# Saudi Students' Views of Science and Technology

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# Abstract

This study explores the views of secondary school students in Saudi Arabia towards science and technology, their attitudes and interests in relation to science and technology topics and what outside school experiences may have impacted their science learning experience.

As well as comparing the perspectives between boys and girls, this study also compared Saudi students with those of countries participating in the Relevance of Science Education (ROSE) project. This study included 610 students (288 girls and 322 boys) recruited from Buraidah City via random sampling. All participants were in the final year of compulsory education. Data were collected from 20 single-sex schools (10 schools for girls and 10 schools for boys) in 2017.

A mixed-methods approach (quantitative and qualitative) was used to explore the views of Saudi students. The Arabic version of the ROSE questionnaire was used to collect quantitative data, whilst focus groups were employed to collect qualitative data. The qualitative data obtained were then used to interpret the quantitative data. The data were analysed using SPSS software. Descriptive analysis was used to find the mean and the chi-squared test was used to explore the statistical significance of the differences in item means between girls and boys.

The results indicated an overall positive attitude towards science and technology and school science among the students. However, the findings showed negative attitudes towards some school science topics. The results also identified factors that influenced students' attitudes towards school science. There were statistically significant differences between girls and boys in some of the items within the ROSE sections.

Comparisons between countries highlighted the similarities and differences between Saudi Arabia and other countries in terms of students' opinions towards learning school science and science in society. The findings of this research provide important information about the views of Saudi students on science, which can be used by science teachers in improving daily teaching practices in the classroom. The findings can also be used as references by education authorities to further improve and develop the science curriculum.

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# Chapter 1: Introduction

## 1.1. Introduction

Nations across the world, both in the ‘developed’ and ‘developing’ countries, are continually engaging in research with the aim of improving education, which is often seen as the cornerstone of the overall wellbeing of the country (Sjøberg & Schreiner, 2004). Chief among the subjects important to policymakers is science education, as this area is crucial to the development of future scientists and engineers who will advance their country’s technology and infrastructure. These individuals will also be essential to the expansion of our understanding of human progress and our perception of the world. Drawing upon the views and concerns of students is a vital element in the formulation of any education policy, not just policies involving the sciences. Students have their own goals and ambitions, and a strong education in the sciences is necessary to attain those career aims; moreover, students bring their own standpoints to the overall conversation on education development (Levin, 2000). In a comprehensive study undertaken by Rudduck, Chaplain, and Wallace (1996) conversations with students of various backgrounds led to the conclusion that the education system in the United Kingdom should adopt an inclusive approach, where policymakers would consult students to discover which aspects of academic life are problematic in terms of fostering low morale or creating a reluctance to perform to the best of their abilities. It is crucial to truly understand these issues, as they can result in negative student attitudes and contribute to a reduced quality of output in their studies.

There is also a school of thought which argues that for any secondary science provision to be deemed sufficient and productive, students must be assured that the fields of science they are studying will be of value to them in their lives and careers (Reiss, 2000). Anderson (2006) echoes this stance, arguing that students are more likely to engage in the education process if there is a focus on matters involving their personal interests and opinions.

The perspective of Saudi Arabian students is the subject of this research. The researcher aimed to investigate their attitudes and interests towards the sciences. To achieve this goal, the researcher employed quantitative and qualitative methods; the Relevance of Science Education (ROSE) questionnaire was used to collect quantitative data and focus group interviews were conducted to gather qualitative data. The following sections will expand upon the research problem and objectives.

## 1.2. **Research Problem**

Despite the worldwide attention directed at the emerging trend of exploring students' views in education (Can & İnalhan, 2017; Tisdall & Punch, 2012), which can contribute to the development of education (Mitra, 2003), the education authority in Saudi Arabia continues to ignore the role of students in education development (Alghamdi , 2014). Indeed, the education regulations in Saudi Arabia do not enable students to contribute to the development of education, including the curriculum. The education authority, treats students as strictly listeners and beneficiaries, without the right to provide their views on the education system (Kim & Alghamdi, 2019). No student unions or students' committees exist. Furthermore, students do not belong to any development committees working with schools or the education authority, because the authority does not believe that students' views are significant.

The Trends in International Mathematics and Science Study (TIMSS) results for 2011 and 2015 ranked Saudi students low in science subjects, indicating that there is a problem which needs to be solved. Students in Saudi Arabia are struggling and facing obstacles which are impeding their educational success, and this is because they have no way to express their opinions to officials working in education.

