students in four countries as among their highest performing subjects, while it was perceived by both female and male students as among the lowest in six countries. Science subjects, however, were equally perceived as

Table 12 *Student perceptions of subject performance by country and by sex*

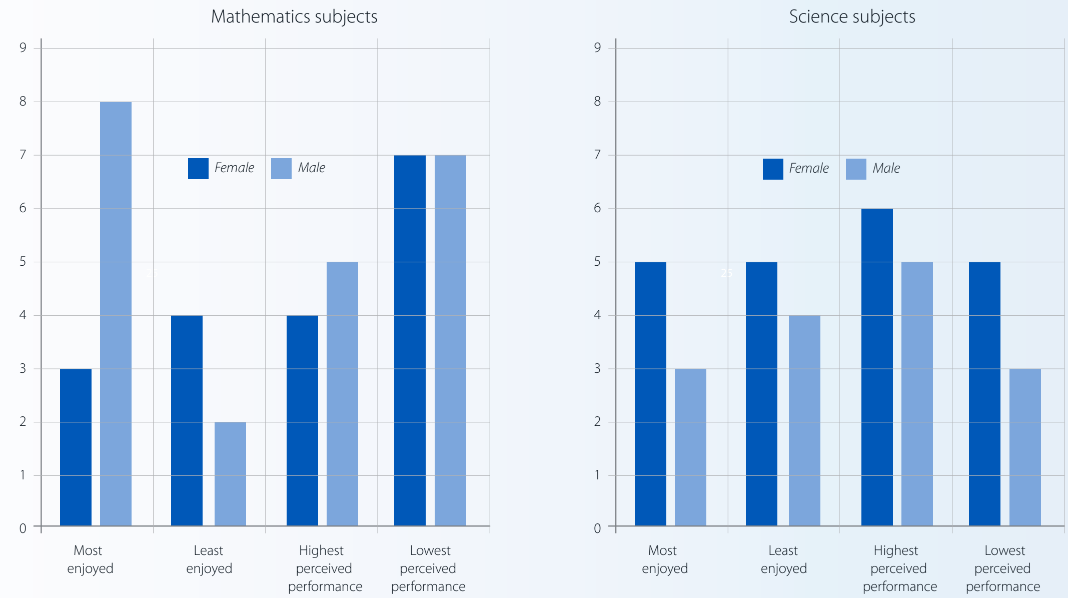
Country	Highest perceived performance		Lowest perceived performance	
	Female	Male	Female	Male
Cambodia	Biology Language/Literature Foreign Languages	Biology History Language/Literature	Foreign Languages Physics Algebra	Foreign Languages Chemistry Algebra
Indonesia	Language/Literature Physical Education Social Science	Physical Education Social Science Language/Literature and Art (tie)	Mathematics Moral and Ethics Education Foreign Languages	Mathematics Moral and Ethics Education Foreign Languages
Malaysia	Language/Literature English Science	Language/Literature Science Geography	Mathematics Geography History	History Mathematics English
Mongolia	Physics Language/Literature Biology	Physical Education Mathematics Technology	Chemistry Mathematics Foreign Languages	Mathematics Foreign Languages Language/Literature
Nepal	Science Algebra Mathematics	Science and Mathematics (tie) Physical Education Algebra	Geometry Chemistry and Geography (tie) Mathematics	Foreign Languages Geometry Mathematics
Republic of Korea	Science Language/Literature Mathematics	Mathematics Physical Education Science	Foreign Languages Mathematics Social Science	Language/Literature Mathematics Science
Viet Nam	Mathematics Language/Literature Foreign Languages	Physical Education Mathematics Physics	Chemistry Foreign Languages Physics	Foreign Languages Chemistry History

Source: Compiled from country reports

among highest performance subjects in five countries by both female and male students, yet among lowest performance subjects by female students in five countries and by male students in just two countries.

Looking more closely at possible linkages between most and least enjoyed subjects (Table 11) and highest and lowest perceived performance (Table 12), mathematics is more likely to appear among the most enjoyed subjects, especially for male students, yet it is also more likely to be perceived as among the lowest performance subjects for both female and male students. Looking more broadly at all subjects chosen by female and male students in each of the seven countries, those chosen as the most enjoyed subjects tended to also be chosen among the highest perceived performance in 27 subject choices (13 among female students and 14 among male students), whereas those least enjoyed were less likely to be chosen in the lowest perceived performance subjects across 16 subject choices (7 among female students and 9 among male students). **Figure 19** displays this information for mathematics and science subjects in order to highlight the frequency with which these

Figure 19 *Frequency of mathematics and science subjects reported by female and male students as most and least enjoyed and highest and lowest perceived performance*



Mathematics subjects

Country	Most enjoyed (Female)	Most enjoyed (Male)	Least enjoyed (Female)	Least enjoyed (Male)	Highest perceived performance (Female)	Highest perceived performance (Male)	Lowest perceived performance (Female)	Lowest perceived performance (Male)
Cambodia		✓	✓	✓			✓	✓
Indonesia			✓✓	✓			✓	✓
Malaysia		✓					✓	✓
Mongolia	✓	✓				✓	✓	✓
Nepal	✓	✓✓	✓		✓✓	✓✓	✓✓	✓✓
Republic of Korea		✓			✓	✓	✓	✓
Viet Nam	✓	✓✓			✓	✓		

Science subjects

Country	Most enjoyed (Female)	Most enjoyed (Male)	Least enjoyed (Female)	Least enjoyed (Male)	Highest perceived performance (Female)	Highest perceived performance (Male)	Lowest perceived performance (Female)	Lowest perceived performance (Male)
Cambodia	✓		✓	✓	✓	✓	✓	✓
Indonesia			✓✓	✓				
Malaysia			✓	✓	✓	✓		
Mongolia	✓	✓			✓✓		✓	
Nepal	✓✓	✓		✓	✓	✓	✓	
Republic of Korea	✓	✓			✓	✓		✓
Viet Nam			✓			✓	✓✓	✓

Notes: For mathematics subjects, each ✓ refers to general mathematics as well as topics such as algebra, calculus and geometry. For science subjects, each ✓ refers to general science as well as topics such as biology, chemistry and physics.

Source: Compiled from student questionnaire results (Annex I) subjects were chosen by students in terms of most and least enjoyed subjects as well as those with the highest and lowest perceived performance.

At the country level, a bivariate correlation analysis conducted as part of the **Cambodia** country report found that from the country level results, a strong correlation was identified between students who reported most enjoying mathematics and science and those identifying these subjects among those where they felt they had the highest performance. While these findings can only represent the samples of students that were surveyed, one may assume that students generally feel that they perform better in subjects that they most enjoy, but that they may not necessarily dislike those subjects in which they feel that they perform lowest. Taking into consideration the findings in Tables 11 and 12, it could be argued that there seem to be more similarities between female and male students by country rather than by gender which along with psychosocial factors could also perhaps be due to how these subjects are taught in the seven countries, and that these choices and perceptions cannot be clearly linked to levels of participation by gender in STEM fields of study in higher education nor with levels of learning achievement. At the same time, these findings do provide useful insight to support further exploration into student attitudes towards mathematics and science in particular.

B. Student attitudes towards mathematics and science

The 2012 PISA results also included analysis on student engagement, drive and self-belief. As part of this analysis, gender differences were observed with regard to attitudes towards mathematics, showing that even in cases where girls performed equally in mathematics to their male counterparts, they reported less perseverance, motivation, a lack of self-belief as well as higher anxiety (OECD, 2013, p. 4). By contrast, results from the questionnaire conducted for this study showed a slightly different situation with regard to student interest, confidence, anxiety, motivation and perseverance towards mathematics and science. While higher anxiety was identified among female students, especially towards mathematics, motivation and perseverance in particular were reportedly higher among female students than among male students.

First examining general interest and perceived importance of these subjects among the seven countries, no statistically significant gender differences were found although there were some minor exceptions. In Cambodia for instance, levels of interest in mathematics and science were generally similar among female and male students yet with slightly higher interest in mathematics among male students and higher perceived importance of both subjects in female students. In Malaysia, interest in mathematics and science was also slightly higher in male students. For instance when asked if they agreed with the statement "I look forward to mathematics/science class", 70 per cent of male students agreed or strongly agreed as opposed to 58 per cent of female students. Nonetheless, both female and male students who participated in the questionnaire in **Malaysia** tended to show a positive attitude towards these subjects by recognizing the importance of mathematics and science subjects both for ensuring success in other subjects as well as their importance for future studies and careers. In Mongolia and the Republic of Korea, general interest in mathematics and science was similar among female and male students. In the case of Mongolia however, there was slightly higher interest among female students, whereas responses from the Republic of Korea showed an equally positive attitude among both female and male students.

While only minor gender differences were observed in some countries with regard to interest in mathematics and science subjects among female and male students, taking a closer look at questionnaire results related to student confidence and anxiety towards these subjects provide further insight into student attitudes.[18] In **Viet Nam** for instance, male students were found to be more confident in mathematics with 30 per cent agreeing with the statement as opposed to 22 per cent of female students. In Indonesia however, a higher proportion of female students reported that they felt confident in mathematics at 23 per cent as opposed to 17 per cent of male students. Looking specifically at levels of anxiety, these varied by country. In Indonesia and Nepal for instance, anxiety towards mathematics performance was near-equal among female and male students. In the case of **Indonesia** this was reported at 34 per cent in female students and 33 per cent in male students. In the **Republic of Korea** where male students tend to outscore their female counterparts in mathematics and science in international assessments, higher anxiety was reported among female students at 37 per cent in mathematics and 31 per cent in science, as opposed to 30 per cent in mathematics and 24 per cent in science among male students. In **Malaysia** however, where female students outscore their male counterparts in international assessments, greater anxiety towards these subjects was also identified among female students. In mathematics, 60 per cent of female students reported anxiety as opposed to 56 per cent in male students, whereas in science 82 per cent of female students reported anxiety as opposed to 78 per cent of male students. To a certain extent, one may consider how far the attitudes of female and male students link to gender differences in learning achievement as was observed in Chapter Four.

Turning to questions related to student motivation and perseverance in mathematics and science, there also appears to be a degree of consistency in relation to interest, confidence and anxiety towards these subjects. Student responses relating to these aspects as part of the questionnaire in the seven countries are reflected in **Table 13**.

These questionnaire responses displayed in Table 13 provide an indication of student attitudes towards mathematics and science. In particular, it can be observed that overall while female students tend to have slightly higher levels of motivation and perseverance, more female students reported anxiety towards these subjects than male students.

