United Nations
Educational, Scientific and
Cultural Organization

UNEVOC
International Centre
for Technical and Vocational
Education and Training

Boosting gender equality in science and technology

A challenge for TVET programmes and careers

Education 2030

Published in 2020 by the
United Nations Educational, Scientific and Cultural Organization
7, place de Fontenoy
75352 Paris 07 SP
France

and

UNESCO-UNEVOC International Centre for TVET
UN Campus, Platz der Vereinten Nationen 1
53113 Bonn
Germany

ISBN: 978-92-3-100417-9 (pdf)

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Copy-editing: International Correspondents for Education

Graphics and layout: Aldrich Mejia

Front cover attribution: Derivative of photo by ThisisEngineering from Unsplash

Acknowledgement

This report was written by Leon Tikly of University of Bristol (UK), Epke Vogel and Carmen Kurvers of CINOP - Centre for Innovation of Education and Training (the Netherlands).

The publication is a collaboration with ten members of the UNEVOC Network – a global platform of technical and vocational education and training (TVET) institutions – who contributed substantially by collecting country-specific information for the study. UNESCO-UNEVOC wishes to express special thanks to the following experts from these UNEVOC Centres: Gitta Siekmann, NCVER - National Centre for Vocational Education Research (Australia); Mariana Zumbado, INA - National Institute of Apprenticeship (Costa Rica); Christina Boateng, University of Cape Coast (Ghana); Shermaine Barrett, UTech - University of Technology (Jamaica); Issam Abi Nader, HITI - Higher Industrial Technical Institute (Lebanon); Epke Vogel and Carmen Kurvers of CINOP (the Netherlands); Mylene Somera of TESDA - Technical Education and Skills Development Authority (the Philippines); Sibusiso Moyo, Durban University of Technology (South Africa); Inga Shad-Dankwart and Stephanie Conein of BIBB - Federal Institute for Vocational Education and Training (Germany); and Catalina Iglesias and Nicole Vallejos, Duoc (Chile).

UNESCO-UNEVOC would also like to thank the following UNESCO colleagues for their feedback and contributions to the draft report: François Leclercq, Wang Libing, Ramon Iriarte, Mark Manns, Amelia Greer Martin, and Ai Sugiura.

The overarching work was overseen and coordinated by Miki Nozawa and Wouter de Regt, UNESCO-UNEVOC.

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Glossary

ASCED	Australian Standard Classification of Education
CINOP	Centre for Innovation of Education and Training
COTVET	Council for Technical and Vocational Education and Training in Ghana
EU	European Union
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (German development agency)
HEART Trust	Human Employment and Resource Training Trust of Jamaica
ICT	Information and Communications Technology
INA	Instituto Nacional de Aprendizaje (National Training Institute of Costa Rica)
ISCED	International Standard Classification of Education
MINT	Mathematics, Informatics, Natural Sciences and Technology
STEM	Science, Technology, Engineering and Mathematics
TESDA	Technical Education and Skills Development Authority in the Philippines
TVET	Technical and Vocational Education and Training
UIS	UNESCO Institute for Statistics
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNESCO-UNEVOC	UNESCO-UNEVOC International Centre for Technical and Vocational Education and Training
VHTO	Landelijk expertisebureau meisjes/vrouwen en bèta/techniek (National Expert Organization on Girls/Women and Science/Technology of the Netherlands)

1. Introduction

Why are gender disparities in STEM-related TVET an issue?

Science, technology, engineering and mathematics (STEM)-related technical and vocational education and training (TVET) has a potentially significant role to play in providing the skills and competencies required to support innovation, productivity and international competitiveness as well as areas of social development including health and education. It is thus an important driver for achieving a range of the United Nations' Sustainable Development Goals and contributing to inclusive and sustainable societies. STEM skills and knowledge can be required for both 'traditional' and 'emerging' occupations; STEM-related careers are often referred to as the 'jobs of the future', driving innovation, inclusive growth and sustainable development. The World Economic Forum (2018) explains that the Fourth Industrial Revolution is changing the world of work, largely driven by technological advancements. The report shows extensive evidence of accelerating demand for a variety of wholly new specialist roles related to understanding and leveraging the latest emerging technologies: artificial intelligence and machine learning specialists, big data specialists, process automation experts, information security analysts, user experience and human–machine interaction designers, robotics engineers and blockchain specialists (World Economic Forum, 2018).

Even as STEM subjects and skills are becoming more essential in today's world, gender disparities are prevalent in these fields. In recent years, much has been done to help inspire girls and women to study and work in technical fields. But girls and women continue to be excluded from participating fully according to the United Nations (2020). Long-standing biases and gender stereotypes are steering girls and women away from STEM-related fields, which means that a large pool of potential skills that could contribute to economic development remain untapped. It can put major constraints on the individual lives of women and contribute to transmitting gender inequalities across generations. This has several negative consequences for (future) economic and social development.

First of all, from a rights-based perspective, the under-representation of girls and women in these fields means that they will continue to be denied the same opportunities as boys and men to develop careers in potentially lucrative existing and emerging areas of the labour market. In its *Does the EU Need More STEM Graduates?* report, the European Commission (2015) projects that employment in STEM occupations in the European Union (EU) (for all levels) will increase by 12.1 per cent by 2025: a much higher rate than the projected 3.8 per cent increase for other occupations in the region. It is expected that in 2025, 46 per cent of STEM-related occupations will require medium-level qualifications which are mostly acquired through upper-secondary-level TVET. A differentiation in wage and wage growth between the STEM workforce and the total workforce in Europe is also evident, and shows the relatively high demand for professionals in the STEM sector. STEM professionals in the EU earn on average 19 per cent more than other groups (Caprile et al., 2015). If girls and women are profiting less than boys and men from these relatively large employment- and income-generating opportunities, existing inequalities in STEM-related TVET can be seen to perpetuate wider gender inequalities in labour market opportunities and income.

Second, from an economic perspective, various studies [1] have shown that combined and diverse teams in organizations in which women and men bring different skills, attitudes and perspectives to the workplace are beneficial for innovation and the development of organizations. In other words, diverse workplaces boost creativity and innovation, thus improving business performance. A study by McKinsey & Company (2018) found that companies in the top quartile for gender diversity on their executive teams were 21 per cent more likely to experience above-average profitability. At the same time, companies with low numbers of women and other under-represented groups were 29 per cent more likely to underperform on profitability. STEM-related TVET fields miss out on this advantage as gender disparities prevail (McKinsey, 2018).

There has been increasing concern among policy-makers and practitioners about the under-representation of girls and women in STEM education. This has been reflected in recent reports launched by UNESCO including *Cracking the Code: Girls' and Women's Education in Science, Technology, Engineering and Mathematics* (UNESCO, 2017) and *A Complex Formula: Girls and Women in Science, Technology, Engineering and Mathematics in Asia* (UNESCO, 2015a). Taken together, these previous studies indicate the following:

- Gender differences in STEM education participation at the expense of girls are already visible in early childhood care and education and become more visible at higher levels of education.
- Girls appear to lose interest in STEM subjects with age, and lower levels of participation are already seen in advanced studies at secondary level.

1 See for example Hewlett, S. A., et al. (2013), available on the Harvard Business Review website (https://hbr.org/2013/12/how-diversity-can-drive-innovation).

- In higher education, women represent only 30 per cent of all students enrolled in STEM-related fields of study based on a global average (data for 2014 to 2016).
- Gender differences also exist in STEM disciplines, with the lowest female enrolment observed in engineering, manufacturing and construction (8 per cent); information, communication and technology (ICT) (3 per cent); and natural sciences, mathematics and statistics (5 per cent).
- Girls and women leave STEM disciplines in disproportionate numbers during their higher education studies, in their transition to the world of work and even during their career cycle.

What does the report aim to do?

While much of the focus to date has been on the participation of girls and women in school and university STEM education, there has been relatively little attention paid to the participation of girls and women in STEM-related TVET despite the significance of this sector. This report provides an overview of the findings of a first scoping study on the availability of data and information on gender disparities in STEM-related TVET for ten countries [2]. It addresses important gaps in existing data and literature related to this topic while aiming to complement and build on existing initiatives in the area of gender and STEM led by UNESCO.

Ten case countries across the world were selected to be covered in this study, thanks to the collaboration of members of UNESCO's global platform of TVET institutions, the UNEVOC Network. These countries were identified based on the interests expressed by the member institutions, their experiences designing and implementing initiatives that addressed STEM-related TVET and gender equality, and their commitments to contribute to the study. While attention has been given to ensure broad geographical distribution, by covering all five global regions, the study team, coordinated by UNESCO-UNEVOC, is aware that these selected countries do not necessarily represent the respective regions. The aim of collecting country-specific information was therefore not to make a comparative analysis between the countries, but was rather to provide examples from selected countries across the globe.

The report synthesizes existing available (global) literature and data with country-level data collected by ten members of the UNEVOC Network.

The specific objectives of the report are to:

- Synthesize evidence concerning:
  - » The participation of female and male students in STEM-related TVET
  - » The performance of female and male students in STEM-related TVET
  - » The proportion of women and men who progress to STEM-related occupations
- Explore the individual, parental/peer, school-level and societal influences on girls' and women's enrolment, learning achievement and progression to STEM-related occupations
- Identify areas of successful practice in increasing the participation and performance of girls and women in STEM-related TVET, and initiatives to improve the participation of women in STEM-related occupations
- Make recommendations for policy and for future research in this area

2 Australia, Chile, Costa Rica, Germany, Ghana, Jamaica, Lebanon, The Netherlands, The Philippines, South Africa

Defining TVET and STEM-related TVET

Coming to a universal definition of STEM-related TVET is complicated by differences in the ways countries define:

- STEM, e.g. disciplinary versus interdisciplinary understanding
- TVET, e.g. differences across country contexts and levels
- Indicators to collect gender-aggregated data on participation, achievement and transition

This report aims to contribute towards a working definition of STEM in TVET.

Technical and vocational education and training

TVET comprises education, training and skills development relating to a wide range of occupational fields, production, services and livelihoods (UNESCO, 2015b). It is not consistently referred to and is provided at different education levels in many countries around the world. As part of lifelong learning, TVET can take place at secondary, post-secondary and tertiary levels and includes work-based learning and continuing training and professional development that may lead to qualifications. It can also be referred to as apprenticeship training, vocational education, technical education, technical and vocational education, occupational education, vocational education and training, career and technical education, workforce education, and workplace education, to name but a few (Hollander and Mar, 2009).

In most countries, formal TVET takes place at upper and post-secondary levels. These correspond to International Standard Classification of Education (ISCED) levels 3, 4 and 5, i.e. upper secondary education, post-secondary non-tertiary education and short-cycle tertiary education. This is the situation in all of the case study countries included in this scoping study, although in some systems such as the Netherlands, Germany, Australia and Lebanon, pre-vocational courses or tracks are also offered at lower secondary level (corresponding to ISCED level 2). More information about the education and training systems in the ten countries represented in this study can be found in annex 1.

STEM-related TVET

This report is concerned with STEM education and training, but, given the context of TVET, it is perhaps more accurate to say that the study is concerned with TVET for STEM careers (which may be different). Generally, the term STEM is used as shorthand for science, technology, engineering and mathematics, and it includes but is not limited to the natural sciences (biology, chemistry and physics) and technology-related subjects including computing and, for example, computer applications technology and mathematics.

STEM in TVET

Definitions of STEM and STEM education vary between countries. Table 1 below provides an overview of the definitions of STEM education and STEM-related TVET as used in nine of the ten case study countries. These definitions can be formalized (for example by a country's ministry of education), but can also be informally used as 'working definitions' within the educational sector of the respective country.

Table 1. Definitions of STEM-related TVET in case study countries

COUNTRY. How STEM-related TVET is defined or understood
AUSTRALIA. The Office of the Chief Scientist defines STEM (for VET and university qualifications) as science, technology, engineering and mathematics collectively referring to a broad field of distinct and complementary approaches to knowledge. For the purpose of analysing the STEM workforce in Australia, a STEM education is defined as imparting content knowledge in STEM fields while providing frameworks in which new problems can be tackled. STEM graduates cite higher-order skills in research, logical thinking and quantitative analysis alongside the qualities of creativity, open-mindedness, independence and objectivity.
CHILE. The Ministry of Education created a working definition in 2019 in which STEM is seen as a way of jointly teaching science, mathematics, engineering and technology in learning processes.
COSTA RICA. In Costa Rica, STEM is often referred to as 'science, technology and innovation' or 'science, technology, telecommunication and innovation'. In the National Training Institute (INA) of Costa Rica, STEM is often referred to as 'non-traditional areas'.
GERMANY. The Federal Institute for Vocational Education and Training uses the term MINT occupations, which includes all activities that require a high proportion of knowledge and skills in Mathematics, Informatics, Natural Sciences and/or Technology. The construction and maintenance of technical plant and equipment is also counted as a central component of an activity in the MINT occupations, but not the operation of machines. When defining MINT occupations, the content of the activity is decisive, but not the environment in which the occupation is exercised, such as craft or industry.
GHANA. In Ghana's Education Strategic Plan 2018–2030, STEM education is defined as an approach to teaching and learning that integrates the content and skills of the STEM disciplines with other disciplines. STEM embodies an interdisciplinary and applied approach to teaching that focuses on the development of transversal competencies alongside STEM skills.
JAMAICA. In Jamaica, there is no general consensus on a definition of STEM across levels of the education system. It is often viewed as the individual science disciplines or as an interdisciplinary approach that integrates the content and skills of STEM facilitated by the 5E methodology: Engagement, Exploration, Explanation, Elaboration and Evaluation. A number of schools are designated as STEM Academies in which special emphasis is given to STEM education. Nine schools have been given this status, and only these schools can call themselves STEM schools.
LEBANON. The current working definition is that STEM-related TVET programmes cover four specializations: industrial; engineering; medical; and commercial and financial.
THE NETHERLANDS. In the Netherlands, STEM education is mostly called 'technical education', 'beta education' or 'beta-technical education' across all education levels and refers to the share of technical (STEM) subjects in the programme. Graduates of STEM-related TVET are said to have received a 'technical diploma'.
THE PHILIPPINES. Disciplines in STEM include architecture and town planning, information technology, mathematics, computer science and natural sciences. However, the Technical Education and Skills Development Authority (TESDA) recommends in its own country report that the Philippine Qualifications Framework should establish a nomenclature and classification of programmes or courses in both TVET and higher education to determine which parts belong to STEM, as well as clarify the occupations under each classification.
SOUTH AFRICA. In South Africa, STEM is understood as referring to science, technology, engineering and mathematics fields. Alternatively, science, technology and innovation (STI) is also used to highlight broader areas linked to innovation and science. In the TVET sector, STEM areas include fields in agriculture, engineering, manufacturing and technology, as well as IT services. Universities also include broader fields in the applied sciences, engineering, health sciences, mathematics and computing.

Table 1 not only highlights that countries have different definitions for both STEM education and TVET education, but it also shows that definitions of STEM-related TVET are often not available. Definitions of STEM in other types of education are more common. One potential reason is the fact that many policies and initiatives for improving the participation of girls and women in STEM education are aimed at girls in primary and secondary education, when girls and women are choosing their further study and career path.

In general, the vision for STEM education is of an interdisciplinary approach in which students apply STEM as appropriate to solve real-world problems, thus reflecting the interdisciplinary nature of the work of STEM professionals (Chalmers et al., 2017). It may involve any combination of STEM disciplines, or a STEM discipline and another school subject; the main characteristic is that it is an integrative approach (Asunda, 2014; Sanders, 2008). The STEM approach is described by Asunda et al. (2016) as follows:

> **"STEM approach refers to a pedagogical strategy that emphasizes application of knowledge, skills and values from the disciplines of Science, Technology, Engineering and Mathematics, in an integrated manner to help students solve problems encountered in the real world."**

This approach is seen as something which promises to engage students (in schools and colleges) because it involves solving real-world challenges such as energy, health and environmental issues (Durik et al., 2015; Kennedy and Odell, 2014).

While the vision for STEM education can be similar, its application can vary from country to country. This was also reflected in the ten case study countries. In Jamaica, for example, STEM is grounded in an inquiry-based/project-based approach facilitated by the 5E methodology. The Ministry of Education takes an integrated view of STEM education in which learning shows the functional relationship between the disciplines. This perspective argues for a combination of academic and technical skills. This integrated approach supports the incorporation of STEM in TVET, and STEM is seen as an effective way of 'rebranding' technical and vocational programmes to make them more attractive and relevant. Similarly, STEM education is described in the Education Sector Plan (Planning Institute of Jamaica, 2009) as an approach to teaching and learning that integrates the content and skills of the STEM disciplines and other disciplines. STEM therefore embodies an interdisciplinary and applied approach to teaching that focuses on the development of transversal competencies as well as STEM skills.

Education for STEM careers

Given the diversity of STEM careers across different country contexts, it is difficult to provide an overarching list of STEM careers. For example, the Occupational Information Network (O*NET, 2019), which is the primary source of occupational information in the United States, categorizes STEM careers as follows: managerial; post-secondary teaching; research, development, design and practitioners; sales; and technologists and technicians. In Australia, the National Centre for Vocational Education Research provides a more comprehensive list of STEM-related occupations and skills packages linked to various occupations. These include farmers and farm managers; specialist managers; arts and media professionals; design, engineering, science and transport professionals; health professionals; ICT professionals; technicians and trades workers; engineering, ICT and science technicians; automotive and engineering trades workers; construction trades workers; electro technology and communications trades workers; food trades workers; skilled animal and horticultural workers; and other technicians and trades workers (Korbel, 2016).

In some countries, STEM careers are named differently, although there is considerable overlap in meaning. In the Netherlands, for example, STEM education is mostly called 'technical education', 'beta education' or 'beta-technical education'. Graduates are said to have received a 'technical diploma'. Techniekpact (a coalition of key stakeholders in the provision of technical education in the Netherlands) sees technical students as students that 'use one or more technical skills "practically" or realistically. They work as a researcher, instrument designer, ICT developer, industrial designer, plumber, engineer, operator or analyst. They have the technical knowledge to build machinery and maintain installations' (Nationaal Techniekpact, 2020). In Germany, the Federal Institute for Vocational Education and Training uses the term MINT occupations as defined by the Bundesagentur für Arbeit (Federal Employment Agency). According to the agency's definition, MINT occupations include all activities that require a high proportion of knowledge and skills in mathematics, informatics, natural sciences and/or technology. In addition to highly qualified MINT occupations, the MINT occupation group also includes so-called medium-qualified MINT occupations. This means that both academic occupations and training occupations belong to the MINT occupations category.

What the above discussion illustrates is the importance of context in understanding what is considered a STEM discipline. These differences may in part be linked to differences in labour market needs which relate to different economic trajectories between countries. Global definitions of STEM, while important, also need to take these differences into account. The above discussion of what counts as STEM is also largely influenced by the way that STEM has come to be understood in high-income contexts. It is important to be aware, however, of the influence of different stages of development on how STEM can be interpreted and understood. In low-income contexts, for instance, it is also necessary to take account of the importance of STEM-related skills in the informal as well as formal sectors of the economy, given the importance of the informal sector for livelihoods. The necessary skill set might be different for both sectors. For example, in most low-income countries, an informal automotive sector includes a multitude of small repair workshops where workers need to be able to do all-round repairs to all types of cars. Specialized or high-tech computer-based repair and maintenance is less prevalent for these shops.

While some STEM careers, such as being an actuary or an architect, generally require university degrees, many STEM careers can be catered for by qualifications such as diplomas offered by TVET colleges, such as engineering, software development and data management. In the context of education for STEM careers in TVET, the STEM approach outlined by Ng (2016) makes sense and perhaps has potential to provide a rich learning experience for students (Asunda, 2014; Dixon and Hutton, 2016).

It is important to recognize that education for STEM careers is more than teaching STEM subjects, both in their traditional silos and using an integrated approach. It should, and usually does, involve developing and bringing together a range of cognitive and affective skills and competencies including foundational literacy (e.g. numeracy), socio-emotional skills (e.g. resilience, curiosity and empathy), higher-order cognitive skills (e.g. critical thinking and creative thinking) and technical occupational skills (e.g. coding, design and construction) (Siekmann, 2016). There is a strong overlap here with so-called twenty-first-century skills, such as problem-solving, collaborative working and communication skills, which are considered essential for economic development (Reeve, 2016).

Based on the above discussion, this study uses the following working definition of STEM in TVET:

STEM-related TVET refers to TVET programmes that aim to qualify students to proceed to occupations where STEM skills are needed.

This working definition includes fields of TVET that can be categorized as STEM core studies while at the same time taking into account the range of sectors and occupations in which STEM skills can be deployed.

We use the ISCED-F 2013 classification of educational fields for defining the core STEM studies:

- 05 Natural sciences, mathematics and statistics
- 06 Information and communication technologies
- 07 Engineering, manufacturing and construction
- 08 Agriculture, forestry, fisheries and veterinary

Most of the STEM areas used in the country cases are within the scope of these four fields.

2. Analysis of country-level data concerning female participation and performance in STEM-related TVET and STEM-related occupations

Overview of nature and availability of data relating to STEM-related TVET

The UNESCO Institute for Statistics (UIS) collects data relating to overall education trends and specifically on progress towards realizing Sustainable Development Goal 4 [3]. Data are collected from official sources from Member States and are therefore a good indication of the availability of comparable data on a national level.

Data relevant for understanding the participation and performance of girls and women in STEM-related TVET are limited. Due to varying TVET systems, it is a challenge to collect comparable data. For example, although UIS is able to collect data relating to female participation in education and training, the data are not disaggregated in a way that would allow for an understanding of participation in the TVET sector specifically. No data are available at a global level concerning the relative performance or completion rates of females and males in STEM-related TVET.

While the availability of comparable data is limited, specific countries do sometimes collect data on STEM-related TVET. The availability and quality of this data varies. This was also reflected in the ten countries that formed part of the study. Australia, Chile, Costa Rica, Germany, the Netherlands and the Philippines are relatively data-rich (although even in these cases, there are significant gaps), while in the other selected countries, the availability of data is much more limited, in many cases confined to data available at the level of TVET institutions instead of the national level.

The ability to compare participation rates between countries is further limited by the lack of standard indicators for collecting and reporting data relating to STEM-related TVET. In some cases, the absence of standardized indicators is linked to different definitions of STEM. There are also differences in the longitudinal nature of data, with some countries such as Australia, Germany, Chile, Costa Rica and the Netherlands being able to supply more specific longitudinal data on participation. The advantage of longitudinal data is that they allow for the identification of trends over time. It is also possible to use longitudinal data to evaluate the success or otherwise of interventions aimed at increasing female participation in STEM-related TVET.

3 SDG 4 aims to 'ensure inclusive and equitable quality education and promote lifelong learning opportunities for all'. (https://sdg4education2030.org/the-goal).

Trends in female participation in STEM-related TVET and STEM-related occupations

Based on the analysis of the available data at global and national level, the following trends are visible.

Girls and women are under-represented in STEM-related TVET

The Cracking the Code report (UNESCO, 2017) contains data relating to the participation of girls and women studying STEM-related subjects in higher education (ISCED levels 5 to 8) at a global level (see Figure 1). While these do not relate specifically to TVET (often most closely associated with ISCED 5 – tertiary short-cycle education), they are at least indicative of broad trends.

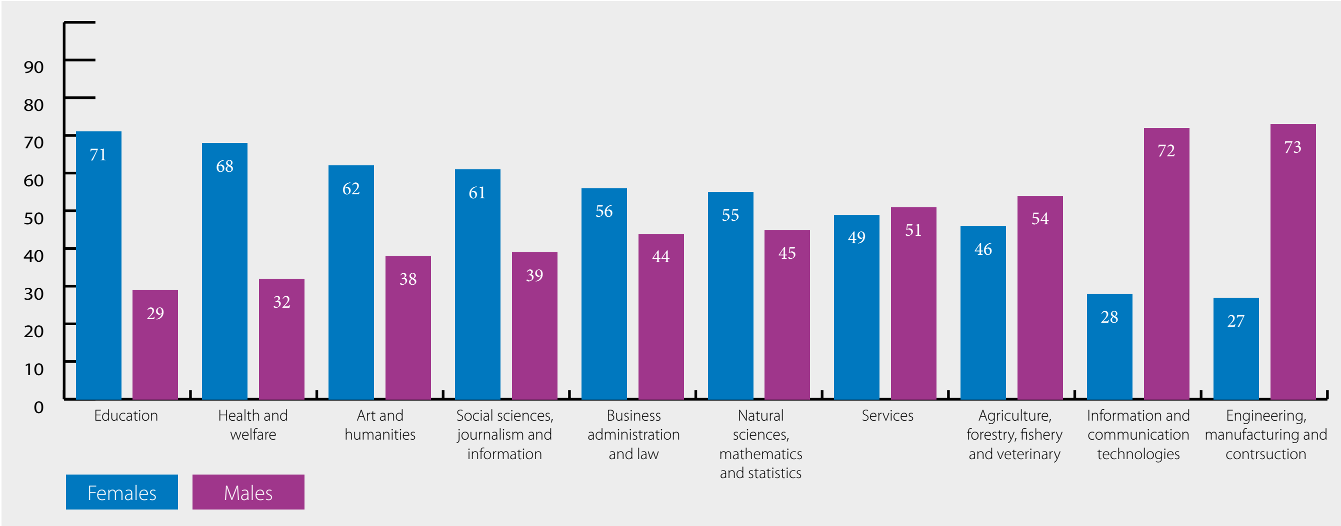
The data show an overall under-representation of girls and women in STEM subjects in higher education, especially in ICT and engineering, manufacturing and construction. The Cracking the Code report also notes significant national and regional variation in the proportion of female students in higher education enrolled in natural sciences, mathematics and statistics, ranging from 16 per cent in the Ivory Coast to 86 per cent in Bahrain. Further, while high proportions of female students are enrolled in engineering, manufacturing and construction in South-East Asia, the Arab States and some European countries, much lower proportions are found in sub-Saharan Africa (see also World Bank, 2019).

Looking at the different country case studies, an under-representation of girls and women in STEM-related TVET is visible (see Figure 2).

The data from the case countries cannot simply be compared to each other due to the differences in STEM and TVET definitions. In Germany, for example, only core STEM subjects are considered STEM areas, whereas in Lebanon health- and commercial-related subjects are added to STEM. Figure 2 therefore does not aim to compare countries, but the country-level data do underline the under-representation of women and girls in STEM-related TVET in general.

Looking in more detail at the TVET system of individual countries, one can see the representation of girls and women in STEM-related TVET and other types of TVET studies (non-

Figure 1. Share of female and male students enrolled in higher education by field of study, global average

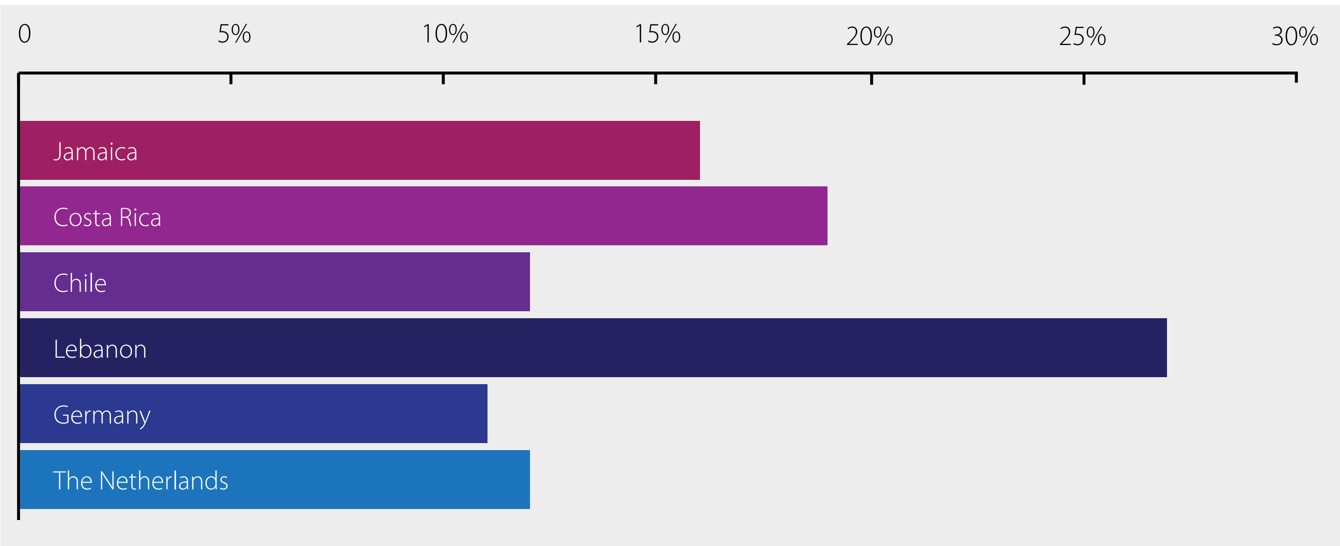


Source: UNESCO 2017, data from UIS 2014-2016, 115 countries and dependent territories

STEM). In Chile, for example, 19 per cent of STEM-related TVET students are women, which is the same percentage as women studying non-STEM TVET. When looking at the Netherlands, a different division becomes visible where girls and women are clearly over-represented in TVET programmes considered non-STEM and under-represented in TVET programmes considered STEM. Of all girls and women in the Netherlands starting their TVET education in academic year 2018/19, only 8.4 per cent chose a STEM-related course and 91.6 per cent a non-STEM-related course (VHTO, 2019b).

Another interesting finding in the country case study data is that the under-representation of girls and women in STEM programmes is specifically evident in TVET programmes compared to STEM subjects in other types of education. This statement is evident when looking at the student intake for academic year 2018/19 in STEM subjects on three education levels in the Netherlands (see Table 2).

Figure 2. Female enrolment in STEM-related TVET programmes



Note:

Data from Jamaica is from 2016–17, Costa Rica is from 2019, Chile is from 2019, Lebanon is from 2017–18, Germany is from 2017, the Netherlands is from 2015–16. The data should be treated with caution due to the differences in STEM and TVET definitions.

Table 2. Student intake in STEM-related programmes for different levels, academic year 2018/19, the Netherlands

	Total number of students	Number of female students	% of female students
Higher education (academic university education)	24786	10379	42%
Higher education (university of applied sciences)	24976	6549	26.2%
Technical and Vocational Education and Training (TVET)	43080	5993	13.9%

Source: VHTO, 2020

There is significant variation in the nature of gender disparities **across** subject areas

Country-level data collected by UNEVOC centres support the global trend of under-representation, although there is significant variation in the nature of gender disparities with respect to subject areas. In general, the country data show that girls and women are represented more equally in STEM-related TVET programmes that aim to qualify students to work in STEM-related areas that are not considered core STEM, for example in the healthcare and media sector.

- Data from Australia reveal that females in the broad field of natural and physical sciences are actually over-represented (>60 per cent in 2018) as many train as laboratory technicians and assistants, mainly in health- and medicine-related diagnostics.
- In Chile, data collected by the Ministry of Education show marked gender imbalances in secondary vocational education (known in Chile as Professional Technical Media Education). Even though the gender gap is minimal when it comes to the total enrolment of girls in TVET in 2019 (49 per cent of TVET students are female), a difference becomes visible when considering the kind of STEM-related subjects girls and women participate in: 25 per cent of students in construction are female, for metalworking this is 11 per cent, for electricity 13 per cent, and for technology and telecommunications 24 per cent. The highest percentage of girls and women can be found in the area of mining, at 43 per cent.
- Institutional-level data from Ghana collected across five higher education institutions show that women are under-represented in all areas, with the exception of applied health sciences where they make up a majority (76 per cent).
- Data from Jamaica reveal a similar picture with female over-representation in STEM-related TVET in health sciences, most areas of teacher education and communication studies, and in some areas of science and sports (e.g. actuarial and applied science). Under-representation is evident in the more core STEM fields such as built environment, engineering and computer science.
- In the Philippines, the highly technical areas of engineering and technology are traditionally male-dominated, with women accounting for no more than 30 per cent of graduates in any academic year during the past 10 years. Similarly, women constitute a small percentage (less than 4 per cent) of those with TVET qualifications in automotive, electrical installation, or metals and engineering.
- In Germany, less variation is visible, mainly due to the definition of STEM being synonymous with the term MINT to signify the disciplines of mathematics, informatics, natural sciences and technology. Here, health sciences are not included as a discrete category of STEM. Nonetheless, the distribution of women in STEM-related studies is not equal: while the proportion of women in natural sciences is almost 50 per cent, in informatics the proportion is only 26 per cent, and in technology only 22.5 per cent.

Consideration of country-level data provides nuance when analysed against global trends. Firstly, as discussed earlier, it underlines the importance of how STEM is defined in different contexts. In some contexts, like in Germany, STEM is not seen as part of health and care areas and data therefore do not take these areas into account. In Jamaica, more 'soft' or 'social' study programmes with STEM elements are included in STEM education. This shows the importance of having national-level data that can capture differences between countries that can be linked to differences in their economic trajectories and labour markets as well as to patterns of inequality based on gender.

There are potentially interesting differences in participation **within** subject areas

There are differences in female participation even within some subject areas.

- Data gathered from the University of Mining and Technology in Ghana show not only that women are under-represented in engineering subjects but that there is variation across different sub-disciplines of engineering, ranging from 11 per cent female enrolment in renewable energy engineering to 35 per cent enrolment in environmental engineering.
- In Lebanon, women are under-represented by a ratio of about 20:1 compared to men in subjects that fall within the broad 'industrial' category. A closer inspection of the data, however, reveals a more nuanced picture. For many programmes that fall under this category, female enrolment is zero for all three years that data are available. There are, however, three STEM categories where women in fact

outnumber men, namely optometry, agri-food industries, and design and manufacture of jewellery.

- 'Industry' is marked as an economic sector for the National Training Institute's TVET programmes in Costa Rica. In this industry programme, 39 per cent of the participants in 2019 were female. Within this industry category, different subjects are distinguished, with female participation percentages varying, such as electrics (15 per cent), food industry (66 per cent), vehicle mechanics (8 per cent), textiles (94 per cent) and material technology (21 per cent). Looking at these participation figures, the diversity within the industry sector is remarkable.

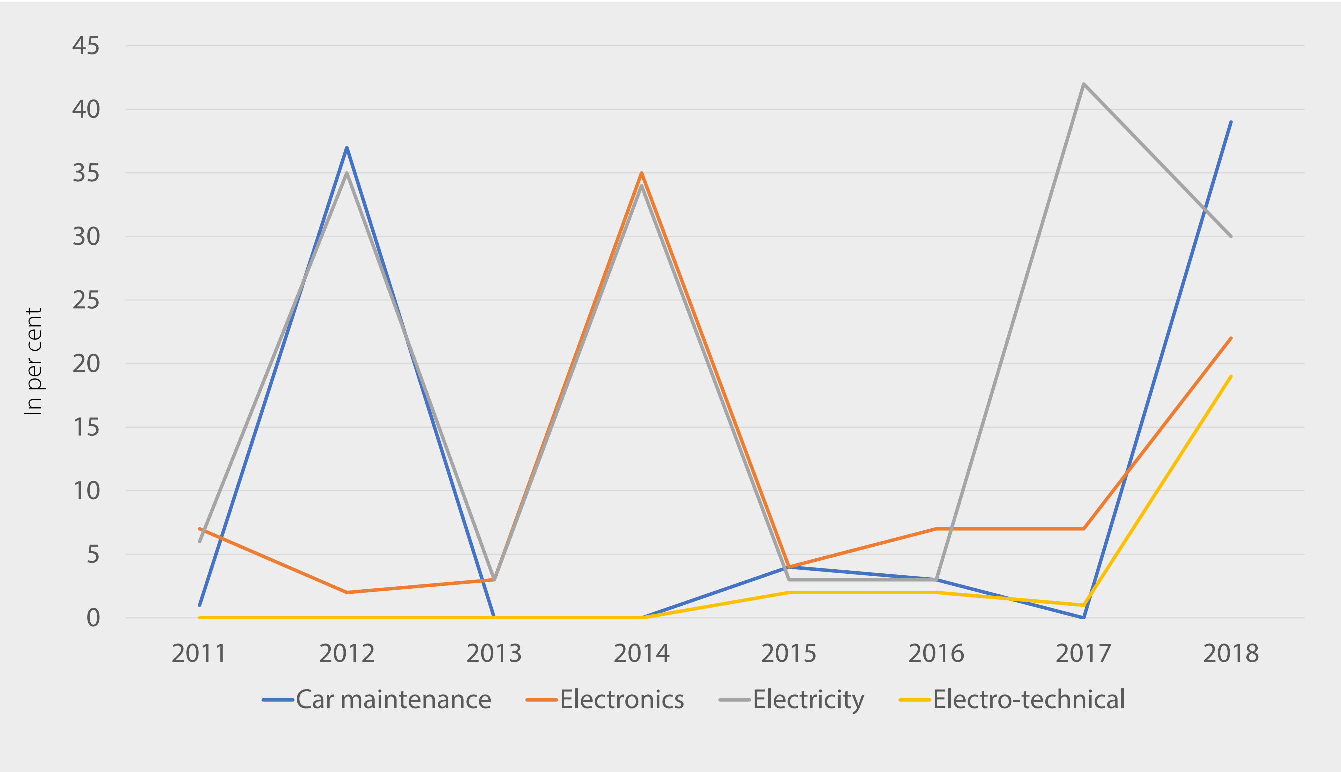
These differences, while broadly consistent with the overall trend of female under-representation in some disciplines, may be significant in better understanding why girls and women are attracted to different programmes within disciplines. The high participation rates of girls and women in some fields – for example in textiles in Costa Rica and mining in Chile – come from gender-related occupational choices that can be observed over time. Problems arise when girls and women face barriers accessing certain fields seen as STEM.

Despite improvements in female participation rates over time, issues remain

It is important to understand the trends over time in female participation in STEM-related TVET. Some of the country data show there has been modest improvement over time. However, some countries have only been gathering data for a couple of years, thus limiting the time frame. Germany and Australia are an exception, with Germany having gathered data since 1993 and Australia since 2003. The following paragraphs and figures show female participation in a few countries in recent years.

- For example, data from **Lebanon** have shown a slight but very irregular improvement in participation of girls and women in secondary and post-secondary STEM-related TVET since 2011. Figure 3 is based on the statistics from the Centre for Educational Research and Development and shows that though female enrolment in STEM trades in the industrial category is increasing, this is subject to drastic fluctuations. This can mainly be explained by the fact that often the initiatives to promote female participation are temporary and in many cases linked to donor-driven incentives.

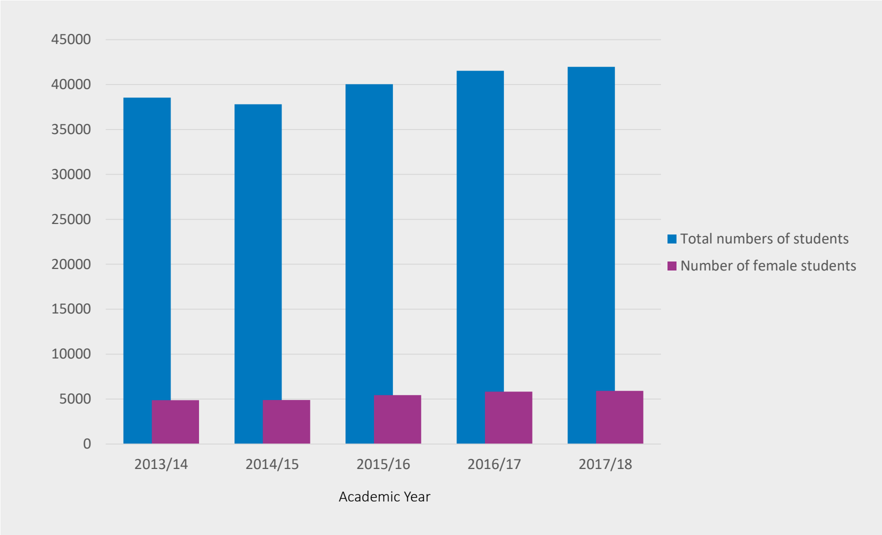
Figure 3: Female enrolment in some STEM-related programmes in the industrial category in Lebanon (%)



Source: Centre for Educational Research and Development (CERD), 2020, indicating number of students in various sectors and their distribution according to gender, age, educational stages, educational regions and governorates.

- In **the Netherlands,** a modest increase is visible in the number of girls and women participating in a STEM-related TVET programme. This increase is visible in both objective and relative terms. In the Netherlands for the study year 2013-2014, 12.7% of students were female, and in 2017-2018 this was 14.1%. However, in order to truly understand and assess such trends, data should be gathered for a longer period of time.