For instance in **Indonesia**, female and male students both felt that their learning could improve if they tried very hard. Among students who agreed with the statement, the figure was 49 per cent of female students and 46 per cent of male students in mathematics, and 47 per cent of female students and 44 per cent of male students in science. In Mongolia and the Republic of Korea however, higher levels of motivation and perseverance were observed among female students in these subjects, despite the fact that each country showed different levels of confidence and anxiety. In **Mongolia**, when asked to respond to the statement, “I want to do well in mathematics”, 86 per cent of female students reported that they agreed with the statement as opposed to 62 per cent of male students, which may perhaps be consistent with the lower levels of confidence among male students. In the Republic of Korea however, where female students reported lower levels of confidence and higher levels of anxiety, they also reported higher levels of motivation and perseverance. For instance, in responding to the statements, “I want to do well in mathematics/science”, 39 per cent of female

18 See questions 14 for mathematics and questions 24 for science in Annex 1.

Table 13 *Student attitudes towards mathematics and science in the seven countries under review by sex (%)*

Mathematics								
	Confidence		Anxiety		Motivation		Perseverance	
Country	% F	% M	% F	% M	%F	%M	% F	% M
Cambodia	51	55	77	70	85	91	91	85
Indonesia	23	17	34	33	49	45	49	46
Malaysia	34	30	60	56	100	100	78	66
Mongolia	16	15	30	26	43	31	46	29
Nepal	30	29	30	30	44	42	44	44
Republic of Korea	23	23	37	30	48	44	43	41
Viet Nam	22	30	8	12	47	47	40	45

Science								
	Confidence		Anxiety		Motivation		Perseverance	
Country	% F	% M	% F	% M	%F	%M	% F	% M
Cambodia	57	55	66	60	77	89	91	87
Indonesia	26	29	27	27	46	41	47	44
Malaysia	40	54	82	78	42	50	74	76
Mongolia	31	32	16	20	46	37	47	36
Nepal	39	37	29	23	48	45	48	44
Republic of Korea	23	26	31	24	47	43	38	38
Viet Nam	12	19	17	20	43	45	36	46

Notes: Pecentage refers to the proportion of students reporting 'agree' and 'strongly agree' within each category.
Low response rates to these questions in Mongolia.

Source: Based on responses to questions 11 and 21 of the student questionnaire (Annex 1).

students and 28 per cent of male students strongly agreed with regard to mathematics, and in science 32 per cent of female students strongly agreed with the statement as opposed to 22 per cent of male students. The findings suggest that despite higher levels of anxiety towards mathematics and science subjects among female students, their higher level of motivation and perseverance may perhaps be a result of feeling the need to try harder than their male counterparts in order to perform well in these subjects. At the same time, the equal level of anxiety reported by female and male students in Indonesia may reflect near-equal levels of learning achievement.

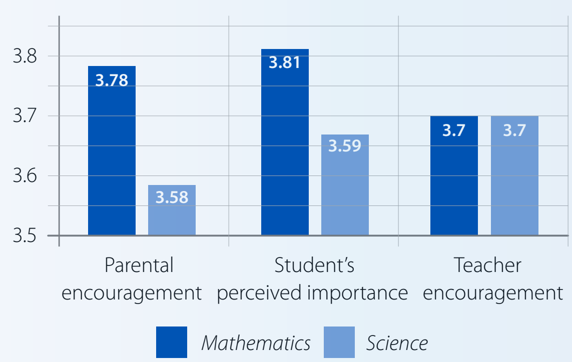
C. Perceived parental and teacher influences

Having explored the attitudes of students towards learning mathematics and science subjects, it is now important to consider parental and teacher influences with regard to these subjects. As part of the questionnaire, students were asked a number of questions related to parental and teacher encouragement, their influence on grades, and their perceived importance of these subjects. Based on these findings, different results arose among the seven countries, with the most interesting cases highlighted in this section. Overall, it appears that there are no statistically significant gender differences among female and male student responses to questions regarding perceived parental and teacher influences with perhaps the exception of Mongolia where more female students perceived parental encouragement as important for mathematics and science at 82 per cent for mathematics and 80 per cent for science, as opposed to 48 per cent and 40 per cent among male students respectively. At the same time, a slight difference was identified when students were asked whether their teachers interacted with them in mathematics class. In this case, a higher proportion of male students supported the statement at 70 per cent as opposed to 60 per cent for female students.

Overall, one finding which appeared in most of the seven countries was that based on student responses, parents were largely perceived as more influential with regard to mathematics. A more detailed analysis presented in the country report for **Cambodia** supports this argument through a paired test analysis, where parents may also be perceived as more influential than teachers among students in general. This is displayed in **Figure 20** where on a 5 point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree) students ranked their perceived parental and teacher encouragement as well as their own perceived importance with regard to mathematics and science.

This mean comparison of parental and teacher encouragement along with perceived importance of mathematics and science among students in Cambodia suggests that while parents and teachers both play an important role in student interest in STEM education, the level of perceived parental encouragement for mathematics (3.78 on a scale of 1-5) seems to be more closely linked to students' perceived importance in mathematics (3.81 on a scale of 1-5) of these subjects as opposed to the level perceived teacher encouragement. Overall, it also appears that in the case of Cambodia, students' perceived importance of these subjects might be more greatly influenced by their perceived level of parental encouragement as opposed to teacher encouragement. In addition, parental encouragement with regard to mathematics is much higher than for science, which is also observed in other

Figure 20 *Level of perceived parental and teacher encouragement and students' perceived importance of mathematics and science reported by students in Cambodia*



Note: questionnaire responses based on a Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

Source: Szmodies and Eng, 2014

countries such as the Republic of Korea, Nepal and Viet Nam. In **Viet Nam** in particular, the level of perceived parental encouragement was not only higher for mathematics, but was also reported by a high number of students compared to other countries. For instance, among both female and male students, 95 per cent of students agreed or strongly agreed that their parents encouraging them in mathematics was important as opposed to 70 per cent of students for science.

Having explored various psychosocial influences in this chapter, as well as the most pertinent results from the student questionnaire among the seven countries of focus, **Box 2** puts these findings into context by presenting the perspectives of Jingmei Li from Singapore, who was among the 2014 UNESCO-L'Oréal International Fellowship Winners, an initiative which awards fellowships to 15 young women from across the world with promising research projects in science. Specialized in

Box 2 *A Story from Jingmei Li of Singapore, 2014 UNESCO-L'Oréal International Fellowship Winner*

When I first wondered why the sky is blue, *or rather, when I first started asking questions – those are my earliest memories of my passion for science. Everything was a wonder then! Science was a lot of being outdoors in the sun, learning about plants and insects. Apart from learning the biology of plants and animals, I feel that I gained a lot from just being outdoors and appreciating nature as well, especially since I grew up in a 'concrete jungle'. I used to go around with this mini book called "A Guide to the Wild Flowers of Singapore", and tried to identify as many roadside plants as possible. As we progressed through primary school we learnt about other aspects of science, which included wires, circuits and light bulbs – these are still things we can see, touch and feel. Science in primary school was more hands-on, and I enjoyed every moment of it! Then in secondary school we went into biology, chemistry and physical laws, which took a little more appreciation and imagination to understand what goes on beyond what we can see and made me realize how much there is to know.*

When girls perform poorly in mathematics and science, the cause is environmental. I believe the explanation does not lie in a gender gap in terms of learning achievement, but rather, it is what female students like better. In some studies, female students are said to prefer medicine to mathematics and science, but that doesn't mean they can't be as good as their male counterparts in other disciplines.

A good dose of encouragement and motivation from my teachers and peers has gone a long way in kindling my passion for science. When I see other people being passionate about work, I feel inspired to be passionate about my own work. True passion is contagious!

I've always likened my scientific career to a relationship - it sometimes feels like I'm married to my work! The secret to any relationship is to keep the love alive, and it's the same with science. Because we're doing basic science, it's not always clear that all the countless experiments and endless analyses we do and re-do have a direct impact for the good of humankind. And when we don't get the results we expect after all the hard work put in, well, that can make a scientist quite mad and jaded. Maybe, just maybe, women need to hear more words of encouragement to keep them going! The biggest challenge is to maintain the faith that everything is worthwhile, and that every small puzzle we solve would contribute to a bigger picture.

There is an obvious disparity between women and men in science, but I also believe that the situation is getting better. Doors have very much opened to women for higher education. In Singapore, it is not uncommon to see an even number of female and male students in many of the science majors. I'm optimistic that it will only be a matter of time before more women are celebrated in science, but of course that would take some commitment from the science community to nurture and support them as well. There are challenges such as managing family, children, as well as their careers, but major accomplishments are that some women manage to strike a really beautiful balance, in a great working environment, doing the thing they truly enjoy. We need more shining role models of women in science to inspire more young women!

Source: Interview conducted by UNESCO Bangkok on 15th September 2014 human genetics, Jingmei Li's story, which is based on an interview conducted by UNESCO Bangkok for the purpose of this study, expresses the impact of relationships and encouragement from family, teachers and peers, as well as the importance of stimulating interest in mathematics and science among students.

While the findings presented in this chapter can only provide an indication of student attitudes and perceptions based on the questionnaire data sample, these findings, as well as those from other studies examined earlier in this chapter suggest that psychosocial influences arguably play a significant role, if not perhaps the most significant role in influencing student achievement and participation in STEM fields of study in higher education. The main reflections from this chapter can be summarised as follows:

- The **importance of psychosocial influences** in shaping student attitudes, achievement and eventually participation in STEM fields has been increasingly recognized through a growing body of research. In particular, studies point to the need to recognize: 1) the vulnerability of certain groups, such as female students, 2) the threat of negative stereotypes, and 3) the importance for students to develop a growth mindset where capability or talent in any given subject is developed over time for any student rather than something predetermined from birth.
- With regard to the results of the student questionnaire, responses on **subject preferences and perceived performance** show that for both female and male students, mathematics and science subjects often appear among the most enjoyed subjects, though mathematics is more likely to appear as among the most enjoyed for male students and among the lowest perceived performance subjects for female students as illustrated in Figure 19. It also appeared that subject preferences tend to be more similar among both female and male students within countries rather than by sex. At the same time, it was found that among all students, science was more likely to be perceived as among the highest performance subjects as opposed to mathematics which was more likely to be perceived among lowest performance subjects.
- Looking at **student attitudes towards mathematics and science** subjects in terms of interest, perceived importance, confidence, anxiety, as well as motivation and perseverance, different findings arose among the seven countries. Some interesting linkages can be identified between student attitudes reported through the questionnaire with participation in STEM fields of study in higher education and learning achievement in mathematics and science as examined in Part A of this report. For instance, in countries where the gender gap in participation and learning achievement was in favour of either girls or boys in mathematics, female students reported higher levels of anxiety across most countries towards this subject.
- Beyond the issue of gender differences in student performance in mathematics and science subjects, there may be further psychosocial influences where female and male students are affected in different ways in terms of their attitudes to these subjects, and could provide an important area for further investigation. **The importance of parental and teacher encouragement** must also be acknowledged, and as was also presented in Box 2, these encouragements are fundamental to all students in addressing environmental and psychosocial influences which have so far limited the participation of women in STEM fields.

7 Labour Market Effects

Having explored a number of factors with regard to women's participation in STEM, this chapter will now consider the extent to which women are represented in STEM fields within the labour market. Before presenting these findings however, the economic and development context of the seven countries under review will be presented, before drawing upon an analysis from the regional desk study.