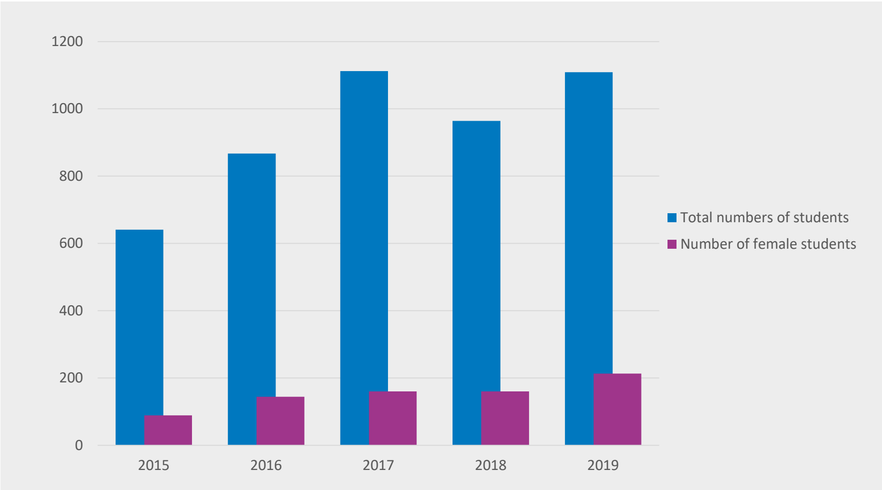
Figure 4. Student enrolment in STEM-related TVET in the Netherlands (beta-technical education)



Source: VHTO 2020, based on data Platform Talent for Technology

- Even though there is no national data on student enrolment in STEM-related TVET programmes for **Costa Rica**, the Unidad de Planificación y Evaluación (the Planning and Evaluation Unit) has collected data on the number of male and female students in the National Training Institute's STEM programmes since 2015. An increase in relative and absolute terms is visible: the female enrolment rate increased from 13.8 per cent in 2015 to 19.2 per cent in 2019.

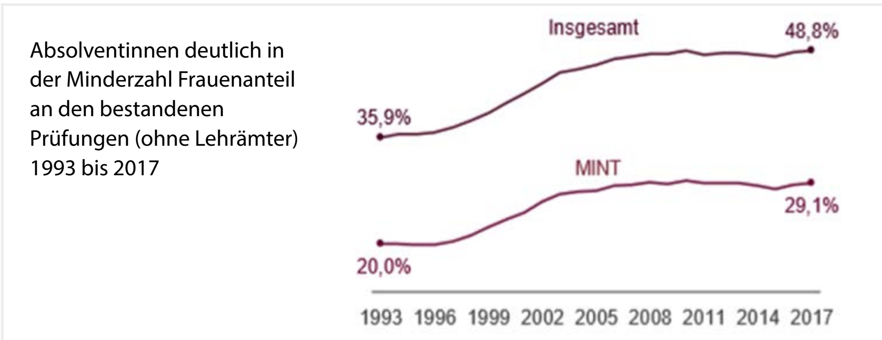
Figure 5. Enrolment in key areas of non-traditional (STEM) studies, Costa Rica



Source: INA, the Unidad de Planificación y Evaluación, statistical databases 2015–2019

- The **German** data shows that although girls and women remain significantly under-represented in STEM subjects, making up only 29.1 per cent of total graduates, there was an increase of 9.1 per cent in female graduates between 1993 and 2017. The MINT line in the figure below shows the proportion of female graduates in STEM education, and the *Insgesamt* (overall) line shows the percentage of female graduates in total.

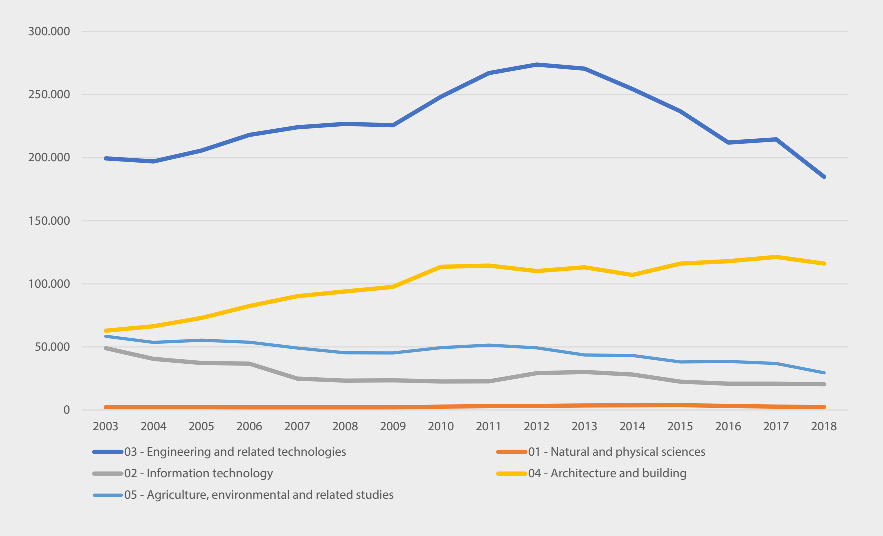
Figure 6. (translation of the title below) Female graduates clearly in the minority. Proportion of women who passed exams (excluding teaching positions) from 1993 to 2017



Source: Bundesagentur für Arbeit, 2019
Note: Insgesamt = Overall

- Data from **Australia** paint a different picture. Figure 7 and Figure 8 show gender disparities in participation in three core STEM areas between 2003 and 2018.

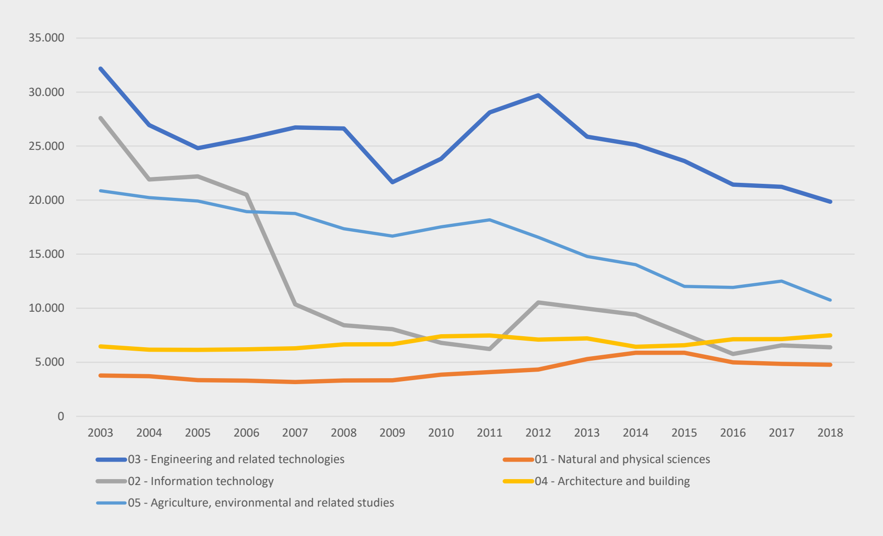
Figure 7. Male students: enrolments by Australian Standard Classification of Education (ASCED) fields of education, government-funded TVET



Source: based on National Centre for Vocational Education Research data

- Data from Australia paint a different picture. The chart below shows gender disparities in participation in three core STEM areas between 2003-2018.

Figure 8. Female students: enrolments by ASCED fields of education, government-funded TVET



Source: based on National Centre for Vocational Education Research data

The figures for Australia show that overall there was limited change in male participation rates between 2003 and 2018 in STEM-related subjects. For female participation, a decrease is visible for engineering, information technology and agriculture, while the rate in natural and physical sciences and architecture has remained relatively stable. The data are interesting in indicating that female participation rates have not improved, despite the introduction of a number of STEM and gender policies as well as strong media attention in 2009 and again in 2013 and 2016.

Taken together, data from the different country case studies highlight the importance of context for understanding changes in participation over time. They also indicate the potential value of longitudinal data in evaluating the effects of different interventions. However, the data need to be taken with caution because they are not sufficiently detailed to allow for a consideration of the effects of different interventions on different stages of STEM-related TVET (they are not disaggregated by ISCED level for example).

Evidence shows that there is a 'leaky pipeline' between STEM-related TVET and STEM-related occupations

Country-level data in general show a gap between the participation of girls and women in STEM-related TVET and their participation in STEM-related occupations in the labour market.

For example, drawing on an analysis of data from the Longitudinal Study of Australian Youth by Lim et al. (2009), we can observe the following trends for **Australia**:

- Undertaking STEM subjects in Year 12 [4] is by no means a good indication of continuing education in STEM subjects, particularly for females.
- Of women doing STEM subjects at school, less than 10 per cent end up in STEM TVET programmes. This percentage is relatively low compared to about 60 per cent of males that continue in such programmes.
- This is most likely due to the nature of STEM courses in TVET (licensed trades, engineering areas) which are typically male-dominated.
- Not doing Year 12 STEM subjects does not exclude individuals from undertaking STEM post-school: in terms of TVET-level courses in STEM, 20 per cent of males and 10 per cent of females (similar proportion to those who undertook Year 12 STEM) studied TVET STEM post-school.
- In terms of TVET courses and STEM occupations, 40 per cent of males remain in a STEM career; however, for females, only 20 per cent remain in a STEM career at age 25.

The findings by Lim et al. shed light on the 'leaky pipeline' phenomenon, i.e. the extent to which girls and women drop out of STEM-related areas during the transition from one TVET level to another and during the transition between TVET and STEM-related careers. The findings are consistent with some of the key messages regarding the participation of girls and women in STEM subjects contained in the Cracking the Code report: gender gaps begin in science- and mathematics-related early childhood education and girls appear to lose interest in STEM subjects with age, particularly between early and late adolescence (UNESCO, 2017).

In addition, the Australian Chief Scientist – providing high-level independent advice to the Prime Minister and other ministers on matters relating to science, technology and innovation – regularly provides data on the TVET STEM qualified workforce by gender. The latest 2020 data show that only 8 per cent of the TVET-level STEM qualified labour force is female (Australian Government, 2020b).

In Costa Rica, the National Training Institute carries out regular monitoring, resulting in reports on female graduates entering the labour market in non-traditional areas in the period 2013–16 *(Evaluación de la inserción laboral de mujeres egresadas del INA en áreas no tradicionales para su sexo en el periodo 2013–2016)*. This report shows some interesting conclusions:

- After training provided by the National Training Institute in non-traditional areas, 35 per cent of the women responding to the survey were employed, and the job placement rate in an area related to their studies was 23 per cent.
- The highest labour market entry rates were in the following sectors: motor vehicles and bicycles, transportation by water and precision mechanics.
- The main reasons why women who sought employment have not managed to find a job are lack of experience, no job opportunities where they live combined with unwillingness to travel or to move to another place, continuation of studies, jobs in their area of study are considered specialities for men, and lack of money to set up a workshop.
- Of the population already working, improvements could be seen in terms of salary increases, though they still vary a lot, from 100,000 Costa-Rica-Colón to more than 300,000 Costa-Rica-Colón.
- There were also changes in the position and work area: ten women who previously worked outside the field in which they studied got a position within it, increasing their salaries to the aforementioned range.

Several other country case studies observe a similar phenomenon. In Chile, 80 per cent of men that study a STEM subject continue to study in a STEM-related subject or enter a STEM career, compared to only 17 per cent of women. However, most country case studies show that there is a gap in availability of data regarding the transition of girls and women from STEM-related TVET to STEM-related occupations in the labour market. In the Netherlands, for example, some individual companies do collect this data for their own use and diversity policies but data are not yet systematically collected. In Jamaica, both the HEART (Human Employment and Resource Training) Trust NTA and the Statistical Institute of Jamaica collect labour market data that are disaggregated by gender. However, the data on specific industries/sectors are not disaggregated by gender. Additionally the HEART Trust, which specifically targets TVET programmes, collects students' profile data based on gender but not based on industries/sectors. These examples show that it would be promising to focus more on generating data at the intersection of STEM-related TVET and the jobs/occupations that connect to STEM areas.

4 Year 12 in Australia is the twelfth or thirteenth year of compulsory education or the first or second year of post-compulsory education, depending on the state.

Gaps in performance data make it hard to understand and effectively address gender disparities in STEM-related TVET

UNESCO's Cracking the Code report paints a complex picture, as can be seen in Box 1.

Box 1. Key messages relating to girls' and boys' academic performance based on international assessments

- Data on gender differences in learning achievement present a complex picture, depending on what is measured (subject, knowledge acquisition against knowledge application), the level of education/age of students, and geographic location.
- Overall, there is a positive trend in terms of closing the gender gap in STEM-related learning achievement in girls' favour, but significant regional variations exist. For example, where data are available in Africa, Latin America and the Caribbean, the gender gap is largely in favour of boys in mathematics achievement in secondary education. In contrast, in the Arab States, girls perform better than boys in both subjects in primary and secondary education. As with the data on participation, national and regional variations in data on learning achievement suggest the presence of contextual factors affecting girls' and women's engagement in these fields.
- Girls' achievement seems to be stronger in science than mathematics and where girls do better than boys, the score differential is up to three times higher than where boys do better. Girls tend to outperform boys in certain sub-topics such as biology and chemistry but do less well in physics and earth sciences.
- Impressive improvements have been observed over time in reducing the gender gap in science in secondary education among countries participating in the Trends in International Mathematics and Science Study. Fourteen out of seventeen participating countries had no gender gap in science in 2015, compared to only one in 1995. However, the limited number of countries does not allow for generalization of these findings.
- The gender gap is slightly bigger in mathematics but improvements over time in girls' favour are also observed in certain countries, despite the important regional variations and the overall gender gap in boys' favour. Gender differences are observed within mathematics sub-topics, with girls outperforming boys in topics such as algebra and geometry but doing less well in general numeracy.
- Girls' performance is stronger in assessments that measure knowledge acquisition than those measuring knowledge application. This difference might suggest that although girls' knowledge in science has increased, they might need to work more on the application of their knowledge and skills in these fields.
- Country coverage in terms of data availability is quite limited while data is collected at different frequencies and against different variables in the existing studies. There are large gaps in our knowledge of the situation in low- and middle-income countries in sub-Saharan Africa, Central Asia, and South and West Asia, particularly at secondary level. There is a need for a broader set of internationally comparative data that cover more countries across all regions.

Source: UNESCO 2017

These findings are significant for highlighting the importance of context including geographical location and level of education and training system for understanding differences between boys and girls in learning outcomes. They also highlight the strides that have been taken in closing the gender gap in performance. To date though, these successes have not been reflected in large increases in participation of girls and women, particularly in traditionally male-dominated STEM subjects and at higher levels of the education and training system.

The findings relating to differences in the application of knowledge and skills between girls and boys may have implications for STEM-related TVET (see below). It should be pointed out, however, that measures of learner outcomes of girls and women in STEM-related TVET subjects are almost entirely absent from the global and country-level data available. This is in contrast to the availability of data relating to performance in STEM subjects in academic education as measured in international assessments. The availability of such data would help to provide further context for understanding gender disparities in STEM-related TVET.

A further limitation of many existing performance data, including those collected through national and international assessments, is that they are cross-sectional rather than longitudinal in nature, making it difficult to track the relative performance of individuals and groups of learners over time and to then be able to calculate the value added provided by different kinds of STEM-related TVET to the performance of girls and women.

Discussion and summary of quantitative data

- It is difficult to make generalizations concerning gender parity in participation and performance at a global level due to the lack of robust comparative data and indicators. In particular, there is a lack of data relating to participation at TVET levels. There are no global indicators that can be used to measure learner outcomes specifically in STEM-related TVET.

- Country-level data are useful for measuring gender parity in relation to nationally determined priorities and indicators. Country-level data have the potential to complement global data by linking issues of gender parity to nationally relevant understanding of STEM linked to local labour market realities. The availability and quality of national-level data is extremely variable across case study countries.
- Government policies that focus on STEM-related TVET often tend not to take gender into account, or only to a limited extent.
- Countries have different definitions for both STEM education and TVET education. National definitions of STEM-related TVET often do not exist.
- In particular, there is a lack of longitudinal data that could potentially be used to track progress over time in meeting gender parity targets, calculate the value added by different levels of TVET to learner outcomes, and/or trace the trajectories of learners between levels of TVET and entry into the labour market.
- Nonetheless, it is possible to observe the following global trends relating to gender disparities in enrolments in STEM-related TVET:
  - » Overall, female participation in STEM-related TVET is significantly lower than that of males at all levels of STEM-related TVET.
  - » There is considerable variation across STEM-related subjects. In areas such as health, welfare, education and some areas of the service sector such as hospitality and tourism, women are often over-represented, while in other areas typically linked to male-dominated occupations in the labour market such as engineering, construction, metal working, electrics and computer science women are under-represented.
- There is some evidence, e.g. from Ghana, that even in male-dominated disciplines such as engineering, there is some variation in the participation of women across different sub-disciplines and this may be worthy of further investigation.
- There is evidence in some countries (Germany, Costa Rica, the Netherlands) of improvement in participation rates of girls and women over time.
- There is evidence of a leaky pipeline between different levels of STEM-related TVET and the labour market. It accords with evidence from the wider literature of a dropping off in interest and participation in STEM subjects by girls as they get older and is therefore worthy of further investigation. The phenomenon of the leaky pipeline, if found to be widespread, might suggest a focus for further research on the transition points between different levels of STEM-related TVET and between STEM-related TVET and the labour market.
- Even though there is evidence of the existence of a leaky pipeline, overall, there is a data availability gap regarding the transition of girls and women from STEM-related TVET to STEM-related occupations in the labour market.
- There is also evidence in some country contexts of improvements in the performance of girls and women in STEM subject disciplines, although this is not even and does not appear to have been translated into noticeable changes in participation in many male-dominated areas in many instances.

3. The barriers and facilitators affecting female participation and performance in STEM-related TVET

In the *Cracking the Code* report, focus was placed on the participation and performance of girls and women in STEM education in general. The analytical framework used provided a good point of departure; however, in the current report, we specifically focus on STEM-related TVET, which requires an adaptation of the analytical framework. The nature of TVET, with its attention to practical skills, ensures that TVET generally works relatively close to the labour market. Throughout the world, we see a strong focus on practical learning in TVET programmes, for example through internship programmes. The transfer to the labour market, which was not taken into account in the Cracking the Code report, is therefore an important focus in the light of this report.

Building further on the analytical framework of the *Cracking the Code* report, new literature and the country case studies for this report, a new and useful analytical framework can be drawn. Figure 9 provides an overview of this analytical framework, in which gender parity in STEM-related TVET is considered at different levels: the personal level (individual learner and family/peers), the institutional level (TVET institutions and labour market organizations), and the societal level (society).

In the sections that follow, the key messages of the different levels of the analytical framework will be considered for TVET, merging evidence from existing literature and from the case study countries. Then, the analytical framework presented in Figure 9 will be adjusted based on the TVET-specific information provided in this chapter.

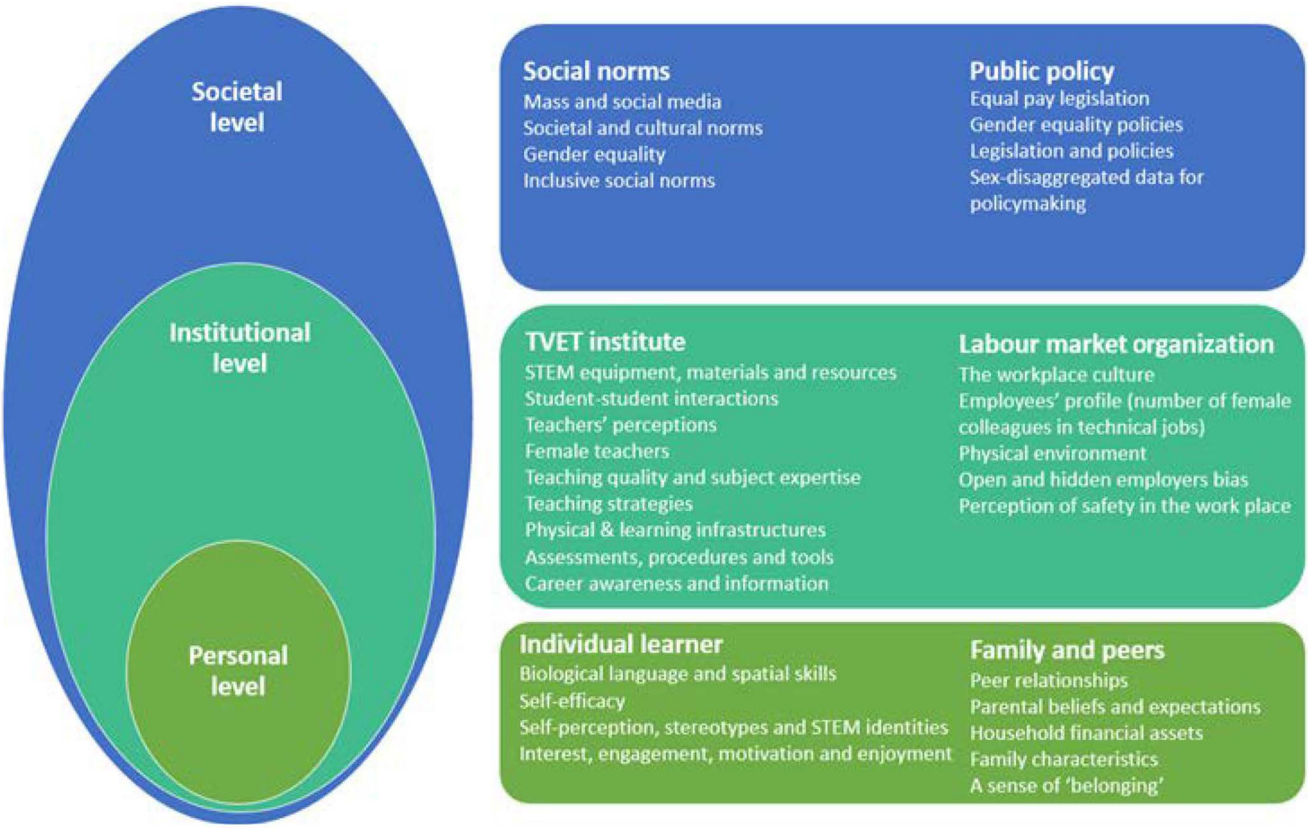
Personal-level factors

Individual learner

Biological factors

Research shows that biological factors are no indication for performance in STEM nor in other fields of study. In her research, Beking (2018) analysed the performance of male and female participants for visual and language assignments and showed there are no gender differences in performance. Even though a difference between girls and boys was visible at the brain level, this had no influence on their performance. In other words, even if there is a 'biological difference', this would not have an effect on performance in STEM (Beking, 2018).

Figure 9. Analytical framework of factors influencing female participation, achievement and progression in STEM-related TVET



In conclusion, biological differences at the brain level between boys and girls have no effect on ability or performance in STEM subjects.

In conclusion, biological differences on the brain-level between boys and girls have no effects on ability or performance in STEM subjects.

Psychological factors

On the personal level, psychological factors influence the behaviour of the individual learner. These psychological factors are thought to reinforce gendered identities and have an effect on the differences between girls and boys in their interest and abilities in STEM subjects.

Even though more research is needed, data from the country case studies suggest that psychological factors are more present and form a greater barrier for girls and women in TVET than in any other type of education. One possible reason for this is the fact that in TVET there are in general fewer female role models than in other types of education. Female TVET students often do not know any role models working in STEM professions who could be an example for them. A second but related reason is the general idea that working conditions in STEM-related TVET careers are more harsh and female-unfriendly (outdoor, physically challenging). The country case studies show perceptions of the 'dirty' and 'unfeminine' nature of some occupations that require manual work and the effects that these perceptions have on the development of gendered identities and aspirations, particularly during puberty. The country case study from Australia suggests that continued exposure to long-held stereotypes of the STEM profession as 'male-oriented, obsessive and socially isolated' can create a loss of interest and career aspirations in these fields for girls. In this respect, there is some evidence from Germany and elsewhere that young girls tend to choose a profession that is supposed to correspond to their ideas about gender (Solga and Pfahl, 2009) and that these beliefs form in (pre-) puberty.

Misinformation about the value of STEM and the opportunities that it presents, as well as the general negative attitude towards TVET occupations, seem to impact the choices of students and drive them towards gender stereotypical specialities.

The specificities related to STEM-related TVET that were raised in the country reports are worthy of further exploration. Further research into the relationship between beliefs about physical strength differences that act as a barrier to girls gaining interest in STEM-related occupations and the actual physical demands required by different occupations would be valuable. Linked to this would be research into the effects of these kinds of widely held beliefs on self-perception, sense of self-efficacy, and interest and engagement of girls and women in STEM-related subjects that appear to be more physically demanding.

Finally, as suggested in the previous section, there is scope for research into the relative performance of girls and boys in STEM-related TVET subjects. For example, in the Netherlands, girls have significantly lower self-esteem regarding beta subjects than boys (VHTO, 2019b). However, research concerning the relative performance of boys and girls in technical subjects (in this case mathematics) shows that they perform approximately the same. This kind of information might prove potentially valuable for challenging gender-based stereotypes among learners, TVET educators and parents.

Examples of initiatives that aim to increase female participation in STEM through personal-level interventions

Box 2. 'Girls in ICT' day celebrated in Jamaica every year

> Over 300 girls were represented as Jamaica's rising talent in the ICT sector in 2019. Since 2017, every year there are 'Girls in ICT' celebrations, during which a Caribbean hackathon is organized. Across the Caribbean, girls were engaged in a two-month immersive webinar-based training, involving activities with international tech mentors and other subject matter experts.
>
> The overall aim of this hackathon is to encourage and empower young women, to spark their interest, and boost their confidence to pursue further studies (also TVET) and careers in ICT. The initiative focuses on the individual girls and young women they aim to reach.

Source: country case study Jamaica

Box 3. The Voice of Girls in Central America

> The Costa Rica based cooperative Sulá Butsu, in cooperation with Google, developed a series of workshops with three specialities in digital music and prototyping of technological solutions to be implemented in six countries: Panama, Costa Rica, Nicaragua, Guatemala, El Salvador and Honduras. The programme aims to train and raise awareness of twelve- to seventeen-year-old girls and their mothers in the use of digital tools so they can tell their stories, express their voice through music or propose technological solutions to their most worrying problems. The training includes introduction to basic digital tools, audio and video editing and publishing, song creation, social media, data management, prototyping tools, and the development of narratives through technology, as well as familiarization with programming and code development.

Source: country case study Costa Rica and https://www.sulabatsu.com/blog/sula-batsu/programa-tic-as-en-centroamerica-en-numeros/

Box 4. Competition sparks inspiration, the case of Rwanda's 'Girls in ICT platform'

> In Rwanda, the 'Girls in ICT platform' aims to inspire girls to join the STEM sectors. Through the annual Ms. Geek competition, the platform inspires female university and TVET students to think critically and design solutions to issues faced by Rwandans today. In this competition, young women compete based on innovative ideas as well as their ability to develop a certain technology or business idea. The purpose of Ms. Geek is to demonstrate that girls and young women can also excel in the technologies and build their confidence in competing in the open market.

Source: https://girlsinict.rw/

Family and peers

On the personal level, family and peers affect the attitudes of girls and women towards STEM education in general. The country case studies provide interesting information on various family and peer factors that are specific to the TVET sector.

Influence on girls' sense of belonging

One of the family and peer effects often mentioned in the country case studies is the influence that family and peers can have on the sense of belonging of girls and women in STEM-related TVET. Beliefs, expectations and norms among family and peers have an effect on the choices girls and women make in pursuing or not pursuing a STEM-related subject in TVET. The general low participation rate of girls and women in STEM-related TVET also means that classrooms, workshops and work areas are male-dominated, which may scare off and intimidate (young) women. Peer pressure from both male and female family and peers often has a much stronger effect on young women than on young men. Peers will let young women understand that it is not appropriate to be among a majority of male classmates or colleagues and young women will feel more vulnerable in male-dominated settings.

On the other side, this peer pressure on girls and women can also have a positive influence on their choice of STEM subjects. According to Mouganie and Wang (2019), data from China show that exposure to high-performing female peers in STEM subjects increases the likelihood that women choose a science track during high school, while more high-performing males decrease this likelihood.

Specific examples of family and peer influence on the sense of belonging of girls in STEM-related TVET are evident in the country case studies:

- In **the Netherlands**, research by VHTO (2017) confirmed the assumption that gender stereotyping mostly comes from family and peers, which happens at an early age and influences the study and professional choices of children greatly. Girls believe at an early age that a technical education or profession is 'not for them'. As a practical consequence, we can see that when girls and women are in the position to choose their TVET subjects, parents often do not encourage them to choose STEM subjects.
- The country case study from **Costa Rica** explains that the National Training Institute sees family and peer factors as the principal barrier for female students choosing STEM-related TVET. The name used by female students as a reference to STEM areas in itself shows a barrier and a sense of not belonging: *'non-traditional areas for women'.* One student explained in an interview that female students need to be able to see other female students proceed in STEM-related TVET. Peers base choices partly on the choices of other peers. It is not motivating to choose STEM subjects when you are the only female student doing so.
- Family and peers disapprove of or advise against girls and women working in a male-dominated field in Lebanon. The Head of a Technical Department explained: 'In car maintenance, people think: *"you mean sending my daughter to work in a garage, surrounded by men?" and this is the mentality across sectors […] These professions seem to be off-limits for women in the collective thinking, even though car maintenance is now very high-tech and does not require as much physical labour as it did in the past.'*

Family expectations of gender roles

The country case study from Ghana explains that in Ghanaian society, women are mostly regarded as the ones who care for the home and family. This expected and gendered role division means families provide more support to boys and men in pursuing educational programmes, and particularly STEM-related ones. Parental attitudes in Ghana are also shaped by ignorance of what different STEM-related occupations entail, a belief that their daughters may 'fail' in STEM-related subjects, and the prevalence of gendered stereotypes about which occupations are suitable for girls.

Other specific examples of family expectations of gender roles were seen in the following country cases:

- Information from **Jamaica** suggests that the main reason for girls and women being less represented in STEM-related TVET is because of both family and community factors. In Jamaica, it is deemed important to maintain an occupational-related family tradition. In the wider community, people speak of a family of teachers, a family of doctors, etc. Children are therefore expected to follow in their family's footsteps, in which girls follow their mothers' and boys their fathers' footsteps. A gendered division of job types is therefore maintained through generations.
- There is evidence from the country case studies that parents and fathers in particular in the context of patriarchal societies can play a positive role in encouraging their daughters to pursue STEM-related courses and occupations. As one female respondent from **Chile** reported, her father would get up every Saturday and take her to a robotics class across Santiago. A female respondent in **Lebanon** reported that she was drawn to the electricity speciality because her father worked in a garage. Her mother supported her decision, and her father did not object.

Financial effects on girls' participation in STEM-related TVET

Another area worthy of further research is the financial effects of pursuing STEM-related TVET on girls' individual choices. The importance of this issue was most evident in the case studies from low- and middle-income contexts. This financial effect can work in two ways. First of all, the costs associated with pursuing STEM-related TVET can have a negative effect on girls and women pursuing these programmes. This can be seen in the data from Ghana and Jamaica, for example, which highlighted the perceived costs of programmes as well as perceptions concerning the financial return to families as being significant in supporting girls' aspirations towards STEM-related programmes and occupations. Secondly, research like that of Stoet et al. (2016) shows that economic considerations can play a positive role in girls and women choosing STEM subjects as it is thought to bring more financial returns than non-STEM education. In this case, the effect is more evident in lower-income countries. In countries with higher levels of economic well-being, a reversed effect is visible where students' decisions are less based on expected financial return (Stoet et al., 2016).

Examples of initiatives targeting family and peers

Overall, the above findings suggest the value of further research into the role of peers and families not only in discouraging girls from pursuing STEM-related TVET courses and occupations but also their potential role in supporting them to do so. This kind of research might prove useful for designing interventions targeted at girls (peers) and their families, including identifying the kinds of information that might assist in dispelling myths and stereotypes and supporting the development of positive attitudes towards STEM-related subjects and occupations.

There are several examples of initiatives aimed at challenging gendered stereotypes and supporting the aspirations of girls and women to get involved in STEM. Two examples are provided in Box 5 and Box 6. While intuitively these programmes seem to address some of the concerns raised above, more information is required to be able to assess the success of these kinds of programmes specifically in attracting girls to STEM-related TVET.

Box 5. The case of Graafschap College in the Netherlands: awareness-raising among parents

Only 4% of students in the technical study programmes of the Graafschap College are female. Although this percentage is small, the institute has seen an increase in recent years. This increase is especially caused by efforts of the Graafschap College to raise awareness among parents of future students.

A research among parents showed that girls are often discouraged to start a technical education at the institute. Employees especially noticed this during information events for new students. Therefore, the institute started the initiative to specifically inform parents on the opportunities of girls and women in their technical (STEM) study programmes and occupations during information events. Female role models (both students and professionals) are invited to talk about their career and experiences in the technical sector. The biases parent's may hold are explicitly addressed during these information events.

Source: personal interview with the Centre for Innovation of Education and Training (CINOP), 2019

Box 6. 'Girls' Day' in Germany

In Germany, the federal government has committed to supporting women in STEM and to increasing the attractiveness of STEM occupations for women by initiating projects or providing subsidies for events or ideas in this context. The aim of numerous initiatives, such as 'Girls' Day', 'Klischeefrei' (cliché free) or 'Komm, mach MINT' (which translates roughly as 'Come and get involved in STEM'), is to help provide girls and women with a better understanding of so-called STEM occupations and in this way increase female representation in these fields. For example, on 'Girls' Day' (which is the most famous initiative in Germany for school pupils in the context of STEM), STEM enterprises and companies offer a one-day internship for female school students. Since it started in 2001, about 1.9 million girls have participated and every year almost 10,000 companies get involved with events.

Source: Nationaler pakt für frauen in MINT-berufen, 2020

Institutional-level factors

TVET institute

TVET institutional-level factors are significant in girls' participation and achievement in STEM-related education. These include factors such as teaching quality; the presence of female teachers who can act as role models; teachers' perceptions; the nature of curricula and learning materials and the availability of STEM equipment, materials and resources; and the nature of assessment practices and their knock-on effect on the perceptions about ability.

The country case studies provide information that describe institutional factors that play a role in female participation and performance in STEM subjects in TVET institutes. This information shows that (educational) career advice provided to girls and women by education staff – such as teachers and career advisers – has an influence on the choices of girls and women. In the case of STEM subjects, this influence is negative in the sense that advice for girls and women often does not include STEM subjects or even advises against STEM.

Related to this negative effect of STEM educational career advice for girls and women is the general low number of female teachers in STEM-related TVET that can serve as role models and influence the career choices of girls and women.

Country case study information:

- The tendency of teaching staff and school career advisers to advise boys to choose STEM careers more than girls is present in the Netherlands. They sometimes even advise girls against STEM, which has a great impact on educational career choices of girls, especially since these choices are made in the Netherlands at a much younger age than in most countries (at the age of fourteen to fifteen).

- The lack of career awareness and career information in educational institutes is also an important barrier for the involvement of girls and women in STEM-related TVET in Jamaica. Due to this lack of career awareness and information, both male and female students are not sufficiently aware of the plenitude of fields of study and their related careers. It makes them choose fields that they know through friends and family, often based on gendered expectations. In addition, there is a tendency of teachers at secondary school level to move boys into technical areas to a greater extent than girls.
- Several STEM career students in Chile who were interviewed for this report pointed out that early years are especially complicated by the sexist comments of teachers and peers and girls feel they must work twice as hard as their male peers to be recognized for their STEM abilities.
- The country case study from Ghana shows that the number of female teaching staff in STEM education (both TVET and higher education institutes) is growing, which is expected to have a positive impact on the number of female students in STEM education as well.
- In Costa Rica, the National Policy for the Equality between Women and Men in Training, Employment and in Benefiting from Products of Science, Technology, Telecommunication and Innovation 2018–2027 indicates that even though overall participation rates do not seem that negative, several sources have pointed out some obstacles such as the low coverage of training activities in rural areas, the budgetary restrictions for scholarships, difficulties in obtaining employment in rural areas and the sexist environments that prevail in the specialities considered typical of the male domain.

Gender stereotyping within the school environment

Much existing research has been undertaken in a school environment (such as in Cracking the Code) and there is a need to conduct more research into the relevance of each of the factors described above specifically within the TVET sector. The country case studies provide some pointers as to the kinds of research considered important by the UNESCO-UNEVOC centres and that might be particularly fruitful in the TVET context.

First of all, as described in the bullet points above, several of the case study reports flagged the effects of gender stereotyping as being an important topic. The case studies from the Netherlands, Chile and Lebanon specifically highlighted the important role of teachers in both perpetuating and challenging gender stereotypes. In these cases, however, research focuses on the teaching of mathematics as a subject in schools (often in secondary schools) rather than teaching STEM-related disciplines in the TVET sector. This focus is logical, as the choice to pursue STEM-related TVET programmes is made by both boys and girls before actually entering a TVET programme. In order to understand the influence of teaching staff on career choices of girls and women already participating in TVET, it would be interesting to conduct further research within the TVET context.

In the case study of Costa Rica, the students in their interviews stated that they often received support from the teaching staff. They also mentioned that the 'Bienestar Estudiantil' teams (psychologists, counsellors and social workers) support them to avoid discrimination based on gender.

In addition to the role of teachers, the case study from Chile also drew attention to the complexities of the effects of institutional culture on the experiences of girls and women in STEM-related TVET. Students interviewed as part of the project reported differences in the nature of the treatment received from teachers and peers depending on how their own femininity was perceived. In this regard, acting more 'feminine' in male-dominated TVET programmes increases the likelihood of girls and women receiving sexist comments. However, in spaces where there are more women who 'break' with being 'feminine', the women are less likely to be discriminated against. This suggests the need for more fine-grained analysis of the complex dynamics of gender discrimination in TVET institutions.

A lack of career awareness and information

It is not possible to choose something you do not know about or which you know only a little. Career awareness and quality career information on STEM areas is crucial for both female and male students. In the country case study of Jamaica, a lack of career awareness and career information is an important barrier to female involvement in STEM-related TVET. Female students are often not aware of the content of STEM fields of study and their related careers. In the case of Costa Rica, the National Training Institute conducts vocational fairs in an exploratory female-oriented way where women can get to know the STEM areas, with the aim of awakening their interest.

Career guidance, coaching and mentorships are instruments through which TVET institutions can support girls in developing realistic but also attractive images of STEM careers, in making well-informed choices, and in discussing and overcoming hurdles and gender-specific challenges along their educational pathway in STEM.

The gender-friendliness of infrastructure

Curricula and learning materials play an important role in promoting girls' interest and engagement in STEM subjects at all education levels. Textbooks often fail to show female STEM professionals or portray women in subordinate roles. Such images can have an effect on the sense of belonging of women and girls in the specific technical areas. This is also true for STEM-related TVET education, but the practical nature of many TVET programmes gives an extra dimension to the gender-friendliness of learning infrastructure in TVET institutions.

In several STEM-related TVET programmes, there is a need for physical handling of machines and appliances. The gender-friendliness of such infrastructure (but also the more general infrastructure such as quality sanitary facilities for both sexes) at STEM departments of TVET institutions can play a key role in the well-being and 'feeling of belonging' of young women during their STEM education. In the country case study of Lebanon, for example, a barrier to the participation of girls and women mentioned was the inability to adjust machines to different body sizes.

Examples of interventions aimed at TVET institutions

There are several examples of interventions aimed at increasing the gender awareness of (teaching) staff in TVET institutions including in the context of work placements/internships. Three of these are highlighted in Box 7, Box 8 and Box 9. More evidence is required, however, as to the success of these kinds of initiatives and their applicability across different institutional contexts.

Box 7. The case of Instituto Superior Dom Bosco in Mozambique: gender training for TVET teachers

TVET teacher training is the main mandate of the institute in Maputo, Mozambique, delivering technical and pedagogical training for qualified teachers. One of the modules in this training is on gender and social inclusion. Teachers learn to understand gender and gender equality issues in the TVET system; they learn how to create safe and conducive learning environments and employ a zero-tolerance approach to gender-based violence and sexual harassment.

Even though all TVET teachers receive this gender training, one specific module is currently (2019/20) being developed by the institute in cooperation with CINOP for TVET teachers in the areas of engineering (mechanical and electrical) and ICT. This gender module focuses specifically on the teaching of technical know-how to girls and women. The goal of this module is therefore to support the performance of girls and women in these technical training programmes.