A more general perspective of gender issues in the labour market shows that in some countries, women's participation remains limited across all fields. While this may be due to sociocultural factors, or the country's level of development, it may also be influenced by the demand for labour in certain fields over others. In order to provide the economic context for each of the seven countries under review, **Table 14** presents a number of indicators with regard to the different levels of economic development and the labour market.

Looking more broadly at the findings from the regional desk study, an OECD study argues that one of the greatest barriers to attracting women and girls into STEM fields is the lack of professional role models in occupations that may traditionally be viewed as predominantly male (OECD, 2011, p. 28). Increased exposure to female role models could potentially help alleviate the negative stereotypes faced by female students with regard to these fields (Hill, Corbett, and St Rose, 2013, p. 41). Estimates show that women make up just 30 per cent of science researchers globally (UIS, 2014a), and the OECD argues that the lack of professional role models for young women in STEM professions could be a factor influencing lower levels of participation (OECD, 2011, p. 28). Beyond the generally low proportion of women employed in these fields, the extent to which varies by country, this chapter will also explore participation by occupation, as well as factors that may influence women's career progression. These two aspects

Table 14 *Economic and development context of the seven countries under review as of 2013*

	Cambodia	Indonesia	Malaysia	Mongolia	Nepal	Republic of Korea	Viet Nam
Income level	Low Income	Lower Middle Income	Upper Middle Income	Lower Middle Income	Low Income	High Income	Lower Middle Income
Population	15.14 million	249.9 million	29.72 million	2.84 million	27.8 million	50.22 million	89.71 million
Gross Domestic Product (GDP)	USD 15.25 billion	USD 868.3 billion	USD 312.4 billion	USD 11.52 billion	USD 19.29 billion	USD 1.305 trillion	USD 171.4 billion
Gross National Income (GNI) <per capita>	USD 950	USD 3,580	USD 10,400	USD 3,770	USD 730	USD 25,920	USD 1,730
Female labour participation rate* <%>	79	51	44	56	80	50	73

Note: *Proportion of the female population aged 15 years old and above (rates as of 2012).

Source: World Bank, 2013

relate to what is known as occupational segregation, which applies to the distribution or concentration of various demographic groups (often with regard to gender), and can occur as horizontal segregation (by field or occupation) and vertical segregation (by rank or grade) (OECD, 2011; ILO, 2013, p. 4). While horizontal segregation would in this case refer to the difference in the amount of females and males employed across different occupations or fields, vertical segregation refers to the difference in the amount of females and males employed across different levels (e.g. support roles to decision-making or managerial roles) (Anker, 2001, p. 149). These terms often refer to the low number of women that enter top managerial and decision-making positions, as well as the tendency for women to be concentrated within a more narrow range of occupations as opposed to men (World Bank, 2012, p. 46).

In light of this, there has been increased concern with regard to the small number of women working in STEM fields such as engineering or computer technology. Due to growing demand for professionals in the field of ICT for instance, particular attention globally has been paid to encouraging more young women and girls to learn to code at the earliest age. For instance, Google has recently started its 'Made w/ Code' initiative, which allows young girls to learn basic coding via techniques presented through 'girl-friendly' online creative projects with the support of an online community, resources and mentors (Google, 2014). The initiative comes as a result of the low representation of women in this field, despite efforts to encourage their participation, with just 30 per cent of Google's workforce being female (Fortune, 2014). In addition to horizontal segregation, vertical segregation also occurs within countries, and in particular with regard to the highest ranking academic positions. Studies show that once women enter professions in STEM, particularly academic professions, a number of barriers to progression in their careers remain. For instance, they tend to leave their professions and change careers earlier and are less likely to reach the most senior positions (Hill, Corbett, and St Rose, 2013, p. 82). Studies have found that perceptions of female professionals in STEM fields can also be subject to bias based on the 'capability-likability struggle', whereby they are either seen as capable, or seen as likeable, but rarely both at the same time, especially as they progress to higher level positions (Ibid).

Looking more broadly at the representation of women across STEM fields, **Table 15** will display an overview of the number and proportion of female researchers in science, technology and innovation in various countries of Asia. Potential links with the results of international assessments as explored in Chapter Four will then be explored. This chapter will then be structured in three short parts considering a number of labour market factors drawing upon examples among the seven countries reviewed: the general participation of women in the labour market as well as job security, examples of horizontal and vertical segregation, and finally, potential links with female participation in STEM fields of study in higher education.

Based on the data displayed in **Table 15** as with other areas explored in this report, there are contrasting levels of participation among countries in the Asia-Pacific region. To a certain extent, linkages can be identified based on this data and the results of PISA 2012 results and TIMSS 2011 results explored in Chapter Four. For instance Japan, which shows the lowest proportion of female researchers in the region at 14 per cent, also showed the highest gender gap in PISA 2012 results – 18 points in favour of boys in mathematics and 11 points in science

Table 15 *Headcount and proportion of researchers in science, technology and innovation in Asia as of the latest available year by sex (%)*

Country/Jurisdiction	Researchers (HC) - Female	Researchers (HC) – Total	% Female	% Male
Cambodia -7	-	-	21	79
Indonesia -6	10,874	35,564	31	69
Japan -2	124,686	892,684	14	86
Kazakhstan -2	5,716	11,488	50	50
Kyrgyzstan -2	961	2,224	43	57
Macau- China -2	231	612	38	62
Malaysia -2	35,938	73,752	49	51
Mongolia -2	885	1,799	49	51
Nepal -3	399	5,123	7.8	92.2
Pakistan-2	14,150	51,954	27	73
Philippines -5	6,004	11,490	52	48
Republic of Korea -2	65,067	375,176	17	83
Singapore -1	11,366	38,432	30	70
Sri Lanka -3	1,906	5,162	37	63
Tajikistan -2	381	1,565	24	76
Thailand -4	19,669	38,506	51	49
Uzbekistan -2	12,639	30,890	41	59
Viet Nam -7	-	-	43	57

Notes: Data as of: -1 = 2012, -2 = 2011, -3 = 2010, -4 = 2009, -5 = 2007, -6 = 2005, -7 = 2002. Data on headcounts not available for Cambodia and Viet Nam.

Source: UIS, 2014d *Abbreviations:* HC - Headcounts

– as was displayed in Table 5. At the same time, Thailand, which showed the highest gender gap in favour of girls in PISA 2012 results – 14 points in mathematics and 19 points ahead in science – shows an equal proportion of women working as science researchers at 51 per cent. This is also observed in Kazakhstan where 50 per cent of science researchers are female and where PISA 2012 scores in mathematics were equal among boys and girls, and 9 points in favour of girls in science, while TIMSS 2011 results show just two points in favour of boys in mathematics and 15 points in favour of girls in science. In Indonesia and Singapore however, where scores were either near-equal or higher in females in these assessments, the proportion of female researchers in science, technology and innovation is lower than 50 per cent. It is in fact 30 per cent in Singapore and 31 per cent in Indonesia.

A. Labour participation in STEM fields and job security

As was explored in Table 14 at the beginning of this chapter, differences among the seven countries reviewed can be identified with regard to female participation in the labour market. In addition to this, the differences in wages can be observed as presented in **Table 16.**

Based on the data presented in Table 16, countries show various levels of female participation in the labour market as well as in wage differences. For instance in Malaysia, where the female participation rate is the lowest at 44 per cent, the equality in wages is the highest after Mongolia at 0.81, with 1 reflecting complete equality. In Nepal, where the female participation rate is highest at 80 per cent, equality in wages is among the lowest at 0.62. In addition to these indicators, the issue of job security also remains, where in some countries women are more likely to work in informal sectors, or where they are overqualified with specific skill-sets and expertise and thus find themselves unemployed. A number of these issues can be identified through the following cases of Cambodia, Viet Nam, Mongolia, and the Republic of Korea.

In **Cambodia** for instance, despite significant economic growth over the last decade, high levels of poverty and low levels of education have meant that women continue to gain employment in industrial and agricultural sectors which demand less skills and educational qualifications, while overall, the total percentage of women in wage employment stood at just 45.8 per cent in 2012 (NIS, 2012). In the case of **Viet Nam**, women are also mostly concentrated in the textile and garment industry, as well as retail and educational and cultural services. Looking at specialized professions in the field of information and communication for instance, women represented a total of 38 per cent of the workforce as of 2010, growing by 2 per cent since 2007, yet in science and technology, they represented 31 per cent as of 2010, a decline from 35 per cent from 2007 (GSO, 2012). As Viet Nam continues its transition from a low to middle income country, with increased connections to the global economy, it is important to ensure that women are equally represented in the formal economy rather than concentration in informal sectors such as own account work, unpaid family work and casual wage labour (Do, 2014). In other countries however, the issue with regard to women's participation in STEM fields lies in the lack of available jobs. For instance in **Mongolia**, female STEM professionals account for a mere 1 per cent of Mongolia's workforce (NSO, 2012).

Table 16 *Female labour participation in the labour market and wage differences in the seven countries under review as of 2013*

	Cambodia	Indonesia	Malaysia	Mongolia	Nepal	Republic of Korea	Viet Nam
Female labour participation rate* <%>	79	51	44	56	80	50	73
Wage differences**	0.70	0.69	0.81	0.82	0.62	0.51	0.63

Notes: * Proportion of the female population aged 15 years old and above (rates as of 2012).

** Scale: 0.00 = inequality; 1.00 = equality.

Sources: Female Labour Participation Rate (World Bank, 2013); Wage differences (World Economic Forum, 2014).

Women who had studied abroad in specific-STEM disciplines such as chemistry, even to doctorate level, later returned to the country to find themselves unemployed. According to the country report, this low demand could be due to the prominence of more 'fashionable' fields for young graduates such as business administration, law and foreign languages (Khishigbuyan, 2014).

The **Republic of Korea** also presents an interesting case when it comes to the participation of women in STEM fields. As a country with one of the highest levels of student achievement in mathematics and science, there is only a small proportion (17 per cent) of female researchers in science, technology and innovation as was observed in Table 15. While the female population outnumbers that of the male population, as well as a higher proportion of students entering higher education being female across all fields (74.5 per cent as opposed to 67.4 per cent being male as of 2013), there remains a 23 per cent difference in the labour participation rate, which comprises 73.2 per cent of males and just 50.2 per cent of females (Statistics Korea, 2014). Analysis from the country report shows that for female students enrolled in STEM fields of study in higher education, their chances of pursuing a career in the field are much slimmer than for their male counterparts. As of 2012 for instance, only 61.4 per cent of female graduates in science, engineering and technology were employed in the workforce, as opposed to 91.4% of male graduates in these fields (WISET, 2012). Indeed, analysis of employment data shows that a much smaller proportion of female graduates in science and technology are successfully employed in those fields in comparison to the proportion of male graduates. Furthermore, their chances of being employed in an office job (as opposed to in a laboratory) are equal to those of females graduating in liberal arts (WISET, 2014).

B. Horizontal Segregation within STEM fields

Looking at the proportion of women in various occupations within STEM, horizontal segregation (or distribution of females and males by occupation or field) can be observed among the seven countries of focus. For instance based on data from 2014, women in Indonesia form a minority of graduates working in specific sub-fields such as electricity, water and gas at a mere 0.24 per cent and 0.74 per cent in mining and quarrying (Statistics Indonesia, 2014). In **Mongolia**, the low level of women's participation in the country's booming mining and engineering sector has also been identified, and may be linked with historical and social factors, as well as health considerations applying to both women and men. For instance, the perception that women are not suited to these professions could be based on labour allocations that were conducted for women and men during the socialist era (ADB, 2005).

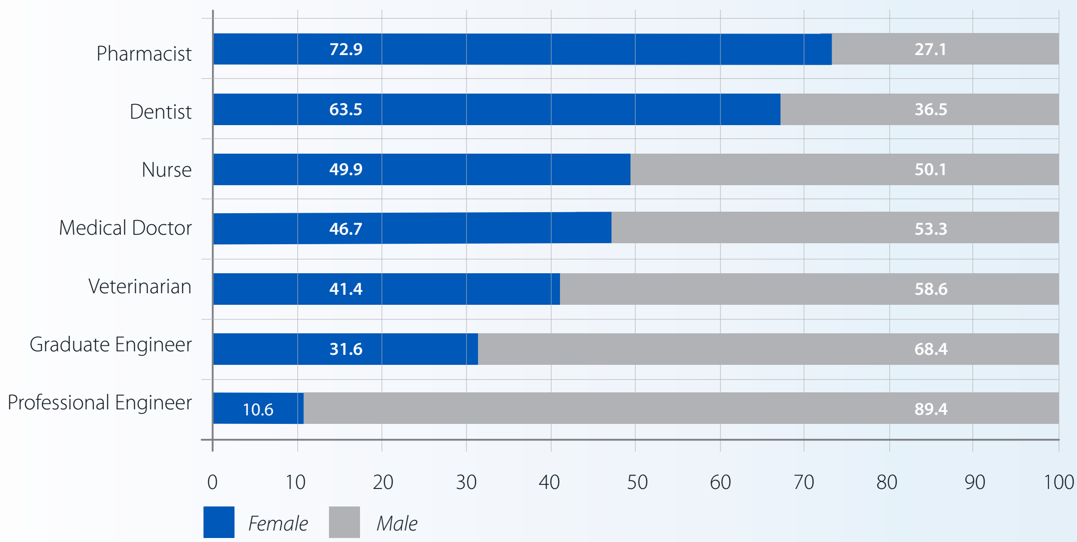
In **Malaysia**, the Government has long recognized the importance of improving women's social, political and economic status which has been clearly outlined in the 10th Malaysia Plan (2011-2015), in which women's issues are noted as one of the key focus areas for the country's economic development (Mahdzir et al., 2014). Across all fields however, the labour force participation rate currently stands at 80.7 per cent for men and just 52.4 per cent for women as of 2013 (Department of Statistics, 2014), and there is a rising demand for STEM professionals with only 29 Research Scientists and Engineers (RSE) for every 10,000 members of the workforce as of 2012 (MoSTI, 2012). With this in mind, while a relatively higher proportion of women are represented in STEM fields in comparison to other countries, they tend to form a majority in some occupations yet remain a minority in others.

Taking a closer look at the proportion of female professionals in STEM by occupation, evidence of horizontal segregation begins to emerge as displayed in **Figure 21**.

As observed in Figure 21, women are highly represented in health-related professions such as pharmacy (72.9 per cent), and to some extent in medicine (46.7 per cent) and nursing (49.9 per cent), yet they only make up 10.6 per cent of professional engineers. While recognizing female professionals' dual responsibilities in terms of balancing family and work life, the Malaysian Government has taken certain measures and established incentives for women across all fields, including establishing child care centres in the workplace, tax exemption incentives for the establishment of such centres, as well as childcare subsidies for families earning below a certain amount in the public sector, among others (Mahdzir et al., 2014).

Looking more broadly at women's participation in the labour market, academic-level positions are often presented in literature as very prestigious positions in STEM fields, and are often where women remain significantly under-represented globally. In **Indonesia**, where they are often working in public universities as government employees, an analysis of permanent university lecturers working under various ministries shows that women are a minority in some STEM-related occupations, for instance in meteorology and geophysics where they make up just 9 per cent, and the National Atomic Nuclear Institution (BATAN) where they make up 14 per cent (DoHE, 2014). Data on the number of academic lecturers in STEM-related study programmes in selected universities[19] also mirror this gender gap, which links to the proportion of female students enrolled in higher education by discipline in Indonesia as observed in Chapter Three. For instance in pharmacy and biology, where the majority of students enrolled were female, female lecturers account for 58 per cent and 53 per cent respectively, a stark contrast to female lecturers in physics (15 per cent) and

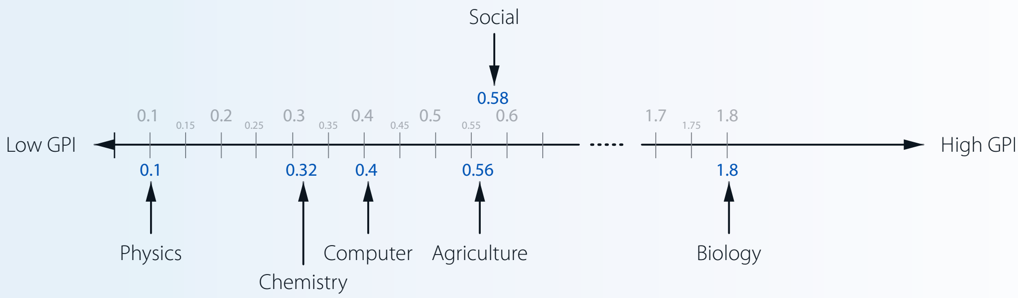
Figure 21 *Proportion of female and male STEM professionals by profession in Malaysia (%)*



Source: Adapted DoHE, 2014, Table 1.4

19 Data collected from three universities: Gajah Mada University, University of Indonesia, and Bogor Institute of Agriculture.

Figure 22 *Gender Parity Index (GPI) of grant-receiving senior STEM researchers in Indonesia*



Note: The figure 1 would constitute perfect gender parity, whereas a figure below 1 shows an advantage to males and above one in favour of females.
Source: Adapted from Directorate of Research and Community Services, 2014.

mechanical engineering (2.5 per cent) (Ibid). In addition, the Gender Parity Index (GPI) for senior STEM researchers that received grants in the year 2013 shows an even lower proportion of female researchers, even in some fields where they tend to make up a majority, as displayed in **Figure 22**.

This data shows that in the cases of Indonesia, Malaysia and Mongolia, a higher proportion of female students are enrolled in STEM fields of study in higher education and women who are working in STEM fields tend to be concentrated in sub-fields such as biology or health as opposed to engineering or physics.

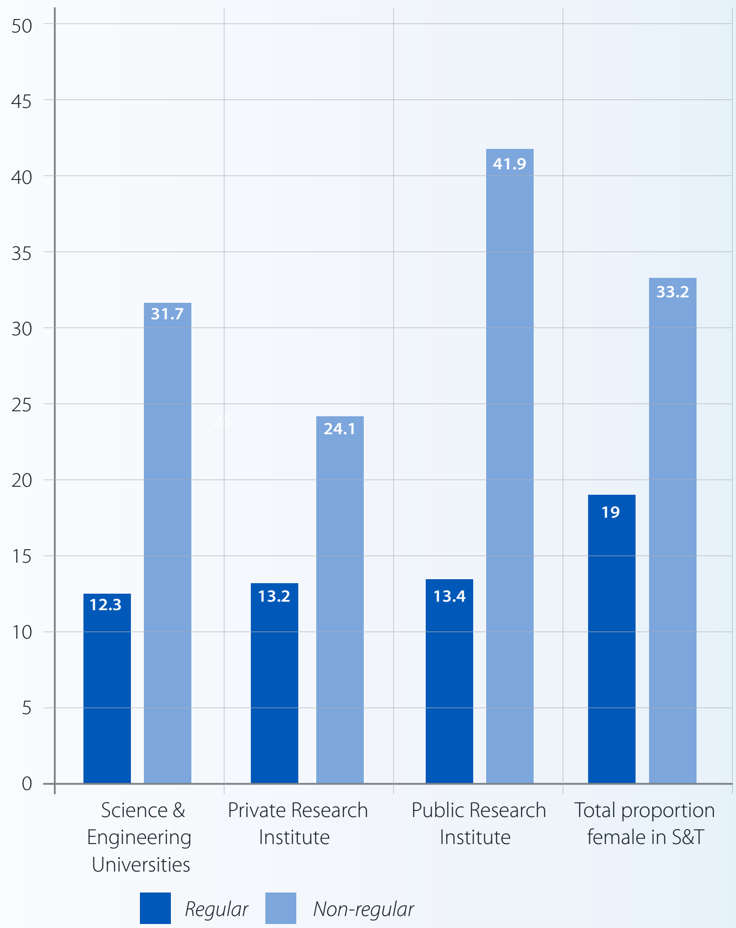
C. Vertical segregation within STEM fields

Taking a look at vertical segregation (or distribution of females and males by rank or grade) in higher level managerial and decision-making positions within and beyond STEM fields, as in many other parts of the world, women remain largely underrepresented in Asia. For instance across all fields, the share of female directors ranges from 10 per cent in the Philippines, 7 per cent in China and Thailand to 5 per cent in Indonesia and under 2 per cent in the Republic of Korea and Japan (CWDI and IFC, 2010). Among the seven countries reviewed, a similar situation can also be observed to varying degrees. Looking at the level of positions that women hold in **Malaysia**, data from 2012 shows that they comprise 21.5 per cent of managers, 55.1 per cent of professionals, and 32.5 per cent of technicians and associate professionals (DoS, 2014). This indicates that even in a country where women tend to participate equally in the labour market as examined earlier in this chapter, they remain a minority in top positions.

When looking specifically at STEM fields, the **Republic of Korea** provides an interesting case when looking at the proportion of women working in STEM-related fields by type of institute and by employment. As displayed in **Figure 23**, female science and engineering professionals working in research and development are often concentrated in non-regular employment as opposed to regular employment,[20] and overall, they are least represented in private research institutes and universities as opposed to public research institutes, factors which may affect their prospects of progressing to higher positions.

20 While regular employment refers to employees appointed for an unlimited period of time, non-regular employment refers to employees contracted for temporary or fixed periods of time.