Source: Internal documentation CINOP, 2019

Box 8. The case of Deltion College in the Netherlands: gender awareness training for teachers

Deltion College focuses on the role of student counselling for student success in general, and for the success of girls and women in particular. The college indicates that gender issues or challenges are often nog experienced as problematic by teachers of the institute. Therefore, they implemented a specific policy measure related to supervision and counselling. The TVET institute organises frequent training sessions for its teachers of technical study programmes about the different approach of boys and girls in daily practice.

Topics that are introduced and explored during these training sessions range from the 'school climate', didactics, pedagogics, information events and intake all approached from a gender perspective. During these sessions, a positive approach is chosen and teachers are challenged to discuss how to adapt their education better to gender differences and the manner in which children learn. In this, differences between boys and girls are not treated as an insurmountable problem, a non-normative approach is chosen in explaining differences between boys and girls. Differences in learning styles and attitudes are treated as possibilities and options that can be used to motivate students.

Deltion College believes that teachers better understand the specific challenges that boys and girls deal with in their education when they are more aware of the differences between boys and girls and by treating these differences in a neutral way. The programme is currently being evaluated. The first qualitative observations seem to indicate that the programme steers towards a change in attitude of teachers that can bring about more understanding.

Source: Belfi et al., 2015

Box 9. Inclusion of gender criteria in the evaluation of education in Costa Rica

The Strategic Action Plan 2018–2023 of the Costa Rican National Policy for the Equality between Women and Men in Training, Employment and in Benefiting from Products of Science, Technology, Telecommunication and Innovation 2018–2027 describes as one of the main objectives the promotion of enrolment and graduation of women in technical, technological and scientific areas. One of the actions that is planned to contribute to this objective is the development and inclusion of gender criteria in the evaluation applied by the National System of Accreditation of Higher Education as well as the INA for the accreditation of careers related to science and technology.

Source: Política Nacional para la Igualdad entre Mujeres y Hombres en la Formación, el Empleo y el Disfrute de los Productos de la Ciencia, la Tecnología, las Telecomunicaciones y la Innovación 2018–2027

Box 10. Introduction of science and technology programmes in girls' schools in Ghana

As part of the "Employment for Sustainable Development in Africa" (E4D) programme COTVET entered into a partnership with Sumsung Electronics West Africa and the German and South Korean institutions for development cooperation GIZ and KOICA to equip four selected vocational training centers with state of- the-art electronics teaching labs and prepare teachers in Competency Based Training (CBT) in electronics and generic subjects. The girls' schools partnering with the project are the first in Ghana to install and operate electronic labs in order to offer specific technical training geared towards the needs of female students and thus enable them to reach the same level of proficiency as their male competitors. The project is accompanied by a comprehensive study that compares the learning environment in all-female groups (3 partner schools) to those in evenly mixed male-female classes (1 school) and tries to find out which model represents the most conducive one for female vocational students to engage in a technical sector. It is expected that the 4 schools will prepare 100 female graduates in electronics per year. The project explains that due to a growing urban middle class, the demand for electronic appliances is on a constant rise. Besides a career in servicing and repair of electronic appliances, the young women will find employment in 'after sales service' or as 'informed salespersons', where professionals capable of giving profound advice to consumers based on sound technical background are in demand. Following a similar concept E4D Ghana has also started an additional project: Female Motorcycle Mechanics and Solar Technicians for Northern Ghana.

Source: GIZ, 2020

The importance of female staff for both theoretical and practical learning activities who can act as role models was reflected in all of the country case studies. Data from Lebanon points to some of the issues and challenges in recruiting female faculty members who can then act as role models. It appears that the number of female faculty members in the STEM-related specialities varies between schools: in the Tourist Technical Institute, there are only 2, whereas the faculty at the School of Industry and Arts is 25 to 30 per cent female in the STEM-related programmes. Furthermore, the school director is a female engineer. The student who was interviewed for the study, who is enrolled in the School of Industry and Arts (a post-secondary TVET institution), confirmed that her teachers were predominantly male. However, she said she feels more comfortable with her female teachers.

Scheduling was identified as a reason for the high rate of female faculty members in one case (women are more likely to accept part-time positions, which are more available in TVET schools) and a reason for the low rate of female faculty members in another case (women are less likely to accept afternoon and evening hours for family reasons). This suggests the importance of research into the recruitment and retention of female staff at different levels of the system and their potential to act as role models.

An issue that emerged from some of the country case studies, including those from Lebanon and Ghana, is the importance of career guidance or career counselling which is in some cases either very limited or totally absent from TVET institutions. In Lebanon, the establishment of guidance and employment centres, as well as certain partnerships, seems to contribute to decreasing the gender gap. The Director of the School of Industry and Arts spoke of the work done by the guidance and employment centres, as well as her own orientation efforts, aimed at encouraging women to enrol in the industrial specialities. This work has helped decrease the gender gap, albeit slightly, in programmes such as topography, woodworking, and construction and public works.

In the Netherlands, VHTO (2019) suggests using female teachers in career guidance methods in the educational context. The feeling of connection to a study programme can increase for female students if they receive guidance from male but also from female teachers as well as female professionals from industry acting as coach, mentor or supervisor. Some TVET institutes in the Netherlands therefore ask their female teachers to do extra guidance activities and to coach female students in how to function well in a masculine learning environment (VHTO, 2019a).

Other areas that are potentially worthy of further study are flagged in the wider literature including issues to do with the nature of the curriculum, the effects of teaching styles and different forms of assessment. What the above discussion begins to draw attention to is the complexity of the factors involved in facilitating gender parity at an institutional level. These factors are suggestive of a holistic approach that encompasses all of the issues involved, from leadership to teaching, learning and assessment to engaging with parents and other stakeholders, initiatives to change the culture of the institution including tackling gender stereotyping and harassment, the recruitment and retention of female staff, and processes of staff development. Many of the interventions discussed tend to focus on one or two discrete areas such as teacher development and awareness-raising. Some interventions, however, are indicative of an institution-wide approach and it would be useful to better understand the effectiveness of these kinds of interventions in the TVET sector.

One example of a more institution-wide approach is the uptake of the Athena SWAN award system in countries such as the United Kingdom and Australia. This award system seeks a more holistic approach to ensuring gender equality. Another example is provided by the learning ambassadors network in the Netherlands (see Box 11). It would be helpful to better understand the real impact of these kinds of institution-wide approaches in the TVET sector.

Box 11. The institution-wide approach: the case of the learning ambassadors network

The Stichting Platform Bètatechniek (since 2019: Platform Talent voor Technologie) organized a knowledge conference in 2018 on 'More Girls in TVET', together with the VHTO. This conference developed into a 'learning ambassadors network', of which the MBO Raad (Council of TVET colleges), VHTO and 17 TVET institutes are part. Meer meisjes in mbo Techniek ('More girls in TVET') is active in lowering the threshold for girls within their own educational institute. This happens through implementing modern curricula, gender-inclusive career guidance, female role models and teachers that are aware of unwanted behaviour. The MBO Raad developed a 'gender scan' that provides TVET institutes with tips for increasing gender equality. The gender scan consists of a quantitative analysis of the intake and qualified outflow of female students.

Source: Platform Talent voor Technologie, 2020

Labour market organizations

In this report, we added labour market organizations to the four-tiered analytical framework of the Cracking the Code report that served as a point of departure for understanding barriers of girls and women in STEM-related education in general (UNESCO, 2017). This addition is needed as labour market organizations often play a significant role in TVET programmes. As TVET focuses on practical learning and work-based learning (in general more than other types of education), students make a connection to labour market organizations during their study programme. This connection is often in the form of on-the-job learning activities such as internships and industry placements and therefore the level of gender-friendliness of the companies offering internships and placements plays an important role in the well-being and acceptance of female TVET students.

Through earlier research conducted by VHTO (2019) and Dockery and Bawa (2018) on the effect of labour market organizations on the participation and performance of girls and women in STEM education and jobs, the following effects can be summarized:

- Both research papers show that the **workplace culture** in labour market organizations has an effect on the participation and performance of girls and women in STEM. Examples that negatively influence participation and performance of girls and women are the general underestimation of technical (STEM) abilities in the workplace, the expectation that girls and women should execute tasks that are considered feminine, and unwanted behaviour that can cause a feeling of insecurity.
- If a labour market organization has a **male-dominated employee profile**, it leads to the feeling of girls and women 'not belonging' during their internship at companies where none or only a few women are working in technical STEM functions. This causes a lack of female role models for girls and women in STEM-related TVET. In the research of Dockery and Bawa (2018), 55.5 per cent of girls and women agreed or strongly agreed that in their technical occupation, women have to prove themselves where men are assumed to be capable.
- The **unconscious employer** bias appears to play a role in side-lining women who are applying for technical (STEM-related) positions, also when it comes to internship positions.
- The **physical environment** affects participation and performance of girls and women in STEM occupations and related labour market organizations. As STEM jobs are often male-dominated, the physical environment is not always adapted well to the presence of girls and women. Examples from organizations that offered internship placements to female students are the lack of women's work clothes, the inability to adapt machines to women's body proportions, and a lack of toilet facilities for women.

To complement the above research on labour market organization effects and draw an even more comprehensive image, information provided in the various country case studies is very helpful.

The country case study from Germany shows that a gendered labour market division is already evident before girls and women access the labour market. The desire for gender-compliant behaviour can lead to a considerable gender difference in the labour market. Based on the gender-typical sense of identity of boys and girls, which typically develops during (pre-) puberty (Sklorz-Weiner, 1998), young girls choose a profession that is supposed to correspond to their gender (Solga and Pfahl, 2009). Because gender-specific stereotypes and clichés still dominate in Germany, which are pushed massively by the media, segregation in the labour market is inevitable (Kelber et al., 2015).

A lack of female colleagues in the work place

Gender stereotyping in the labour market and choosing a profession that is supposed to correspond to one's gender, as described above in Germany's case, leads to unequal participation of girls and women in STEM-related occupations. For occupations that follow STEM-related TVET in particular, the percentage of female representation is often even less than for other STEM education levels.

The case studies from Germany, the Netherlands and Australia all highlight the issues of a lack of female employment, particularly in senior positions in companies involving STEM occupations. They also highlight problems of a sexist working culture including sexual harassment at work, an absence of mentoring and career progression for women, a lack of female representation in advertising, and the use of gendered language to describe occupations.

The case studies show that this lack of female visibility within labour market organizations also has an effect on the lack of part-time and flexible working options and more family-friendly conditions that might make working in STEM-related occupations more attractive to women. If there are no or few women within the company or in decision-making positions, their needs and voices are at risk of being ignored. More evidence is needed regarding the effects of labour market conditions on the career aspirations of girls and women in the STEM field.

Especially in the case of internships during TVET, young women gain their first experiences with work, the workplace and its culture. Negative expectations or first experiences will result in a decrease in female participation. VHTO research (2019) shows that an internship company where more than three women work in a technical function has a positive influence on the workplace culture and on the feeling of safety of female interns.

Employers' open and hidden gender preferences

In several country case studies, evidence suggests that both open and hidden gender preferences exist within companies. In the Philippines, gender preferences are evident in job advertisements posted online: some employers seem to prefer men for particular job openings (engineering and technical jobs). This preference for male employees is also reflected in the total employment in industries such as iron and steel, copper manufacturing and plastics, with electronics (semiconductors and electric wiring) the exception, where more women are employed.

For STEM-related TVET programmes and on-the-job learning activities, it would be helpful to better understand the processes involved in assignment of students to internship placements and the role of gendered stereotypes and organizational cultures in influencing placement decisions. It would also be interesting to see whether selection is more gender-equal if (more) female staff are involved in the selection and placement of female students in companies and divisions that provide a safe and female-friendly environment.

An unsafe environment challenges female participation

Another important factor highlighted in the country case studies is the remoteness (of technical/industrial plants), related transport issues and inappropriate sanitary facilities, as well as the lack of female supervisors for female students.

Evidence from Australia, Chile and the Netherlands suggests that issues of stereotyping, sexual harassment and other forms of bullying are present in these labour market organizations and scare off women and especially young girls. This may have an equal if not greater impact than such issues in the TVET classroom as students are more vulnerable in the context of a company. In Australia, 51 per cent of women in STEM jobs have reported being discriminated against on the basis of their gender. Half of women and one in ten men in Australian STEM workplaces have faced sexual harassment during their career. Of people experiencing sexual harassment, 70 per cent had chosen not to report it due to fear of reprisal or reputational damage, and concerns about the adequacy of organizational policies and procedures. These figures are concerning and can explain – together with other effects – the relatively low participation of girls and women in STEM-related TVET and the labour market.

Examples of interventions to improve female participation in on-the-job learning in labour market organizations

Box 12. Practical tips for internship guidance of female students during their STEM-related TVET programme in the Netherlands

The 'More Girls in Technical TVET' initiative works together with several TVET institutes to increase the participation and retention of girls in technical (STEM) TVET programmes. In order to ensure this, quality internship guidance is deemed to be crucial. The programme provides some practical tips for TVET institutes on internship guidance of girls and women:

Choosing an internship: guide female students in the choice of their internship. Ensure they are aware of the various options they have and ensure they form a good image of the occupations, so that female students can make well-informed decisions.

- **Before the internship:** discuss beforehand with the labour market organization where the internship will take place whether the company is able to offer adequate services and guidance to female students. Examples of adequate services are the possibility to adjust machines to various body sizes, the availability of uniforms in various sizes, the presence of other female colleagues in technical occupations, the promotion of a female-friendly climate where sexist language or disturbing posters are not tolerated (VHTO, 2019).
- **During the internship:** conduct progress interviews with the female students, organize a meeting for female students during a return-day at the TVET institute, where they can exchange their internship experiences, and intensify the supervision of female students who conduct an internship in a company with fewer than three women in a technical position.
- **After the internship:** did you encounter a negative experience with a non-female friendly labour market organization? Prevent that other students (female and male) are conducting an internship with this company in the future by establishing a 'black list' for such companies.

Source: VHTO, 2020

Box 13. The internship case: safe internships

In the Netherlands, students in TVET programmes conduct several internships in different companies / organizations during their studies. The Foundation School and Safety (Stichting School en Veiligheid) provides vocational institutes and internship supervisors with information about the social safety of students during their internships. Examples of social insecurity are bullying, discrimination and sexual intimidation. This initiative started for all vocational institutes and students, but it has an extra role to play for female students in STEM related TVET programmes. Girls and women in STEM related TVET do not only find themselves in a male-dominated study programme, but also in a male-dominated working environment. The Foundation helps internship supervisors and TVET institutions in taking measures to ensure female students are able to talk about unsafe situations, and to promote social safety in a learning working environment.

Source: School en veiligheid Stichting, 2020

Societal-level factors

On the societal level, both social norms and public policies affect the participation and achievement of girls and women in STEM. Societal-level factors that are flagged repeatedly in the country case studies are the relationship between gender equality and wider societal and cultural norms, the effects of mass and social media, and the presence of policies and legislation. This section highlights the social norms mentioned in the country case studies; more in-depth information on public policies is covered in Chapter 4.

In the Costa Rican case, the importance of focusing on cultural and social norms – and therefore wider society – to change perceptions on the abilities and participation of girls and women in STEM education and occupations is clear. Interventions that focus solely on the decision-making of girls and women tend to ignore the importance of societal influences, as individual decisions are not made in a vacuum. On the question about what should be done to promote female participation in STEM in Costa Rica, a female student indicated that more awareness should be raised within society, and not only among its women: 'Because it involves all people.' She then added that women pursuing STEM careers will start working in a male-dominated field. This field can be identified as a macho culture in Costa Rica, which can pose barriers for girls and women. That is why awareness should be raised in all areas of society, and not be limited to targeting girls and women.

A finding from the qualitative data from Lebanon draws attention to the social views of perceived biological factors. For example, in Lebanon, there is a general societal belief that STEM-related careers involve physical labour and a certain physical strength that prevents girls and women participating in these careers. The Director of the School of Industry and Arts stated this assumption as follows: *'I have a firm belief that when they set their minds to it, women are truly capable of achieving their goals. The disadvantage in some areas is the weight of the work. For example, in industrial mechanics, women might not be able to perform the work from a physical standpoint […] Despite that, I have had a female student enrol in a maintenance programme and she is now in her second year and is a very successful student.'*

Similarly, speaking about the participation of women in the Systems and Networks programme, the Director of the Tourist Technical Institute in Lebanon stated: *'They [women] are afraid that the programme entails manual labour, such as cabling, and they tend to move away from that. However, when they come and see for themselves, they realize that there is no cabling and that is when their perception changes.'*

These quotes illustrate the widely held belief that girls and women are unsuitable for some STEM-related occupations because of the physical demands involved. What is interesting here is that the idea of (a high level of) physical demand is especially linked to TVET programmes and its corresponding occupations, and in a lesser way to STEM at other education levels. It is not clear, however, whether girls and women really do struggle with the physical demands involved in some STEM-related TVET occupations or whether this is an example of a gender stereotype that is used to prevent girls and women from entering male-dominated professions. There is scope for further research in this area, specifically to compare popular beliefs with the reality of the physical demands of different STEM-related TVET programmes and the relative ability of girls and boys to undertake the kinds of physical labour involved.

Is there a gender equality paradox in STEM-related TVET?

Even though *Cracking the Code* indicates that in countries with greater gender equality, girls tend to have more positive attitudes and confidence about mathematics and the gender gap in achievement in the subject is smaller, other research suggests the existence of a gender equality paradox. Despite the tendency to see more patriarchal societies providing barriers for girls and women to pursue STEM-related TVET or STEM careers, research shows that more gender-equal societies have fewer women taking STEM degrees (Stoet et al., 2016). Further research is needed to understand this potential gender equality paradox in STEM-related TVET.

Examples of interventions on the societal level

Box 14. Public campaigns to stimulate participation of women in STEM

In Costa Rica, the National Training Institute's Gender Equality Policy Action Plan 2013–2017 *(Plan de Acción de la Política de la Igualdad de Género 2013–2017)* included the development of public campaigns to counter the traditional social representations that sustain the gender division within the area of work and outside of the households. The aim is to promote income generation of women in non-traditional areas (in Costa Rica, STEM areas are called 'non-traditional areas'). This aspect was also introduced in the Strategic Action Plan 2018–2023 of the aforementioned National Policy.

The public campaign was developed to target women and STEM companies that can hire these women. This included organizing vocational fairs and demonstration fairs with appropriate strategies to promote the interest of women in non-traditional areas.

Source: Instituto Nacional de Aprendizaje (2013)

Box 15. Role model and ambassador videos as part of COTVET's MyTVET campaign in Ghana

As part of the Ghana Skills Development Initiative, a programme supported by the European Commission and German and Swiss cooperation, COTVET has recently implemented a national MyTVET campaign, aimed at highlighting the importance of the TVET sector in Ghana and increasing enrolment. The campaign embraces activities such as the National Skills Competition, TVET clubs in junior high schools, a 'Women in TVET' conference, career guidance and counselling, and the use of TVET ambassadors and role models. Most of these activities have a specific focus on female participation such as the development and dissemination of videos of female role models in STEM careers.

Source: Ghana Skills, 2020

4. Overview of government strategies for promoting gender equality in STEM-related TVET

The ten case studies show that in all countries, government policies have been developed that (partially) address the promotion of STEM-related TVET. This promotion often focuses on the quality of STEM-related TVET and an increase in the number of students that participate in these subjects. Only some of these policies place a focus on the topic of gender, gender equality, or participation of girls and women. There seems to be a gap there. To illustrate this gap, Table 3 provides an overview of the policies in some case countries that focus on promoting TVET but with limited attention to gender.

The Jamaican government has taken the decision to identify and designate a number of schools as STEM Academies in which special emphasis will be given to STEM/TVET education. Nine schools have been designated this status in the first phase of the programme. Even though there is no explicit mention of the need to address gender disparities in these STEM Academies, the country case study information suggests that the programme is thought to benefit both male and female students.

Reference to gender or gender parity is not always made explicitly in these policies, even though these policies are referred to when talking about gender.

On the other hand, there are specific STEM-related TVET policies that focus on coping with gender challenges. These policies can be categorized into two main types: (i) strategies aimed specifically at the education and training sector to address gender disparities in STEM subjects; and (ii) strategies aimed at redressing gender disparities in STEM-related occupations that have implications for the education and training system. Examples of each type of strategy are given in Box 16 and Box 17.