Figure 23 *Proportion of female professionals in science and technology by institute and employment type in the Republic of Korea as of 2012 (%)*



Source: Adapted from MSIP, 2014c

As shown in Figure 23, a high proportion of female professionals in STEM fields are classified as non-regular workers, and only a minority of women make up regular workers at 19 per cent as opposed to 81 per cent of men working in science and technology. Looking more closely at science and engineering universities and both private and public research institutes, between 12.3 and 13.4 per cent of those in regular employment are women, as opposed to between 86.6 and 87.7 per cent of men. In the case of the Republic of Korea, this indicates less job stability for women, which has also been considered as a barrier to women's career prospects across all fields in the labour market in various countries (UNESCO and KWDI, 2013). In addition, retention of women in the workplace is another constraint for progressing to higher positions. Among female professionals who decided to discontinue their profession in STEM fields for instance, the main reasons included having children (53.1 per cent) and marriage (17.9 per cent)

(WISET, 2013b). The lack of childcare facilities may further hamper the ability of women working in STEM fields to balance life and work commitments. For example, data shows that childcare facilities in the workplace are established and operated by only 326 out of 2,583 (11.2 per cent) of STEM institutions (MSIP, 2014c).

This chapter demonstrates that a number of gaps remain with regard to women's participation in the labour market overall, and in particular in specific STEM fields where they remain largely underrepresented. The main findings can be outlined as follows:

- Looking at economic and development indicators across the seven countries under review, **female participation in the labour market** and wage differences between women and men are still unequal across all fields of work.
- The **proportion of women in STEM**, or as displayed in Table 15, the number of female researchers in science, technology and innovation, can vary widely by country yet in most countries in Asia, women remain a minority.
- It could be argued that there may be a **potential link between the gender gap in learning achievement in mathematics and science and the proportion of female researchers.** For instance, in countries where boys outperform girls in mathematics and science in international assessments, there tends to be a lower proportion of female researchers than in countries where boys and girls have equal scores or where girls outscore boys.
- The lower participation of women in STEM fields also means that there is a **lack of female role models in STEM**, which can further affect young women's choices for further study and their future careers in STEM fields. In countries such as Mongolia, there appears to be a mismatch between the fields within STEM fields that females are choosing to pursue as opposed to those for which there is demand. In others, such as the Republic of Korea, data shows that female graduates in STEM-fields are also less likely to be employed in STEM fields than their male counterparts.
- With regard to **horizontal segregation,** it appears that women are concentrated in specific occupations within STEM and that there may be a link to the enrolment of female students in STEM by field of study in higher education. For instance, a higher proportion of women work in professions related to medicine or biology as opposed to a low proportion of women working in physics or engineering, which relates to the proportion of female students enrolled in these respective fields of study in higher education.
- Looking at **vertical segregation** in terms of the distribution of women by rank or status within STEM, women are less likely to be in higher level positions. In the case of the Republic of Korea for instance, women are more likely to be in non-regular work, which can greatly affect their prospects for promotion to such positions. At the same time, it appears that limited support offered to women working in STEM fields may affect retention as well as progression in these fields due to the difficulties faced in maintaining a balance between family responsibilities and professional life – a balance which could also be shared by male scientists.

Part C

Girls and Women in STEM: Where to from here?

8 Reflections

Based on the review of various areas relating to gender and education in this report, it could be argued that a number of links can be observed between female students' learning achievement in mathematics and science and the participation of women in STEM fields of study in higher education as well as in the labour market. For instance, among countries where male students' learning achievement is higher in these subjects, female students tend to be less well represented in STEM fields in higher education and the labour market than in countries where female students achieve a higher level of learning performance in mathematics and science. Several factors, bracketed under educational, psychosocial, and labour market influences all contribute in one way or another to gendered learning achievement and participation in STEM fields of study, which generate some important points for reflection.

First, STEM is a vast collection of fields where women participate to varying degrees. While a high proportion of women may be enrolled in specific disciplines such as biology or medicine in higher education, in most countries women remain a minority in physics, mathematics and engineering – a situation which continues in the labour market. At the same time, the importance of psychosocial influences should not be underestimated. Psychosocial influences arguably constitute one of the most determining factors in shaping the perspectives and choices of female and male students with regard to pursuing further study and a career in STEM as observed in responses to the student questionnaire. The higher level of anxiety reported by female students in most of the seven countries under review, regardless of the gender gap in achievement in STEM-related subjects, demonstrates that there is need for greater care to alleviate anxiety among female students by both teachers as well as parents. For instance, this was identified in countries where the gender gap in learning achievement in mathematics and science was in favour of girls with a high proportion of women enrolled in STEM fields (e.g. Malaysia), as well as countries where the gap is in favour of boys with a comparatively lower proportion of women enrolled (e.g. Republic of Korea). Further research is required to assess how psychosocial factors affect females with regard to mathematics and science subjects beyond the issue of learning achievement. As illustrated in the case study in Box 2 and across Chapter Six, encouragement of students appears particularly important, whether from peers, teachers, parents or employers.

Educational actions, such as the proportion of female role models in teaching at higher levels of education, as well as gender-responsive teaching strategies, curricula, career counselling and scholarship programmes, could also play a significant role in addressing gender disparity and promoting a more balanced representation of women and men in STEM fields. Case studies show that female and male students may place equal importance on mathematics and science subjects, yet are not represented equally. Through design and implementation of gender-responsive interventions, female and male students may be able to pursue fields of study in which they can excel and exert genuine passion in STEM-related education and careers. Finally, there is a need for governments to provide more targeted support to attract more girls and women into STEM fields, particularly those in which they are underrepresented, through education and labour market policies, including enforcement of laws regarding gender equality.

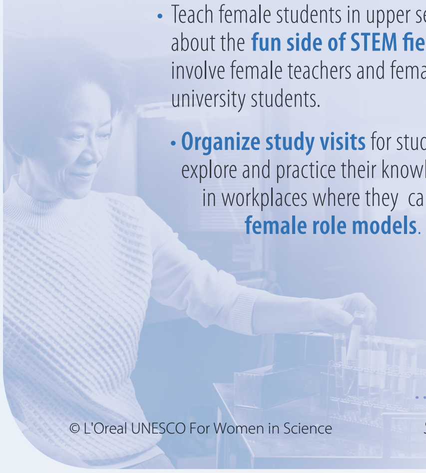
With this in mind, a number of gaps and areas for improvement can be identified based on the main findings presented in this report. These areas for consideration are presented below in the form of reflections on the issues common to most countries reviewed, as well as from country-specific policy considerations presented in Annex 5. Box 3 provides the considered perspective of Kayo Inaba, 2014 Laureate of the L'Oréal-UNESCO For Women in Science Awards, which reflects well the overall findings of this report.

Areas for consideration:

- **Gender-responsive action from governments**, through education and labour market policies, including enforcement of gender-related laws, as well as specific initiatives for advocacy and awareness raising, is needed to attract more girls and women into STEM fields.
- In order to ensure the effective implementation of policies related to education, gender and/or STEM, **coordination between ministries** should be strengthened. This may involve joint programmes across various government sectors such as ministries of education,

Box 3 *Reflections from Kayo Inaba of Japan, Asia-Pacific Laureate of the 2014 L'Oréal-UNESCO For Women in Science Awards*

Within and beyond STEM fields, there are a number of actions and measures that could be taken to help encourage more young women to pursue careers in fields that they love:



- Teach female students in upper secondary about the **fun side of STEM fields** and involve female teachers and female university students.
- **Organize study visits** for students to explore and practice their knowledge in workplaces where they can meet **female role models**.
- Set **quotas** at various levels for the recruitment and promotion of women in STEM fields, including for senior and executive positions.
- Provide **clear and fair guidelines** for the recruitment, retention, and promotion of female employees.
- Introduce **support programmes for women** which include mentoring and career development, as well as provision of female-friendly working arrangements such as cover during maternity leave and remote working arrangements.
- Establish a **zero-tolerance policy** towards any type of harassment against and isolation of women in the workplace.

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Source: Interview conducted by UNESCO Bangkok on 15th September 2014 women's affairs or gender equality, science, technology and innovation, as well as labour.

- Further **data disaggregated by sex** is needed to conduct in-depth analysis at country level and help provide a clearer picture of women's and girls' participation within STEM, which will inform policies and programmes for increased participation of women in STEM-related education and employment sectors such as engineering and physics.
- **Curricula and learning materials** should undergo further rigorous review from a gender perspective to ensure that they do not perpetuate gender stereotypes. This would ideally involve a representative group of stakeholders with male and female experts in order to ensure different perspectives.
- **Teacher education and policies on recruitment** must ensure a fair representation of both male and female teachers in all subjects, including mathematics and science, at all levels of education and especially in higher levels of education where students look to their teachers as role models as they begin to shape career perspectives and choices.
- Teacher education, be they pre- and in-service programmes, should be transformed to ensure that teachers are trained in **gender-responsive teaching strategies** so that female and male students can develop their full potential in STEM-related subjects.
- Appropriate funding for **equipment and resources** should be allocated in order to stimulate student interest in mathematics and science, particularly among female students. Allowing students to practically apply their learning in real-life situations as well as creative and hands-on experiments will not only contribute to enhancing the quality of learning but also increasing student interest in learning these subjects.
- Structured and formalized **gender-responsive career counselling programmes** should be considered in order for both female and male students to have support and objective guidance as they begin to shape their career choices.
- **Scholarship programmes** targeted at girls and women in STEM would also contribute to increased opportunities for young women to pursue further study and eventually careers in STEM fields.
- Promoting more **female role models in STEM** fields, whether female teachers in mathematics and science at the secondary level, female students and faculty members in higher education, and more broadly more women working in STEM fields, is an important strategy to attract girls and women into STEM fields.
- Finally, adequate **support programmes and initiatives for female STEM professionals** would help to address some of the factors which can cause them to discontinue their careers, including family responsibilities. This will also help them be equipped with the most up-to-date knowledge and skills in a field which experiences fast-paced change and innovation.

9 Conclusions

Climate change, global health epidemics and other significant threats to global peace and prosperity require new solutions through scientific innovation and technological advancement. Despite this, our world today faces a global shortage of professionals entering STEM fields of study and occupations, most notably among female populations in all regions of the world. What then, lies at the heart of this critical shortage? And in Asia, what can be done to attract more girls and women into STEM fields? Starting from the earliest ages through to the STEM fields in secondary and higher education as well as in the world of work – several factors, be they educational, psychosocial and/or labour market effects, interact and influence in shaping the pathways of the next generation of STEM professionals as has been examined in this report.

While boys continue to outscore girls in mathematics and science in learning assessments in some countries, the gap is narrowing, especially in science. In other countries such as Malaysia and Thailand, a reversed gender gap can be observed in favour of female students. At the same time, the gender differences in achievement as well as the career pathways of young women and men within STEM fields in these countries and across the seven countries are apparent. To a certain extent, this is reflected in the proportion of female students enrolled in STEM fields of study in higher education as well as their representation in STEM sectors in the labour market in these two countries. Nonetheless, across all countries, the proportion of women and girls represented in the highest levels of achievement such as the Nobel Prize, Fields Medal or International Olympiads remain significantly low.