Table 3. Overview of policies that focus on promoting TVET without much attention for gender, for the Netherlands, Jamaica, South Africa and Chile

Country	Government policy promoting STEM-related TVET	Focus on gender
The Netherlands	Five government policies promote STEM-related TVET: for example the Emancipation Policy that stimulates STEM career paths for young people and the Masterplan Beta and Technology that improves the image of technical education. The Foundation Platform Bètatechniek was established by the Ministry of Economic Affairs and Climate, the Ministry of Education, Culture and Science, and the Ministry of Social Affairs and Employment to stimulate the quality and quantity of STEM education in the Netherlands to meet the demands of the labour market. The foundation works together with educational institutes, businesses and governments to make technical education more attractive for young people.	A clear focus on gender is placed in only one policy; the other policies do not pay attention to gender aspects.
Jamaica	TVET integration programme in primary and secondary education that promotes student exposure to STEM-related TVET concepts and occupational fields.	No specific focus on gender.
South Africa	National Certificate (Vocational) programmes with a strong focus on mathematics and science as cognate subjects promote student improvements.	No specific focus on gender.
Chile	In recent years, the government of Chile has put effort into promoting the STEM area in general. For example, between 2003 and 2010, the Programa Enseñanza de Ciencias Basado en la Indagación, an inquiry-based science teaching programme, was implemented in schools.	No specific focus on gender in the programme. The government did initiate other strategies with the main goal to stimulate gender equality in STEM-related TVET. Gender issues are therefore not incorporated in general STEM-related TVET strategies but form a strategy on their own.

Box 16. Government strategies aimed specifically at addressing gender disparities in STEM subjects in education and training

- In **Australia,** the national Women in STEM Strategy (Australian Government, 2020a) outlines the government's vision and role in supporting increased gender equity across the STEM sector. Together with the Women in STEM Decadal Plan (Australian Academy of Science, 2019) authored by the science community, these strategies aim to increase women's STEM participation and retention at all levels of the education and training system.
- In **Chile**, the Ministry of Education and the Ministry of Women and Gender Equity promote strategies that aim to reduce gender gaps in STEM-related TVET education in their Quality without Biases Agenda 2018–2022. They aim to increase the participation of women in STEM-related TVET by offering scholarships to women that study for a STEM career in TVET and by providing mentors to girls and women studying in STEM-related TVET and upper secondary education.
- **Costa Rica** has two national policies closely related to reducing gender gaps in education and training in areas related to STEM: the National Policy for Effective Equality between Women and Men 2018–2030 and more specifically the National Policy for the Equality between Women and Men in Training, Employment and in Benefiting from Products of Science, Technology, Telecommunication and Innovation 2018–2027. Besides, as a national institute, the National Training Institute implements its own Policy for Gender Equality. This policy was designed in 2013 with the support of the International Labour Organization and the Spanish Agency for International Cooperation. The more recent National Policy and its Action Plan assigns specific actions to the National Training Institute as the implementing agency.
- In **Lebanon**, issues of gender parity in STEM subjects are addressed within the context of broader TVET policy. The National Strategic Framework for Technical and Vocational Education and Training in Lebanon 2018¬–2022, for example, identifies the 'failure of TVET providers to challenge the gender division in labour market specializations' (Ministry of Education and Higher Education, 2018, p. 20) as one of the key challenges that it endeavours to address. The framework proposes the review of the legal, technical and infrastructure barriers that currently constrain the inclusion of marginalized groups and to actively promote the increased participation of women in non-traditional occupations, through awareness campaigns and reasonable accommodation of their needs. An action plan on inclusive education and enrolment in TVET was subsequently developed by UNICEF experts, but this did not specifically address the participation of women in non-traditional occupations.
- The **Philippines**' National Technical Education and Skills Development Plan 2018–2022 addresses the widespread call of the underprivileged and marginalized sectors for social inclusion, including women's participation in non-traditional trades and STEM-related fields. The plan specifies that between 2019 and 2022, the target of a 3 per cent increase in the number of women enrolled in non-traditional trades is mapped to monitor the increase in the number of women in these trades, which includes STEM-related fields.
- In 1991, TESDA Women's Center was created in the **Philippines** and focuses on promoting the economic empowerment of women and gender equality. Gender and development mainstreaming in TVET is focused towards building awareness of gender equality to increase the participation of women in TVET, specifically addressing the low enrolment of women in non-traditional programmes. Training on gender awareness, gender-based programme/project planning and gender analysis are all addressed through the TVET gender and development initiatives. The Center, as secretariat to the TESDA Gender and Development Focal Point System, has a pool of trainers with expertise in conducting gender sensitivity training, gender analysis, and results-based management programme monitoring and evaluation.
- In **Ghana**, COTVET released a Four-Year Corporate Gender Strategy in 2013 as part of the cooperation between the Council and GIZ: Ghana Skills Development Initiative. The strategy shows that less than 2 per cent of skilled workers in lucrative technical sectors are female and specifically calls for affirmative action to integrate more girls and young women through targeted vocational training into those trades (Ghana Skills, 2020).

Box 17. Government strategies aimed at redressing gender disparities in STEM-related fields in the labour market

- In **Australia**, strategies in redressing gender disparities in the labour market as well as in education are both presented in one approach: the Women in STEM Strategy.
- In **Germany**, the federal government has committed to supporting women in STEM and to increasing the attractiveness of STEM occupations for women by initiating projects providing subsidies for events or ideas in this context (Bundesministerium für Bildung und Forschung, 2008).
- In **the Netherlands**, the Nationaal Techniekpact 2020 (National Technical Pact) explicitly aims to improve the flow of students to technical (STEM) jobs by focusing on 'talent development' and 'career guidance'. Part of the strategy is the Action Plan for Gender Focus in TVET, where one aim is to increase the number of female STEM-related TVET students that transfer to the labour market.
- In **Costa Rica**, the National Training Institute implements the Breaking Moulds Strategy to incorporate female graduates into formal job market areas with little female participation. Examples of these job market areas are electrics, metal working and mechanics, all considered STEM in Costa Rica.

Based on the country-level data, there is no evidence of the relative impact of different kinds of government strategies on gender disparities in STEM-related TVET and more research is needed in this area.

A potential advantage of the second broad approach – in which government strategies aim to redress gender disparities in STEM-related fields in the labour market – is worthy of further exploration as it adopts a more systemic response to gender inequality. This approach addresses gender disparities in the labour market and in education and training together. This seems appropriate given the inter-relationships between factors at different levels of the system that impact on the participation and progress of girls and women in STEM-related TVET, a point that is expanded on next.

Initiatives to improve female participation and performance in STEM-related TVET

Some of the policy frameworks identified have also translated into specific interventions. These are captured in Box 18 and Box 19 in relation to specific countries. Between them, they encompass initiatives aimed at increasing female participation in STEM education including targeted government scholarships.

Box 18. Initiatives aimed at increasing female participation and performance in STEM education

- **Scholarship programmes:** the Chilean government intends to introduce a new scholarship programme in 2021 aimed at 'women with a scientific-technological vocation' who study professional technical media education at secondary level (ISCED level 3) and who intend to embark on a STEM career. In the Philippines, scholarships are provided under the Universal Access to Quality Tertiary Education Act, Special Training Program for Employees, Training for Work Scholarship Program, and Private Education Student Financial Assistance that actively promote female participation in STEM-related TVET.
- **Provision of infrastructure:** in Jamaica, the government has designated a number of schools as STEM Academies in which special emphasis will be given to STEM education. Nine schools have been designated this status in the first phase of the programme. Although not specifically addressing gender disparities, girls are assumed to benefit from overall improved levels of access.
- **Mentoring schemes:** 'STEM Women's Days' is a mentoring programme organized by Girls in Tech in Chile that pairs girls of school-going age with female students from technical and professional institutes and universities.
- **Female support groups:** in Costa Rica, the National Training Institute organizes meetings and support groups for women in 'non-traditional areas' with the aim to encourage female students in these areas to continue their studies.
- **Curriculum improvement/innovation:** in Chile, activities have been developed, such as speed-dating style chats and/or workshops in robotics, programming and 3D printing, to bring science and technology closer to school education.
- **Professional development:** several examples were provided earlier in the institutional-level section. The policies aimed at increasing gender sensitivity and teaching skills of teachers and TVET staff, with the aim to raise the participation and attainment rates of girls and women in STEM.
- **Efforts to improve the quantity and quality of data:** some of the countries are in the process of implementing the UNESCO Gender Advancement SAGA system, which seeks to systematize indicators at the country level to identify gender gaps in the STEM area.
- **Distance and e-learning:** in the Philippines, the provision of online TVET programmes has paved the way for an increase in the number of students, including women, to read and learn STEM-related TVET in a non-traditional way. The free TESDA Online Program offers training in various non-traditional skills to female participants.

Box 19. Initiatives aimed at increasing the participation of women in STEM occupations

- **Establishment of specific bodies to champion gender in STEM:** e.g. the Women in Science, Technology, Engineering and Mathematics Ghana (WiSTEMGh) was officially launched in Ghana in 2018 in order to inspire the younger generation to take up STEM careers. The 'learning ambassadors network', in the Netherlands champions 'More girls in Technical TVET' (Meer meisjes in mbo Techniek). This includes implementing modern curricula, gender-inclusive career guidance, female role models and teachers that are aware of unwanted behaviour. The MBO Raad developed a 'gender scan' that provides TVET institutes with tips for an increasing gender parity. The gender scan consists of a quantitative analysis of the influx and qualified outflow of female students.
- **Mentoring schemes:** e.g. the Ghanaian government has also introduced internship and mentoring programmes for females in tertiary institutions pursuing STEM and TVET programmes. For example, the Millennium Development Authority (MIDA) has instituted an internship programme targeted at two hundred female students a year to gain practical skills relevant for the job market in the power sector. In the Netherlands, the National Techniekpact explicitly aims to improve the flow of students to technical fields by focusing on 'talent development', 'career guidance' and 'technical subjects in earlier education'
- **Providing dedicated support and counselling:** e.g. as part of a Ghanaian government initiative, most TVET institutions have also established a gender desk in order to provide support and counselling for females.
- **Making information available to girls and women about STEM Careers:** e.g. in Germany initiatives such as "Girls' Day", "Klischeefrei" or "Komm, mach MINT" [which translates roughly as "Come and get involved in STEM"] aim to provide women with a better understanding of STEM occupations and in this way increase the proportion of women in these fields. For example, on Girl´s Day STEM enterprises and companies open the door so that female school students who can spend a one day internship in a STEM occupation. From the beginning in 2001 up to now, about 1.9 million girls participated in Girl´s Day and every year and almost 10,000 companies get involved with events.

- **Promoting positive images of women in STEM in the media:** e.g. in Australia in order to ensure that equitable and diverse voices were being heard on the radio, a radio production team collected data on the gender of guests and realised that only one-third were women. They set a target of 50% guests who are women on-air and actively sought women's voices, using resources such as the Women's Leadership Institute of Australia's Women For Media database. This approach prompted other high profile media programs to set targets and be transparent about their guest diversity.
- **Developing awareness amongst male leaders:** e.g. in Australia Male Champions of Change (MCC) provide guidance for all STEM leaders. The Male Champions of Change Panel Pledge is a signed commitment for organization leaders to only be involved in panels that involve women in a meaningful way. They have developed a resource with approaches to avoid the 'merit trap', which is now being routinely used by 70% of MCC organizations in recruitment, promotion and related processes.
- **Improving labour market opportunities and conditions for women in STEM occupations:** e.g. many German companies are now trying to make career entry easier or more attractive for women through for examples flexible working time models, teleworking or - generally spoken - family-friendly framework conditions. In addition, large companies in particular offer special support programmes, such as mentoring programmes, women networks, promotion of young talent, etc., in order to make it easier for women to advance to management level. However, despite numerous initiatives and programmes, women are still rarely represented in management positions (29,2%, see Destatis 2018).

Many of the initiatives mentioned in the boxes have not been evaluated and it is important to know more about their impact. As indicated in the introduction, many of these initiatives are linked to a wider government strategy. In many of the countries, strategies aim at a systemic response through simultaneously targeting different parts of the system. This seems entirely appropriate considering the systemic nature of the issues involved in addressing gender disparities in STEM-related TVET. It is therefore important to better understand how interventions work in isolation but also together as part of a holistic response. This underlines the importance of collecting data and evidence at different levels of the system to better understand change in gender disparities at the level of the individual, the institution and the system as a whole.

5. Conclusions and recommendations

Based on the literature and country case analysis described in this report, some general recommendations have been identified. These recommendations should be made country-specific and contextualized, as culture and history (which are vastly different between case countries) have a strong influence on gender equity, definitions and STEM careers.

- Overall, we can conclude that no generally accepted definition of STEM-related TVET exists yet and this can be partially explained by the limited research on this specific subject that has been undertaken by international and national bodies. Definitions of STEM and STEM education vary between countries as well as the definitions and scope of TVET. We also concluded from the research that definitions of STEM-related TVET are often not available.
- This lack of a clear and common definition hinders the collection of data and information from different countries, despite the use of common indicators. Where some countries consider a Bachelor of Science as TVET, this is not the case in most other countries. While in some countries (e.g. Lebanon) education in the field of health is considered STEM, this is not the case in most other countries.
- In general, the figures received from the country cases show a clear under-representation of girls and women in STEM-related TVET. However, there is significant variation in the nature of gender disparities with respect to subject areas within the STEM fields.
- Despite a very modest increase in recent years in female participation in STEM-related TVET, we can still see a strong leaky pipeline between STEM-related TVET and STEM-related occupations or STEM-related higher levels of education. Monitoring of policies and actions through consequent data collection is only organized in very few countries.
- Despite seemingly successful approaches to promote female participation in STEM-related TVET, this is not yet reflected in large and sustainable increases in participation of girls and women, particularly in traditionally male-dominated STEM subjects and at higher levels of the education and training system.

Availability and implementation of specific policies

- The existence of specific laws, policies and/or interventions addressing gender disparities in STEM-related TVET seems to be rather limited; research should be done to find more examples of these laws, policies and interventions, with analysis of their actual implementation, monitoring and evaluation. Overall, there is a lack of information on the (long-term) impact of policies, strategies and specific measures, and there should be a systemic response to understand the impact of those measures on the participation and performance of girls and women in STEM-related TVET. Proper monitoring and evaluation based on data will also help to adapt and tailor policies and measures to the current realities and address specific issues.
- In many cases, strategies or single actions in wider policies for the promotion of (female) participation in STEM-related TVET aim at a systemic response by simultaneously targeting different parts of the system.
- In several middle- and low-income countries, policies and actions focusing on gender equality in TVET are donor driven, as is the case for Ghana and Lebanon.

Barriers and facilitators affecting female participation and performance in STEM-related TVET

- While influential reports such as Cracking the Code have provided useful insights into gender in relation to STEM education and therefore function as a useful point of departure for the present study, much more research is needed into how these insights relate to the specific context of STEM-related TVET.
- Existing evidence is that while biological factors, including genetic makeup, the structure of the brain, hormones and physical strength, influence female participation and performance in STEM-related TVET, they are not determining factors. In the context of STEM-related TVET, the influence of some biologically driven factors such as physical strength need to be better understood.
- At a psychological level, gendered stereotypes were identified as playing a critical role in the development of gendered identities that impact on STEM. More research is needed on the relationship between performance in STEM-related TVET and the development of self-efficacy and motivation.
- Peer and especially parental beliefs and attitudes, including those of the father, can potentially play an important role in both preventing and facilitating participation of girls in STEM-related TVET.
- TVET institute-level factors play a role in relation to participation and performance, including the culture/ ethos, teaching, learning and assessment, availability and nature of learning materials, presence of female role models,

engagement with parents, and the availability and use of participation and performance data.

- Labour market organizational-level factors such as workplace culture, physical infrastructure, the presence of female role models in technical jobs (employee profile) and hidden or explicit employer preferences play a role in relation to participation of girls and women. These not only determine participation in the job market after education, but also affect the participation of girls and women in STEM-related TVET as industry learning – for example through internships – is often part of the TVET programme.

- A number of interventions are being used at an institutional level to address gender disparities in participation and performance but these need to be better evaluated.

- A range of social factors were also identified as being worthy of further research, including the effects of gendered cultural norms and values, the role of the media, the effects of government policy and legislation, and the influence of gender dynamics and opportunities in labour markets.

- Governments have adopted a range of laws, policies and/or specific interventions to address gender disparities in STEM education. However, there is an overall lack of implementation and monitoring and evaluation of the implementation. Often, action plans do not exist or are not referred to. Even if reports are submitted by concerned technical working groups, these are not readily available to the public or for policy-makers and relevant agencies.

- As indicated by the UNEVOC Centre in the Philippines, the main challenges faced in the efforts to promote female participation and achievement in STEM-related fields in TVET and transition to STEM-related occupations is to define on a national scale what STEM and STEM-related TVET are. There is still a lingering perception of what male and female jobs are and this limits young people's choices of what education and work they will pursue in the future.

- Career guidance, coaching and mentorships are instruments through which TVET institutions can support girls to develop realistic but also attractive images of STEM careers, to make well-informed choices, and to discuss and overcome hurdles and gender-specific challenges along their educational pathway in STEM.

Collection and analysis of data

- There is a need to develop indicators at a global level that can better capture changing patterns of participation and performance of girls and women in STEM-related subjects, particularly at ISCED levels 2 to 5.

- There is a need to develop indicators at a national level that while complementary of global indicators (therefore allowing for international comparisons) can also be used to measure progress towards gender parity in relation to local STEM priorities.

- There is a need for longitudinal data, particularly at a national level, that can be used to measure changing patterns of participation and performance of girls and women over time in STEM-related TVET; the value added by different levels of TVET; and the effectiveness of different interventions aimed at promoting gender equity to trace the trajectories of girls and women through the TVET system and into the labour market.

- Future research might usefully focus on the transition points between different levels of STEM-related TVET and between different levels of STEM-related TVET and the labour market.

Future research into the barriers and facilitators driving female participation and performance in STEM-related TVET

- Although existing evidence concerning the participation and performance of girls and women in STEM education can provide a useful point of departure, more research is needed into the personal, institutional and societal factors that affect female participation in STEM-related TVET.

- In order to truly grasp the possibilities for improvement and impact of various interventions and initiatives taking place on the personal, institutional and/or societal level, more research is needed into the effects of these different kinds of interventions on female participation and performance in STEM-related TVET.

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7. Annexes

Annex 1. Methodology

The report synthesizes available literature and data with country-level data. Country-level research was undertaken by UNEVOC Centres in ten countries from around the world: Australia, Chile, Costa Rica, Germany, Ghana, Jamaica, Lebanon, the Netherlands, the Philippines and South Africa. These differ in the ways TVET is provided (annex 1), the relative priority given to STEM-related TVET at different levels of the system, the nature and extent of gender disparities and initiatives to tackle these, and in the impact of different economic, social and cultural factors on the nature of the disparities observed. In seeking to draw inferences across diverse contexts, the report thus makes use of a comparative case study methodology. This involves firstly seeking to understand phenomena (in this case gender disparities in STEM-related TVET) in their real-life country contexts and then to develop an analysis and synthesis of the similarities, differences and patterns across the country cases (Yin, 2008). To this end, a guiding framework for the case studies was developed by the Lead Consultant, UNESCO-UNEVOC and the participating UNEVOC teams (annex 2). The guiding framework was used as a basis for data collection and analysis between countries and includes details of the specific methods used. A summary of key aspects of the methodology used for the study is given below.

Research questions for the scoping study

The following research questions guided the scoping study:

1. How does the following vary between participating countries:
    a. the participation of female students in STEM-related fields of study in TVET;
    b. the performance of female students in STEM-related TVET;
    c. the proportion of girls and women transitioning from STEM-related TVET to STEM-related occupations?
2. What are the individual, parental/peer, institutional level, system level and societal influences on girls' uptake, learning achievement in STEM-related TVET and progression to STEM careers?
3. What are the enabling and hindering factors involved in conducting research on gender equality in STEM-related TVET?

Identifying the level of focus

Countries vary in the priority given to different levels of STEM-related TVET. The team also had to take account of pragmatic considerations including the availability of relevant data. In the light of these considerations, whilst the UNEVOC Centres focused on gender disparities in STEM-related TVET across the TVET system as a whole, the principle focus was on formal TVET at secondary and post-secondary levels.

Desk-based literature review

Each participating UNEVOC centre undertook a desk-based research of national and regional (where applicable) policies, strategies, reports, academic and 'grey' literature (i.e. research and consultancy reports, doctoral and masters theses, etc.) to provide an overview of: the wider policy context relating to how STEM-related TVET is defined and understood in their country; the participation of girls and women in STEM-related TVET; and an initial indication of the issues relating to gender equality in STEM-related TVET.

Some additional desk research has been conducted by the author(s) to complement with further country examples.

Interviews/ focus groups with key stakeholders

The purpose of the interviews/ focus groups was to follow up on the issues identified in the literature review concerning the wider policy context and gender equality in STEM-related TVET. The choice of interviewees varied between country contexts but included policy-makers at national or regional level with responsibility for TVET policy in the relevant national Ministry; policy-makers at regional level (where relevant); representatives from businesses engaged in STEM-related areas; representatives of trades union covering STEM-related occupations; TVET college staff, including management (principals) and TVET educators in STEM-related subjects; female students enrolled in STEM-related areas.

Identification and initial analysis of available quantitative data

Besides the qualitative evidence, a key component of the scoping study is to better understand the availability of different kinds of quantitative data relating to the participation and performance of women and girls in STEM-related TVET. To this end key government reports were analysed to identity availability of data relating to

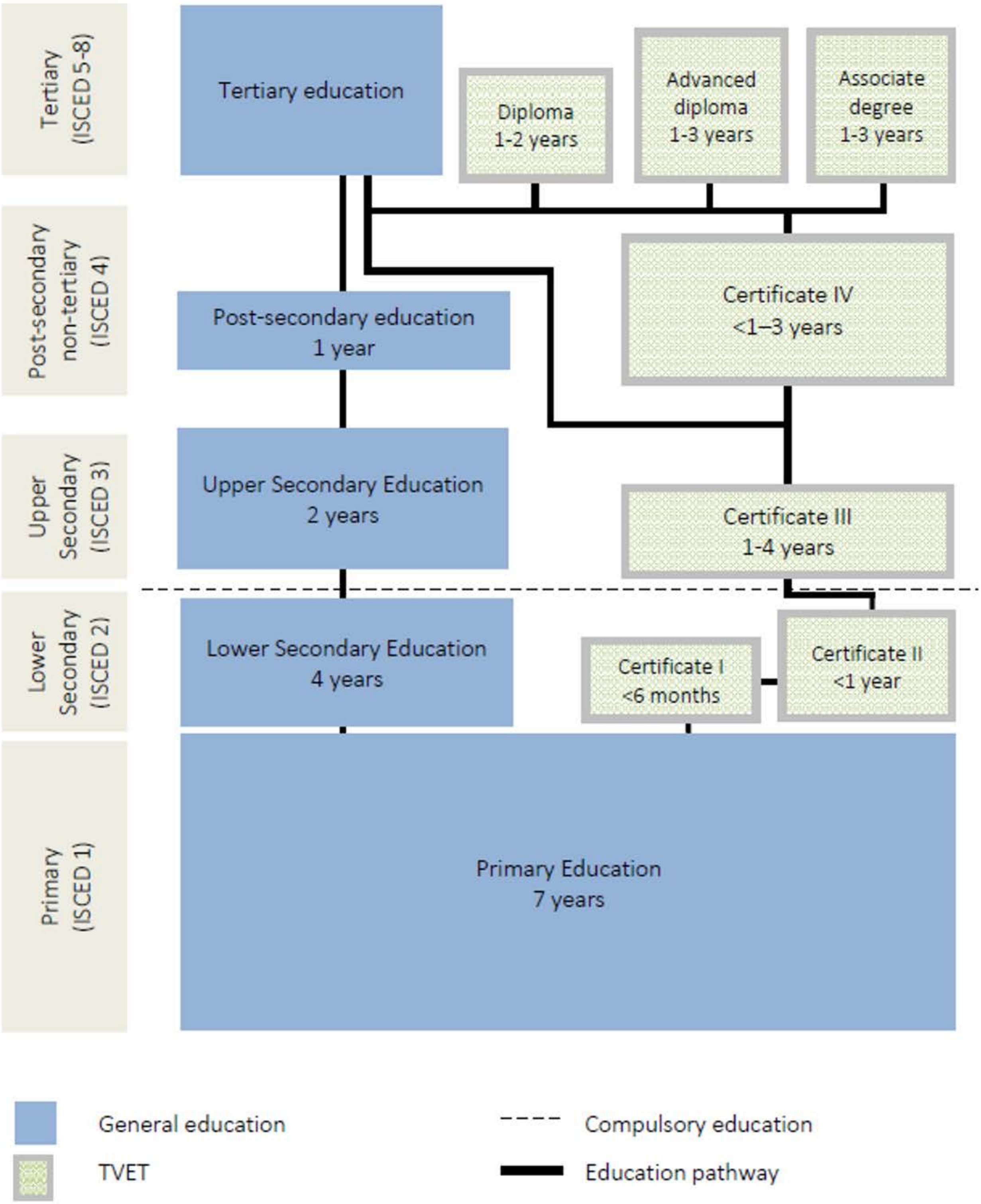
- the participation of female students in STEM-related fields of study in TVET

- repetition and completion rates of female students in STEM-related TVET
- performance of female students in STEM-related TVET
- Transition rate for girls and women to STEM-related occupations

Annex 2. TVET in the education system in the case study countries

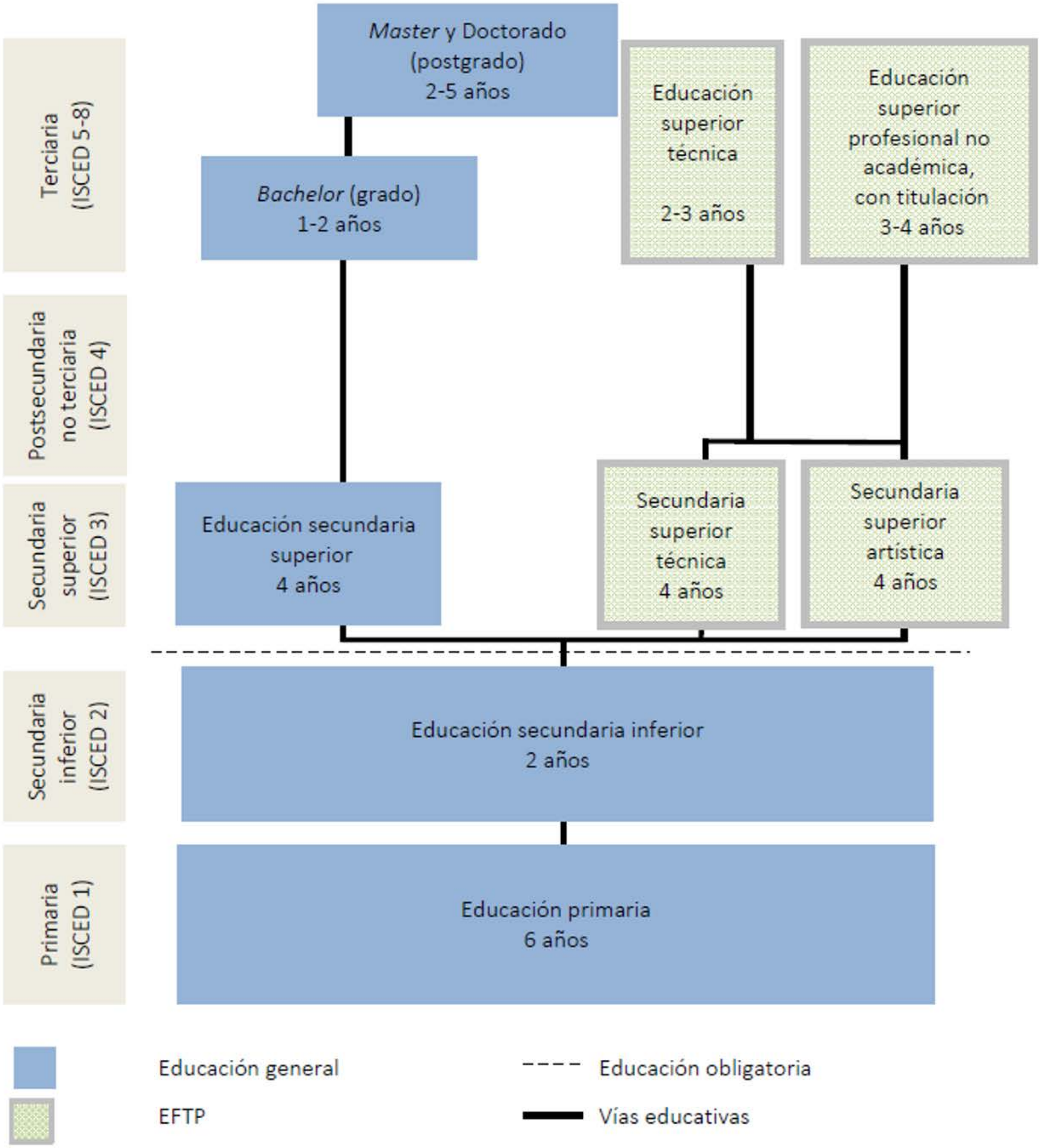
(compiled by UNESCO-UNEVOC)