The different research methods used in this study have allowed for a deeper understanding of these patterns, through examining the gender dimension of learning achievement and participation in STEM, in light of possible psychosocial, labour market and educational influences. The concentration of female students enrolled in specific STEM fields of study such as biology and health sciences as opposed to the very low proportion in physics and engineering appears to be reflected among all seven countries under review, both in higher education as well as in the labour market. Turning to educational and psychosocial influences, findings from Cambodia and Indonesia, for example, demonstrate no significant gender differences in terms of interest and attitudes towards science and mathematics. Instead, the conclusions from these two countries suggest that the main factor affecting the achievement of both female and male students lies in the quality of education. Indeed, teaching and learning should be improved through the provision of highly qualified teachers and improved teacher preparation, as well as higher levels of student involvement in the learning process.

According to the results of the data collected across all of the seven countries, female students tend to have a more positive attitude towards mathematics and science, as well as higher motivation, perseverance and desire to pursue further education in STEM fields of study. This however, does not necessarily translate into a higher level of participation and learning outcomes of women in these fields in education and the labour market. In addition, the higher degree of anxiety towards mathematics and science subjects among female students in most of the seven countries reviewed suggests that specific actions should be taken to attract more girls and women into STEM fields of study and careers through appropriate policy interventions. Such gender-responsive interventions may include teacher recruitment and training policies, scholarships, and partnerships with STEM sectors at the labour market level, including with institutes, universities and the private sector.

While a number of gaps and areas for improvement remain with regard to the promotion of girls and women in STEM (as observed in Chapter Eight), there are also some positive signals. The gender gap in learning achievement in mathematics and science is narrowing, especially in science, while at the same time both female and male students showed a positive attitude towards these subjects in the seven countries under review.

Although female students reported a higher degree of anxiety towards mathematics and science, they also report a higher degree of motivation and perseverance in most of these countries, which shows their desire to succeed in these subjects. Looking at participation in higher education, in some of the seven countries under review the proportion of female graduates in science, technology and innovation (see Figure 4), as well as the proportion of female researchers in these fields (see Table 15) is near equal to the proportion of men, particularly in the case of Malaysia and Mongolia as well as in some other countries of Asia. Looking at prestigious awards obtained by female STEM professionals, such as the awarding of the Fields Medal for mathematics to a woman for the first time in 2014, as well as the continued work of the L'Oréal-UNESCO For Women in Science Awards, these arguably show a positive step in highlighting female role models in STEM fields for young women worldwide.

This report has aimed to contribute knowledge with regard to gender, learning achievement and progression to STEM fields in Asia. In exploring the role of educational, psychosocial and labour market influences however, it is clear that there are areas remaining which require further investigation. The varying levels of female participation within STEM fields both in higher education and the labour market, in particular in fields such as physics and engineering presents one area for further exploration. With regard to learning achievement in international assessments, further analysis focused on countries that are both among the highest performing and with a relatively smaller gender gap in student performance in mathematics and science (e.g. Singapore and Hong Kong- China) could help identify determining factors and draw lessons for other countries in the region. Further analysis could also be conducted with regard to the selection and participation of student delegations in International Olympiads, while promoting young medallists and in particular female medallists as youth role models in their countries. Turning to psychosocial influences, more research is needed at country level to inform governments on how student attitudes and interests towards mathematics and science are affected, and in particular among female students, to enable them to thrive in whatever field they wish to pursue, including STEM fields. More broadly, countries would be encouraged to investigate a number of the areas examined in this report through in-depth review within their country context.

Science, Technology, Engineering and Mathematics are fields of study which each contribute significantly to global innovation and development, particularly now as we move further into increasingly knowledge-based societies. The pursuance of STEM among women and girls – both in education and employment – is still limited and this is true not just of developing countries but of all countries including those of Asia. If women are to stand alongside men as equal contributors to the building of just, peaceful and prosperous societies, they must be ensured the equal opportunity to learn in all areas, including STEM. By exploring the gendered dimensions of learning and participation in STEM fields, as well as psychosocial and labour market influences, this report has served to expose the multivariate factors inhibiting the greater engagement of women in STEM and in doing, shine light of the ways in which policymakers and practitioners may together work towards gender equality in Asia and beyond.

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Annexes

Annex 1. Student Questionnaire

Instructions

Please answer all of the questions in this questionnaire and read each one carefully. The questionnaire aims to obtain your views and attitudes on different subjects you are studying at school, with specific sections on mathematics and science, as well as your views on further study and career interests. When answering the questions, reflect on how you feel about each statement. Note that this survey is anonymous and that your name will not be recorded or shared at any time.

Background Questions

Q1. What grade are you in?

Grade	

Q2. What is your age?

Years old	

Q3. Are you Female or Male?

Female	
Male	

School Subject Preferences

Q4. Which of the following subjects do you ***most*** enjoy at school?

Please tick your top three choices.

Algebra	
Biology	
Chemistry	
Design/Technology	
Geography	
History	
Life Skills	
Moral and Ethics Education	
Physical Education	
Science (general)	
Art	
Calculus	
Computer Science	
Foreign Languages	
Geometry	
Language and Literature	
Mathematics (general)	
Music	
Physics	
Social Science	

If other, please specify ....

....

....

Q5. Which of the following subjects do you ***not*** enjoy at school?

Please tick your bottom three choices.

Algebra	
Biology	
Chemistry	
Design/Technology	
Geography	
History	
Life Skills	
Moral and Ethics Education	
Physical Education	
Art	
Calculus	
Computer Science	
Foreign Languages	
Geometry	
Language and Literature	
Mathematics (general)	
Music	
Physics	
Social Science	

If other, please specify ......

Q6. Which of the following subjects do you think you perform ***best*** at in school?

Please tick your top three choices.

Algebra	
Biology	
Chemistry	
Design/Technology	
Geography	
History	
Life Skills	
Moral and Ethics Education	
Physical Education	
Science (general)	
Art	
Calculus	
Computer Science	
Foreign Languages	
Geometry	
Language and Literature	
Mathematics (general)	
Music	
Physics	
Social Science	

If other, please specify ......

Q6. *continued* Please specify why you think you perform best in these subjects :

Q7. Which of the following subjects do you think you perform ***worst*** at in school?

Please tick your bottom three choices.

Algebra	
Biology	
Chemistry	
Design/Technology	
Geography	
History	
Life Skills	
Moral and Ethics Education	
Art	
Calculus	
Computer Science	
Foreign Languages	
Geometry	
Language and Literature	
Mathematics (general)	
Music	
Physics	
Social Science	

If other, please specify ....

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Q8. During this academic year [or during the last 12 months] have you received any fee-paying supplementary tutoring beyond official school hours (at school, in a tutoring centre, at home or anywhere else)?

Yes ☐

No ☐

If yes, please specify which subject (tick all that are applicable):

Biology	
Mathematics	
Chemistry	
Physics	
Other subjects (please specify):	

Please indicate the reasons for receiving tutoring (tick all that are applicable):

To improve examination score	
My parents chose it for me	
My teachers recommended it	
To learn school subjects better	
Many of my friends are doing it	
Attracted by advertisement	
Other reasons (please specify):	

Q7. *continued* Please specify why you think you perform worst in these subjects :

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....

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Mathematics

Views and attitudes towards mathematics

Q9. Which mathematics topic do you like the ***most***?

Please tick one topic below:

Algebra	
Geometry	
Calculus	
Other (please specify):	

Q10. Which mathematics topic do you like the ***least?***

Please tick one topic below:

Algebra	
Geometry	
Calculus	
Other (please specify):	

Q12. What do you like the ***most*** about mathematics class?

Please explain in the space below:

....

....

....

....

....

Q13. What do you like the ***least*** about mathematics class?

Please explain in the space below:

....

....

....

....

Q11. Views and attitudes towards mathematics in general.
Please state how far you agree or disagree with the following statements:

Please tick one box for each row only.

		Strongly Agree	Agree	Not sure	Disagree	Strongly Disagree
A	I enjoy mathematics class.					
B	I feel confident about my abilities in mathematics.					
C	I do not feel confident about my abilities in mathematics.					
D	I want to do well in mathematics.					
E	I look forward to mathematics class.					
F	If I study very hard I think I can improve in mathematics.					
G	I can solve mathematical problems easily and quickly.					
H	I have trouble solving mathematical problems and take time to understand.					

Q14. Grades in mathematics.

Please state how far you agree or disagree with the following statements:

Please tick one box for each row only.

		Strongly Agree	Agree	Not sure	Disagree	Strongly Disagree
A	I worry about my mathematics grades.					
B	My grades in mathematics are good.					
C	My grades in mathematics are poor.					
D	I feel I perform better in mathematics than most of my classmates.					
E	I feel that most of my classmates perform better in mathematics than me.					

Q15. Importance of mathematics.

Please state how far you agree or disagree with the following statements:

Please tick one box for each row only.

		Strongly Agree	Agree	Not sure	Disagree	Strongly Disagree
A	It is important for me to do well in mathematics so that I can do well in other subjects at school.					
B	Mathematics is important for my everyday life.					
C	Mathematics is important for my future education.					
D	Mathematics is important for my future career.					

Q16. My teacher(s) in mathematics class.

Please state how far you agree or disagree with the following statements:

Please tick one box for each row only.

		Strongly Agree	Agree	Not sure	Disagree	Strongly Disagree
A	My teacher(s) is fully prepared and confident when teaching mathematics.					
B	My teacher(s) encourage(s) me to do well/better in mathematics.					
C	My teacher(s) has(have) suggested that I should study mathematics for my further study/career.					
D	My teacher(s) influence(s) how well I do in mathematics.					
E	My teacher(s) make(s) me feel enthusiastic about mathematics.					
F	My teacher(s) interact(s) with me when teaching mathematics.					
G	If I struggle with a mathematics problem, I ask my teacher(s) for help.					
H	If I ask my teacher(s) for help with a mathematics problem, he/she/they ***always*** try to help me.					
I	If I ask my teacher(s) for help with a mathematics problem, he/she/they ***sometimes*** try to help me.					
J	If I ask my teacher(s) for help with a mathematics problem, he/she/they ***rarely*** try to help me					

Q17. My teacher(s) in mathematics class.
Please state if your mathematics teacher in the current school year is female or male:

Female	
Male	

If you have more than one teacher for general mathematics in the current school year or for specific topics e.g. algebra, calculus or geometry, please state their gender for each in the space below:

Q18. My parent(s)' views on mathematics.
Please state how far you agree or disagree with the following statements:

Please tick one box for each row only.

		Strongly Agree	Agree	Not sure	Disagree	Strongly Disagree
A	My parent(s) encourage(s) me to do well/better in mathematics.					
B	My parent(s) tell(s) me mathematics is important for my further study.					
C	My parent(s) tell(s) me mathematics is important for my further career.					
D	My parent(s) has/have suggested that I should study mathematics for my further study/career.					
E	My parent(s) influence(s) how well I do in mathematics.					
F	My parent(s) make(s) me feel enthusiastic about mathematics.					