Australia



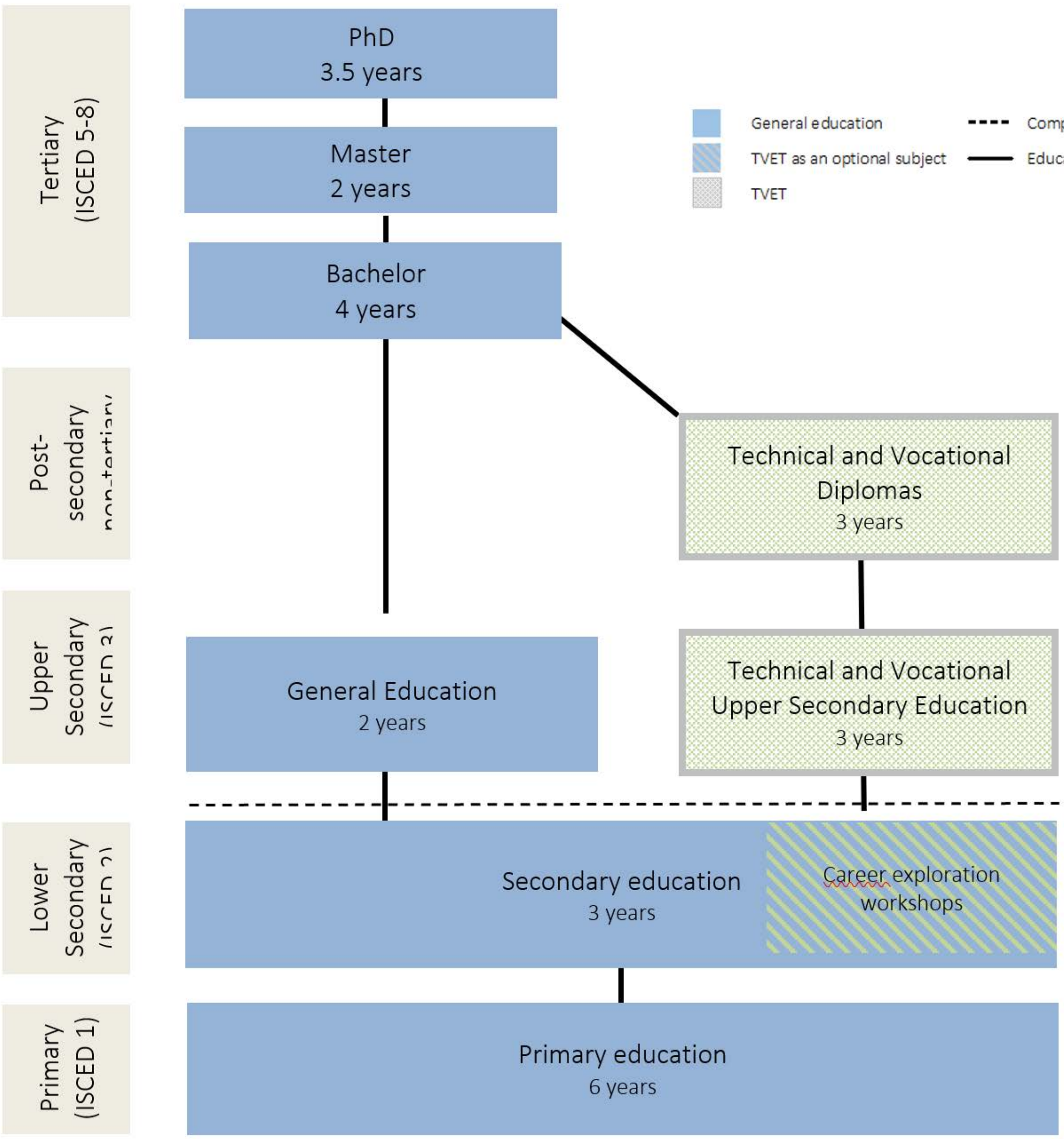
Compiled by UNESCO-UNEVOC

Chile



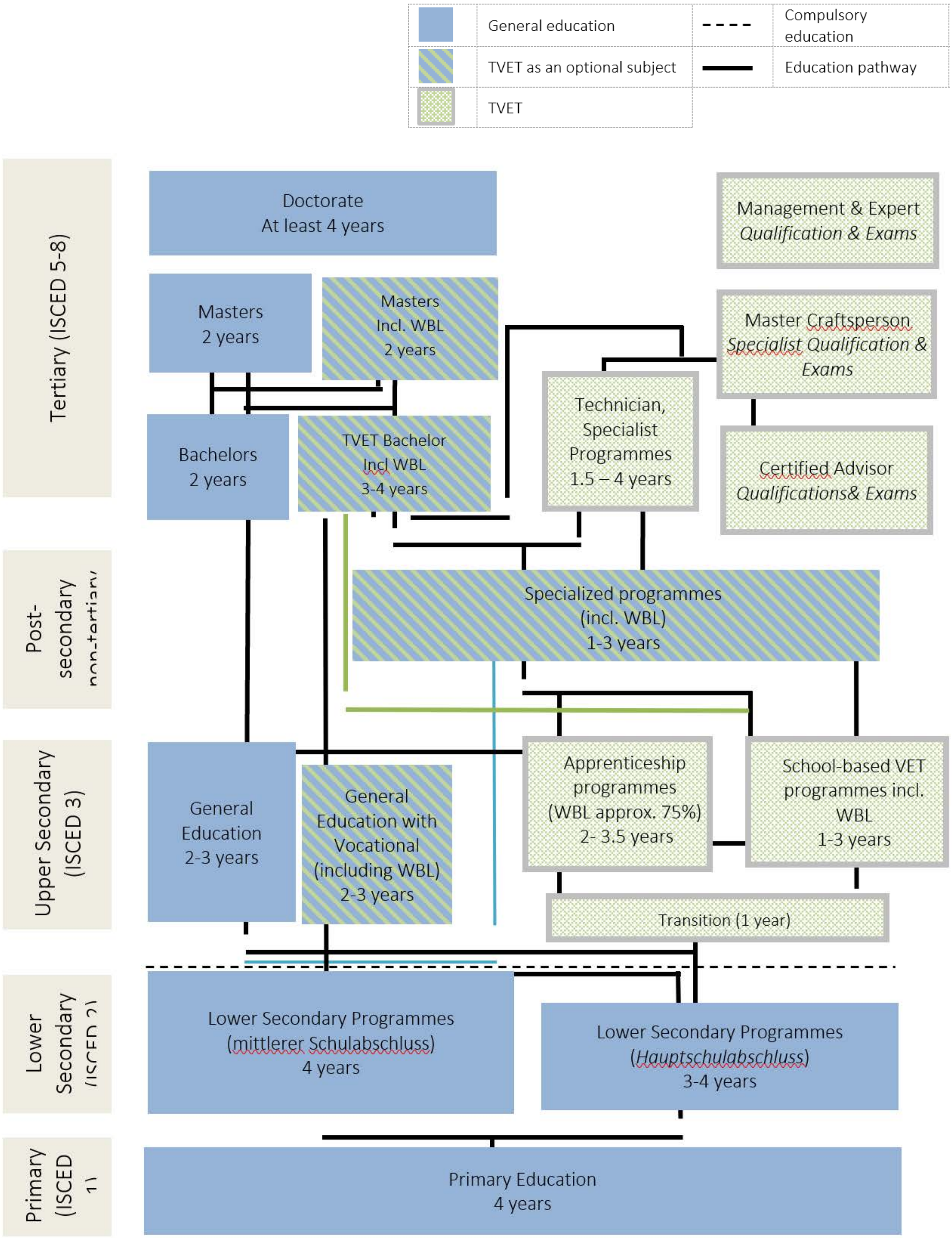
Compiled by UNESCO-UNEVOC

Costa Rica



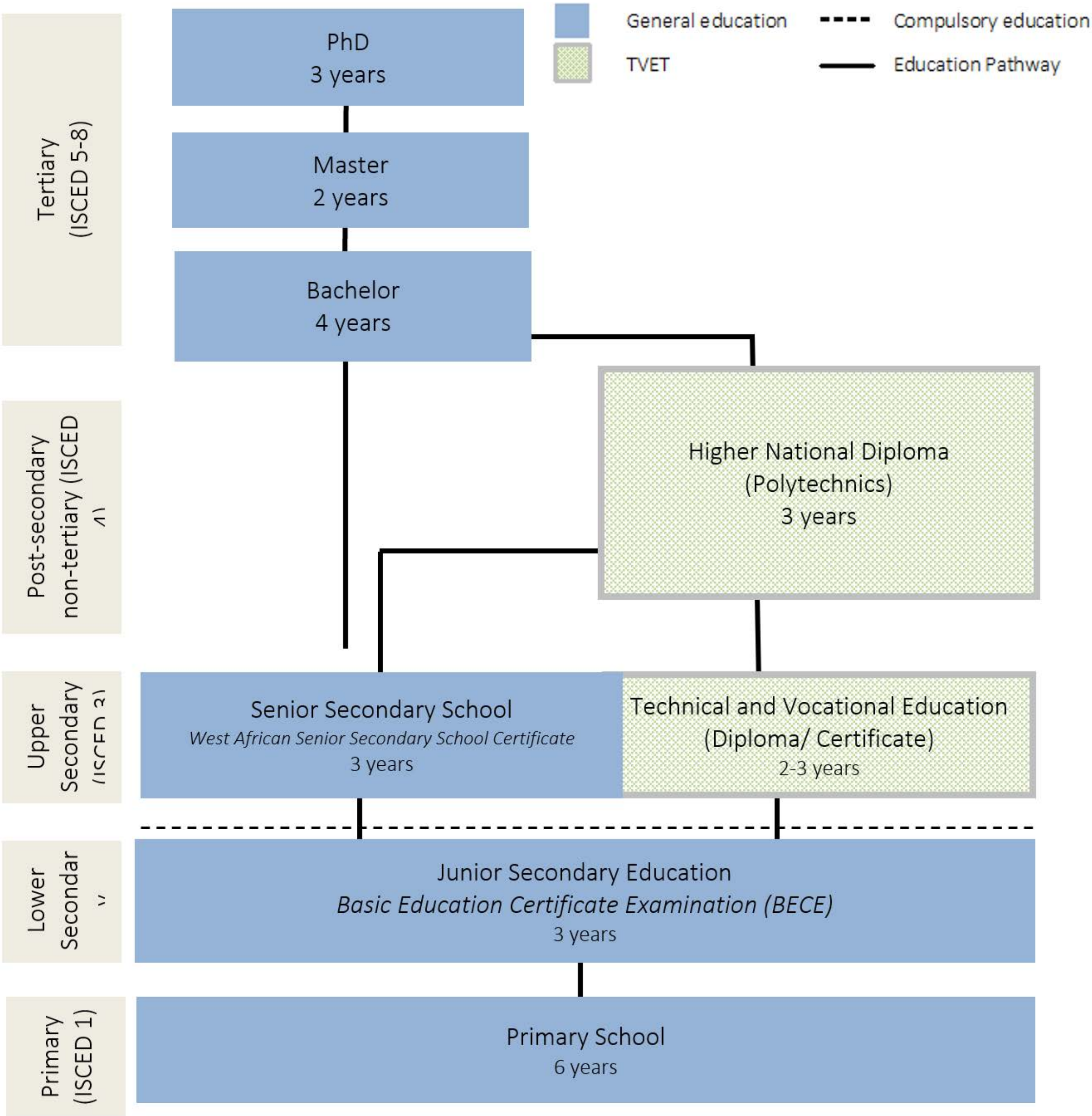
Compiled by UNESCO-UNEVOC

Germany



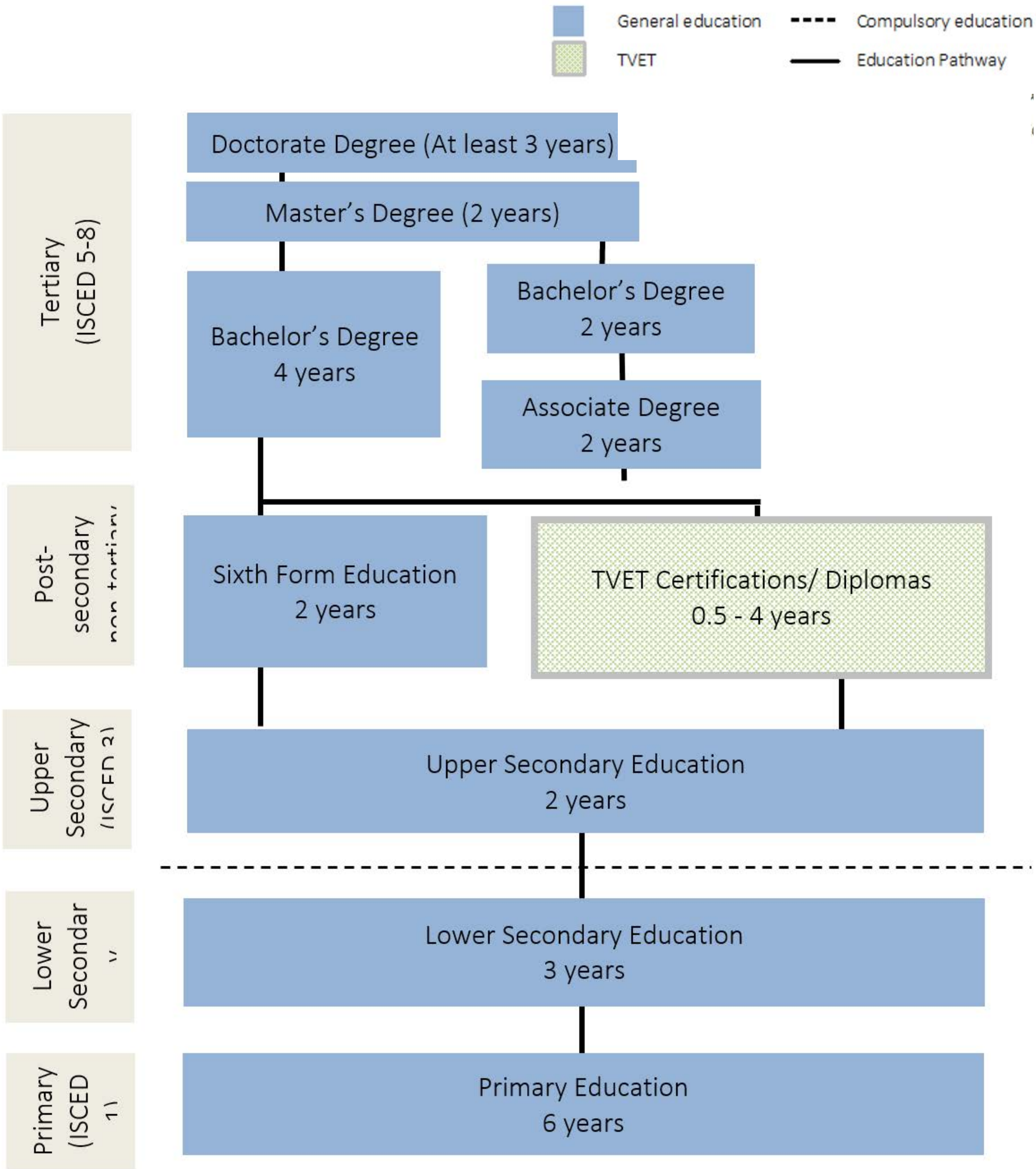
Compiled by UNESCO-UNEVOC

Ghana



Compiled by UNESCO-UNEVOC

Jamaica



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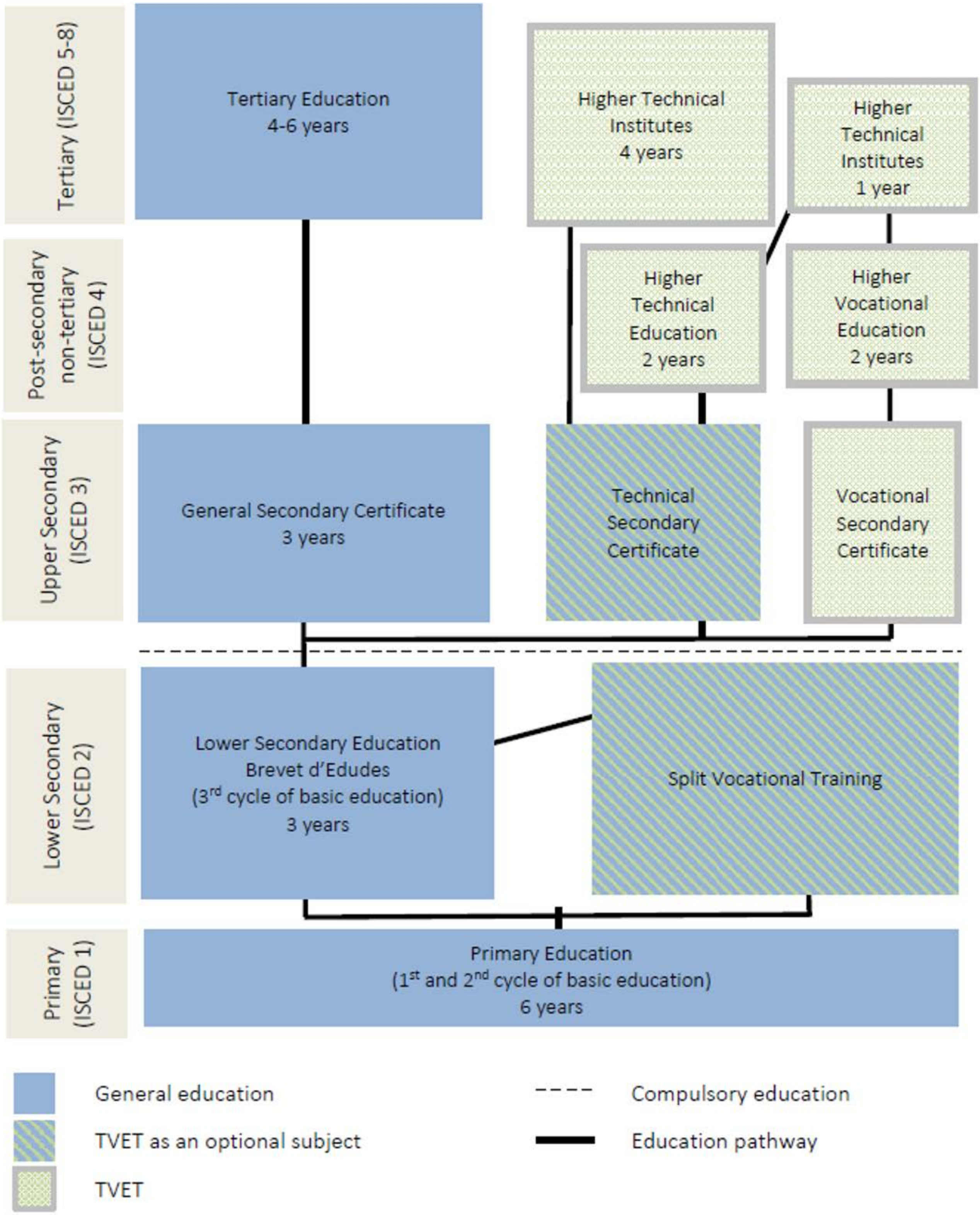
Lebanon



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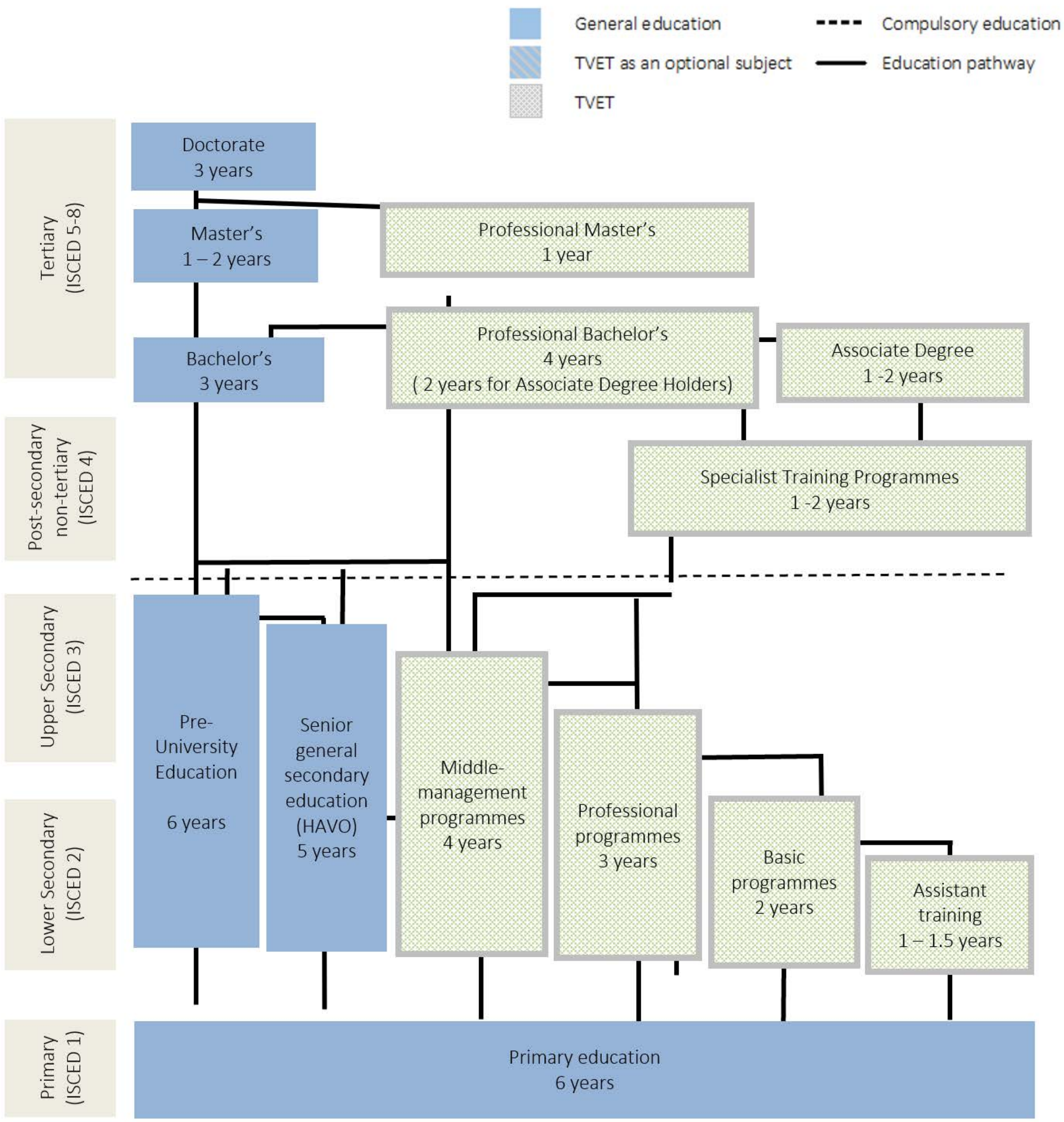
The Netherlands



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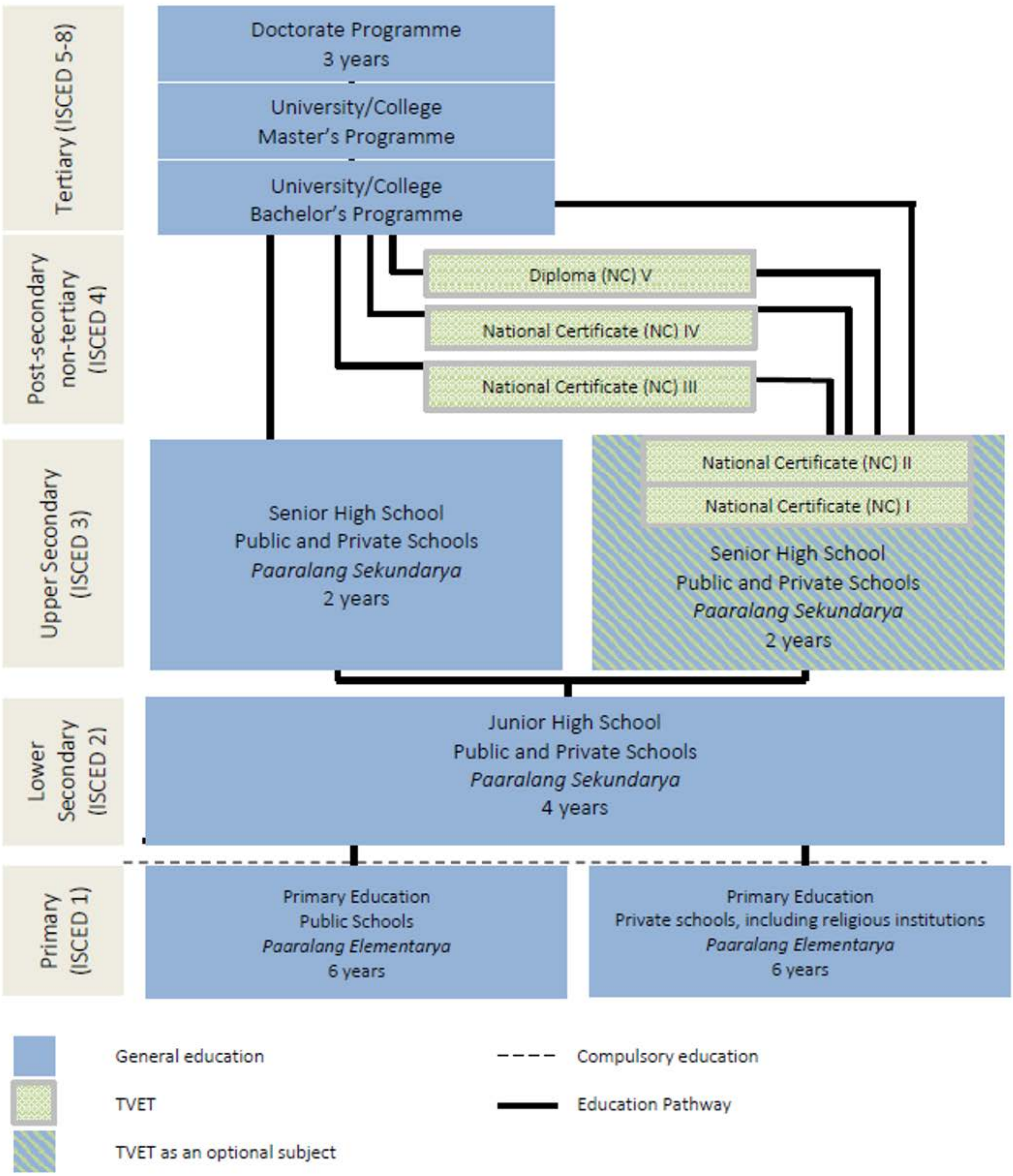
The Philippines



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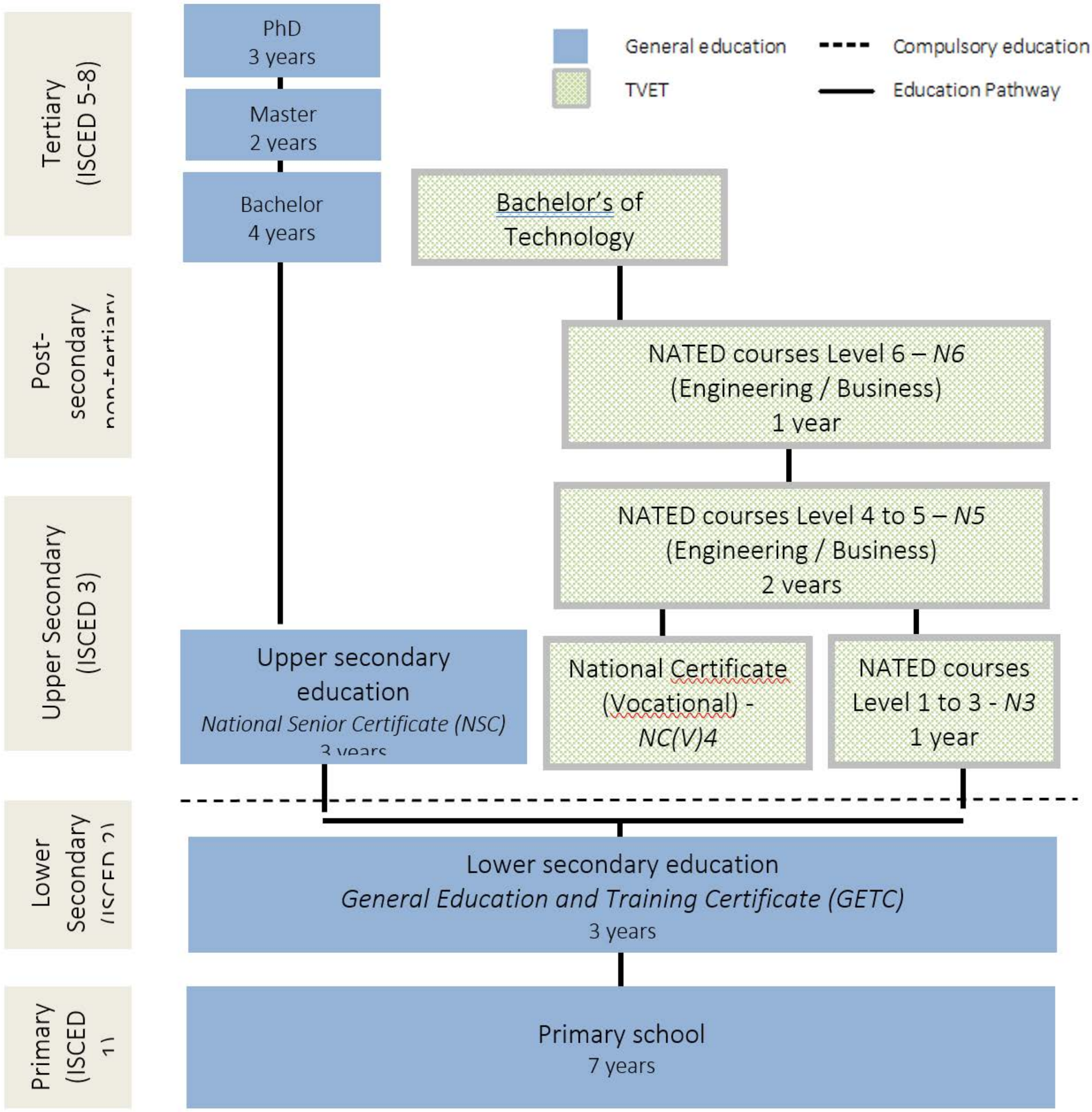
South Africa



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United Nations
Educational, Scientific and
Cultural Organization

UNEVOC
International Centre
for Technical and Vocational
Education and Training

While technical and vocational education and training (TVET) has the potential to bolster the participation of women in the labour market, this potential is not always well understood and capitalized on. In general, female students are lowly represented in TVET compared to general programmes, and in particular girls and women tend to be under-represented in the fields that require science, technology, engineering and mathematics (STEM) skills and knowledge.

In addition to being required for 'traditional' and 'emerging' occupations, STEM skills and knowledge are often needed for the so-called 'jobs of the future', driving innovation, inclusive growth and sustainable development. Greater female participation in these programmes and careers can potentially contribute to their empowerment and drive social well-being. Gender inequalities in access to STEM related fields in TVET, however, can affect the access to and participation of women in specific occupational areas.

This report examines the key issues concerning girls and women's participation and achievement in STEM-related TVET programmes and their transition STEM related careers. It synthesizes existing literature and country experiences collected from members of the UNEVOC Network, UNEVOC's worldwide platform of TVET institutions.

4 QUALITY EDUCATION

Sustainable Development Goals