Science

Views and attitudes towards science

Q19. Which science topic do you like the ***most***?

Please tick one topic below:

Biology	
Physics	
Chemistry	
Other (please specify):	

Q20. Which science topic do you like the ***least***?

Please tick one topic below:

Biology	
Physics	
Chemistry	
Other (please specify):	

Q22. What do you like the ***most*** about science class?

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Q23. What do you like the ***least*** about science class?

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Q21. Views and attitudes towards science in general.
Please state how far you agree or disagree with the following statements:

Please tick one box for each row only.

		Strongly Agree	Agree	Not sure	Disagree	Strongly Disagree
A	I enjoy science class.					
B	I feel confident about my abilities in science.					
C	I do not feel confident about my abilities in science.					
D	I want to do well in science.					
E	I look forward to science class.					
F	If I study very hard I think I can improve in science.					
G	I find science easy and learn quickly.					
H	I find science difficult and take time to understand.					

Q24. Grades in science.

Please state how far you agree or disagree with the following statements:

Please tick one box for each row only.

A	I worry about my science grades.					
B	My grades in science are good.					
C	My grades in science are poor.					
D	I feel I perform better in science than most of my classmates.					
E	I feel that most of my classmates perform better in science than me.					

Q25. Importance of science.

Please state how far you agree or disagree with the following statements:

Please tick one box for each row only.

		Strongly Agree	Agree	Not sure	Disagree	Strongly Disagree
A	It is important for me to do well in science so that I can also do well in other subjects					
B	Science is important for my everyday life.					
C	Science is important for my future education.					
D	Science is important for my future career.					

Q26. My teacher(s) in science class.

Please state how far you agree or disagree with the following statements:

Please tick one box for each row only.

		Strongly Agree	Agree	Not sure	Disagree	Strongly Disagree
A	My teacher(s) is fully prepared and confident when teaching science.					
B	My teacher(s) encourage(s) me to do well/better in science.					
C	My teacher(s) has/have suggested that I should study science for my further study/career.					
D	My teacher(s) influence(s) how well I do in science.					
E	My teacher(s) make(s) me feel enthusiastic about science.					
F	My teacher(s) interact(s) with me when teaching science.					
G	If I struggle with a mathematics problem, I ask my teacher(s) for help.					
H	If I ask my teacher(s) for help with a science exercise, he/she/they ***always*** try to help me.					
I	If I ask my teacher(s) for help with a science exercise, he/she/they ***sometimes*** try to help me.					
J	If I ask my teacher(s) for help with a science exercise, he/she/they ***rarely*** try to help me.					

Q27. My teacher(s) in science class.

Please state if your mathematics teacher in the current school year is female or male:

Female	
Male	

If you have more than one teacher for general science in the current school year or for specific topics e.g. biology, chemistry or physics, please state their gender for each in the space below:

....

....

....

....

Q28. My parent(s)' views on science.

Please state how far you agree or disagree with the following statements:

Please tick one box for each row only.

		Strongly Agree	Agree	Not sure	Disagree	Strongly Disagree
A	My parent(s) encourage(s) me to do well/better in science.					
B	My parent(s) tell(s) me science is important for my further study.					
C	My parent(s) tell(s) me science is important for my further career.					
D	My parent(s) has/have suggested that I should study science for my further study/career.					
E	My parent(s) influence how well I do in science.					
F	My parent(s) make(s) me feel enthusiastic about science.					

Plans for Higher Education and Future Career

Q29. Do you plan to pursue higher education after graduating high school?

If yes, proceed to the next question, if no then you have completed the questionnaire.

Yes ☐

No ☐

Q30. Do you plan to study one of the subjects you most enjoy (selected in question 4) at higher education?

Yes ☐

No ☐

Please state the subject you would like to study at higher education. Explain why you plan to continue study in this area:

Q31. Do you think that the subject chosen in the previous question (30) is the field of study that you wish to pursue as a future career?

Yes ☐

No ☐

Please state what career you would see yourself working in once you graduate from higher education. Explain why you would see yourself working in this field.

Thank you!

Annex 2. Classroom Observation Sheet

Background Information:

Location (please √ or fill relevant information):	Urban		Rural	
	Name of school:		Name of City/town:	
	Name of district:		Name of province:	
Grade:				
Class Subject (please √):	Algebra		Biology	
	Calculus		Chemistry	
	Geometry		Mathematics (general)	
	Physics		Science (general)	
	Other (please specify):			
Teacher Gender (please √):	Female		Male	
No. of students:	Female		Male	

Classroom/Seating arrangement:

Draw a classroom map to show the learning environment and seating arrangement. Please note that in science classrooms, some space may be allocated for science experiments and equipment. Please label the front and back of the classroom, the board, where the teacher stands, student desks, as well as any doors, windows, heaters, fans or other relevant points. Please ensure classroom desks by gender, it may be possible to see if students tend to sit separately by gender or mixed. Clarify with the teacher if there is a fixed seating arrangement which they have implemented.

Lesson description:

Include a short description of the lesson: this can include researcher's impressions and reflections as opposed to general description of facts.

Teacher attitudes/support:

Are the boys and girls receiving equal amount of attention/support from the teacher?

Does the teacher seem fully prepared and confident with the subject content?

When asked to clarify a question or provide more support, does the teacher equally give this attention to female and male students?

How would you describe the way the teacher calls on students to talk in front of the class?
Can any differences be observed in terms of frequency or attitudes with regard to female and male students?

If applicable, how does the teacher assign groups for exercises/experiments (are they gender mixed or segregated)?

Do you notice any gender stereotyping towards students (particularly with regard to ability of female and male students in the subject)?

Do you have any other observations in regard to the teacher?

Student attitudes/participation in the classroom:

Are students seeking clarifications or asking for help or support from the teacher on certain exercises?

How often do students ask for help from their teacher in the class? Can any differences be observed between female and male students?

Are students encouraged to express themselves in class?

Is there a difference between female and male students when they express themselves in class?

Do female or male students seem confident when talking in front of their classmates?
How would you describe their behaviour?

Are boys and girls equally participating in classroom activities such as asking questions, answering teachers' questions, participating in discussions and taking part in project work?

If applicable, how involved are female students in group exercises as opposed to male students?

Do you have any observations in regard to the level of motivation of female and male students?

Do you have any other observations in regard to the students?

Equipment and learning/teaching materials:

How would you describe classroom equipment and learning/teaching materials used in this class?

Are they distributed equally to all students?

If they are limited, how does the teacher allocate these to specific groups of students?

Any other observations?

Additional Information:

Annex 3. Guiding Questions for Semi-Structured Interviews in Indonesia

These guiding questions were developed as part of the country research conducted in Indonesia, and were based on the initial research framework for this project.

Q1: Are there any norms or special rules that have been implemented for women's education based on your experience?

Q2: What are the social perceptions of women working in paid employment in general?

Q3: What are the social perceptions of women working in paid employment in science, mathematics and technology sectors?

Q4: Are there any particular social or cultural factors that may cause women not to work in paid employment jobs? Please describe any factors that you think might exist.

Q5: How far did your parents encourage your education with regard to mathematics, science and technology career?

Q6: As far as you know, what government employment schemes for graduates to enter STEM sectors exist? Are these schemes equal for men and women? If there is any difference, please describe.

Q7: As far as you know, are there any private sector employment schemes for graduates to enter STEM sectors? Are these schemes equal for men and women? If there is any difference, please describe.

Q8: Did your teacher encourage you to pursue further education in mathematics, science or technology? What kind of support/encouragement is given to you?

Q9: Are there any career counselling programmes available in schools? Are they gender-sensitive?

Q10: What was your reason of choosing career in science, technology, or mathematics?

Q11: What factors encouraged you in choosing career in the field?

Q12: What factors discouraged you from choosing this field of work?

Q13: What factors might have discouraged you to be successful in this field?

Q14: From your perspective, what factors affect women in choosing career of science, mathematics, or technology?

Q15: Are there any rules or regulations specifically for women in your profession? If so, please describe.

Q16: If you did not choose to pursue a career in science, mathematics or technology what are your reasons?

Annex 4. Statistical Tables on Female Participation in STEM-Related International Olympiads by Country/Jurisdiction in 2014

INTERNATIONAL BIOLOGY OLYMPIAD 2014										
Country/Jurisdiction	Gold		Silver		Bronze		Total Medallists		Total Delegation	
	F	M	F	M	F	M	F	M	F	M
Australia				2	1	1	1	3	1	3
China		3		1				4		4
India			2	2			2	2	2	2
Indonesia		3	1				1	3	1	3
Japan		1		3				4		4
Kazakhstan				1		3		4		4
Kyrgyzstan										4
Mongolia						1		1	3	1
Pakistan					2		2		3	1
Republic of Korea	1	1		2			1	3	1	3
Singapore	1	2		1			1	3	1	3
Sri Lanka									2	2
Tajikistan						1		1		4
Thailand		2	1	1			1	3	1	3
Turkmenistan										4
Uzbekistan									3	1
Viet Nam			1			3	1	3	1	3
Total Number	2	12	5	13	3	9	10	34	19	49
	F	M	F	M	F	M	F	M	F	M
%	14	86	28	72	25	75	23	77	28	72

Note: Delegations of four students per participating country/jurisdiction.

Source: IBO, 2014

INTERNATIONAL OLYMPIAD IN INFOMATICS 2014

Country/Jurisdiction	Gold		Silver		Bronze		Total Medallists		Total Delegation	
	F	M	F	M	F	M	F	M	F	M
Australia		2		2				4		4
Bangladesh									1	3
China		4						4		4
Hong Kong- China		1		1		2		4		4
India		1	1				1	1	1	3
Indonesia						4		4		4
Iran		2		2				4		4
Japan		1		2		1		4		4
Kazakhstan				2		1		3		4
Kyrgyzstan										4
Macau- China									1	3
Malaysia						2		2		4
Mongolia										4
New Zealand						1		1		4
Republic of Korea		2		1		1		4		4
Singapore		2		1				3		4
Sri Lanka										4
Tajikistan										4
Thailand		2				2		4		4
Turkmenistan										4
Viet Nam				2		2		4		4
Total Number		17	1	13		16	1	46	3	81
	F	M	F	M	F	M	F	M	F	M
%	0	100	7	93	0	100	2	98	4	96

Note: Delegations of four students per participating country/jurisdiction.

Source: IOI, 2014

INTERNATIONAL OLYMPIAD IN MATHEMATICS 2014

Country/Jurisdiction	Gold		Silver		Bronze		Total Medallists		Total Delegation	
	F	M	F	M	F	M	F	M	F	M
Australia		1		3		2		6		6
Bangladesh				1		1		2		6
China		5		1				6		6
DPR Korea		1		4				5		6
Hong Kong- China			1	3		2	1	5	1	5
India				1		3		4		6
Indonesia				2	1	2	1	4	1	5
Iran				4	1	1	1	5	1	5
Japan		4		1		1		6		6
Kazakhstan		1		1		4		6		6
Kyrgyzstan									1	5
Mongolia						5		5		6
New Zealand				1		1		2		6
Pakistan						1		1		6
Philippines				1		3		4	1	5
Republic of Korea		2		4				6		6
Singapore		3		2		1		6		6
Sri Lanka						2		2		6
Tajikistan						2		2		6
Thailand				4		2		6		6
Viet Nam		3	1	1		1	1	5	1	5
Total Number		20	2	34	2	34	4	88	6	120
	F	M	F	M	F	M	F	M	F	M
%	0	100	6	94	6	94	4	96	5	95

Note: Delegations of six students per participating country/jurisdiction.
Source: IMO, 2014

INTERNATIONAL OLYMPIAD IN PHYSICS 2014

Country/Jurisdiction	Gold		Silver		Bronze		Total Medallists		Total Delegation	
	F	M	F	M	F	M	F	M	F	M
Australia				2		2		4		5
Bangladesh										5
Cambodia									2	3
China		5						5		5
Hong Kong- China				4		1		5		5
India		2		3				5		5
Indonesia	1					2	1	2	1	4
Iran				5				5		5
Japan			1	3		1	1	4	1	4
Kazakhstan		3		2				5		5
Kyrgyzstan						1		1		5
Macao- China		2				2		4	1	4
Malaysia										5
Mongolia				2		2		4		5
Myanmar										2
Nepal										5
Pakistan										5
Singapore		3		2				5		5
Republic of Korea		5						5		5
Sri Lanka				1		4		5		5
Tajikistan						2		2		5
Thailand		4		1				5		5
Turkmenistan						2		2		5
Uzbekistan									1	3
Viet Nam	1	2		2			1	4	1	4
Total Number	2	26	1	27		19	3	72	7	114
	F	M	F	M	F	M	F	M	F	M
%	7	93	4	96	0	100	4	96	6	94

Note: Delegations of five students per participating country/jurisdiction with the exception of Myanmar and Uzbekistan.

Source: IPhO 2014

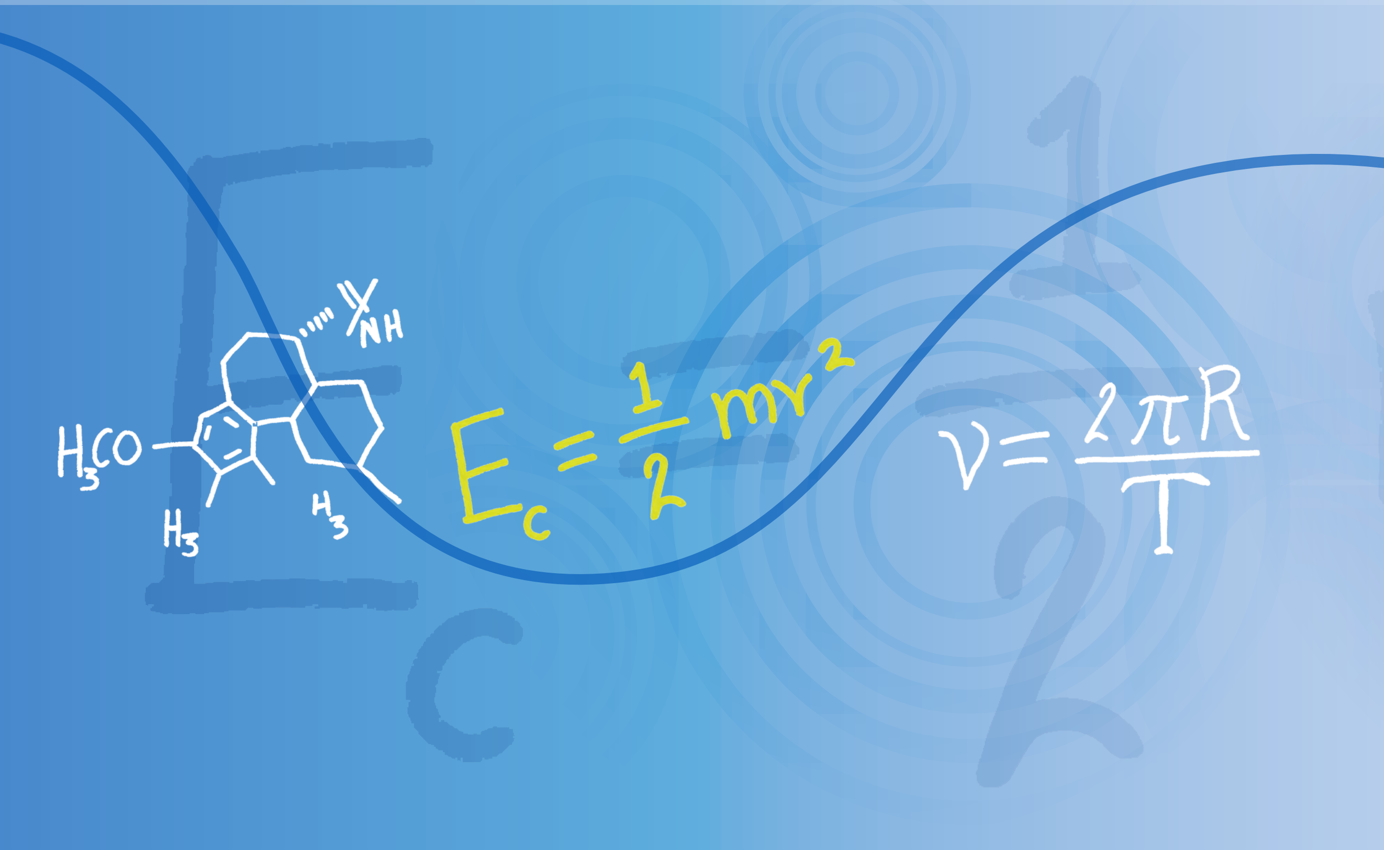
Annex 5. Country-specific Policy Suggestions

Introductory note:

The following country-specific policy suggestions are drawn from the country case studies produced by national researchers in the seven countries under review. They provide a more detailed set of policy suggestions based on the country context.

Country	Policy Suggestions	
Cambodia	• Compile and analyze the STEM-related projects and programmes supported by NGOs and International Organizations that provide important financial and professional support, in order to share their experiences and to inform education policy and reform. • Increase resources for and monitoring of higher education institutions (both public and private) to monitor compliance with international standards for education and to foster credibility and recognition as quality institutions. • Provide increased resources and qualified teachers to improve the quality of education and meet the goals of the Education Sector Plan (ESP).	• Allocate more resources to provide the necessary equipment for the learning of mathematics and science, thereby fuelling interest of female and male students alike in these subjects. The use of science labs for hands-on and creative learning for instance, can increase students' beliefs and attitudes towards science as a career and help overcome negative stereotype threat with regard to gender and ability. • Recruit and retain highly qualified teachers with positive attitudes towards the teaching of mathematics and science with a view to creating an environment in which students are active participants in their learning, and where they can apply their learning to real life situations.
Indonesia	• Strengthen teacher recruitment policies to ensure that the most qualified and best performing teachers are selected, in addition to stronger policies on teacher education and evaluation to improve the quality of education provision in Indonesia. • Review the current remuneration policy, whereby all teachers receive remuneration regardless of their level of performance, in order to incentivise teachers with good performance.	• Conduct a gender analysis and review of teaching and learning materials for all subjects, in particular in mathematics and science, to ensure that they are gender-sensitive. • Establish assessment policies that place more emphasis on higher order thinking skills for implementation at school, district and national level, in order to support student learning, performance in international assessments, and to address the issue of cheating in national examinations.
Malaysia	• Conduct further research to inform policy in addressing the emerging gender gap which has resulted in alarming trends in male students' underperformance and lower participation in education, in order to avoid the marginalization of young boys and men. • Develop and introduce specific education strategies targeting performance in mathematics and science that are gender-sensitive, in order to help bridge the gender gap in achievement and help support performance of male students in these subjects.	• Ensure that higher education enrolment policy takes a number of credentials into account in addition to academic achievement such as the diverse competencies, abilities and potential of both female and male students.

Mongolia	• Include the notion of negative stereotype threat with regard to gender in STEM education as part of teacher education curricula to increase teachers' gender sensitivity in the teaching of mathematics, science and other STEM-related subjects. • Consider the need for necessary equipment and resources in implementing science and mathematics curricula, particularly in rural areas, so that female and male students are able to better learn through practical activities that can fuel their interest and perspectives in pursuing a career in these fields. • Introduce scholarship programmes for students to pursue study in STEM disciplines in higher education with gender disparities taken into consideration.	• Raise awareness of role models in STEM careers for both female and male professionals, including through better partnership between public and private sectors. • Ensure more effective coordination between education and science and technology policies, in view of creating schemes that can increase job opportunities, encourage STEM research in universities, strengthen the capacity of national institutes such as the Academy of Science – all while encouraging equal participation from both women and men.
Nepal	• Introduce career counselling, scholarship and loan opportunities in schools as well as in higher education to encourage female students to pursue further study and careers in STEM. • Address the importance of parental education and engagement through education policy, in order to address the heavy workload and burden of domestic duties that are often borne by girls and which have a great impact on their opportunities to learn at home. • Ensure more equal representation of female and male teachers at all levels of education through teacher recruitment policies, in order to improve the increment and retention of female students.	• Increase gender parity in primary education, to ensure that all female students, particularly those in rural areas, have an equal opportunity to progress into secondary education through an overall higher investment in girls' education. • Address gender disparities in the labour market through interventions that provide equal opportunities for women and men to pursue careers in STEM.
Republic of Korea	• Develop appropriate learning and support strategies for the minority of female students in the highest levels of achievement, as well as those concentrated in intermediate and basic levels of achievement in mathematics and science, in order to enable them to thrive in STEM-related subjects. • Place a stronger emphasis at policy implementation level, as well as review of policy effectiveness for initiatives that seek to promote women and girls' participation in STEM in order to ensure their impact. • Consider the decline in proportion of female teachers as the level of education increases in future research, particularly in terms of teacher-student relationships and learning outcomes.	• Provide training and guidance to teachers and career counsellors, so that they may promote the benefits of entering a career in STEM for young women. • Extend technical and professional development for female STEM professionals who have taken career breaks, in particular due to family responsibilities, to enable them to catch up with fast-paced development and innovation in STEM fields and equip them with the updated knowledge, skills and techniques that are required in order to eventually return to their profession.
Viet Nam	• Ensure concerted efforts to support and implement the Gender Equality Law (2006), as well as policy efforts to take into account women from ethnic minorities and rural areas, and to increase women's participation in decision-making through specific projects and activities. • Revise education curricula as well as teaching and learning materials to better promote gender equality; through addressing gender stereotyping and taking into account cultural and linguistic differences in preparation for the new curriculum to be completed by 2015.	• Provide increased training and incentives for women to enter a broader range of occupations in the labour market, for instance to enter newly created jobs in high-tech industries.



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