Although international research has been done to investigate the role of students' views, no such study exists in Saudi Arabia in general, and particularly in the field of science and technology. Therefore, the aim of this study is to fill this gap by exploring the views of Saudi students using the ROSE questionnaire, designed for an international comparative programme in the University of Oslo, (see section 1.6). This is the first study to employ ROSE in Saudi Arabia. Using this questionnaire allowed for listening to Saudi students' views and subsequently identifying their opinions on, and attitudes towards, science and technology.

## 1.3. **Research Objectives**

1. To explore the views of Saudi Arabian students towards scientific subjects.
2. To provide insight into the key features of education development that can lead to advances in secondary school science provisions.
3. To uncover what differences, exist between the views of male and female students with respect to the sciences.

4. To investigate how the views of Saudi Arabia students towards science compare with those of students in other countries.

These objectives bring us to certain questions, which are outlined below.

## 1.4. Research Questions

The main question of this research is:

**What are Saudi secondary school students' views of science and technology?**

This is addressed through the following sub-questions:

1. What is the students' interest in school science and technology?
2. What is the students' experience of out of school science and technology?
3. What are the Saudi students' responses to science and technology?
4. What are the Saudi students' responses to school science?

## 1.5. Significance of the Study

There has been a dearth of research into the experiences and views of Saudi school students regarding technology and science education. Therefore, this thesis will expand knowledge of this subject and the study's data and conclusions will provide valuable information to those in charge of formulating policy in Saudi Arabia. This study will provide insight into which aspects of education can be adjusted; for example, the content of textbooks could be upgraded to capture students' interest and keep them engaged in the learning process. The results of this research will also provide an opportunity to broaden the understanding of gender-specific concerns and issues as they relate to science education.

## 1.6. The Relevance of Science Education (ROSE) Project

The ROSE Project is a global comparative research located in the University of Oslo and run by Professor Svein Sjøberg. The project aims to investigate the significant factors affecting the learning of science and technology from the students' perspective, on the rationale that understanding students' views and perceptions as learners is necessary for developing effective science education. Around the world, about 40 countries participated in the ROSE Project. The views of the participating students were obtained in the final year of compulsory education in science and technology in those countries.

Based on the questionnaire that was administered to all the students who participated in the ROSE Project, the views of Saudi students towards science and technology have been compared with students in other countries who also participated in the ROSE project. The data of other countries were obtained from Professor Svein Sjøberg, while reports and information about the participating countries beyond the details of the ROSE questionnaire are available on the project's website, "https://roseproject.no" (Sjøberg & Schreiner, 2010).

Since the ROSE project was designed for international comparison, numerous countries with varying ranking on the human development index participated; for example, the ROSE questionnaire was used to evaluate students in the UK as well as students in Guinea. Therefore, the current research used the ROSE questionnaire to compare the Saudi students' results with those of their peers.

## 1.7. **Human Development Index**

The Human Development Index is a statistical index developed by the United Nations (UN) that uses life expectancy, education and per capita income indicators to rank countries into four levels of human development that indicate the level of well-being of the world's people. It has been published annually as a report since 1990 and shows the efforts of the United Nations Development Program (UNDP) to develop countries and improve the situation of their citizens. According to the Human Development Report for UNDP for 2017, Saudi Arabia ranked 39th out of 189 countries in the list of countries with very high human development.

As an oil-producing country and the world's largest oil exporter, Saudi Arabia is a rich country, with high income and a consequent high per capita income. At the same time, while the high income of the Saudi government has enabled it to spend lavishly on health and education services, the country is not considered among the developed countries. This contradictory situation exists because the Saudi economy depends mainly on oil without diversification of sources of income such as industry. Therefore, although Saudi Arabia has a very high level of human development, the lack of industrialisation makes it at least currently, ineligible to qualify as "developed", according to the economic and developmental factors.

In the current research, it is notable that Saudi Arabia is considered to be a developing country in international comparisons among students who participated in the ROSE Project. As mentioned previously, because of the country’s high income, it is not ranked among the poor developing countries of Africa and Asia. At the same time, due to the country’s lack of industrialisation, it is not an industrial country like Japan and America and those of Europe.

# Chapter 2: General Background

## 2.1. Introduction

As this research focuses on Saudi students and the Saudi education system, this chapter provides background information about Saudi Arabia and Saudi education.

The chapter begins by outlining the Saudi education policy, and educational goals. Furthermore, there are sections covering Saudi education's managerial and administrative structures, and the role of the Ministry of Education. Since this research is concerned with science and technology, the chapter will also discuss science education in Saudi Arabia.

## 2.2. Saudi Education Policy and Goals

The key principles and aims of the Saudi education system are outlined in the Saudi Supreme Committee for Educational Policy's 1970 Educational Policy. According to the Ministry of Education the policy has three main aims: to ensure that all adults in Saudi Arabia are able to read and write; to improve the efficiency of national education; and to ensure that the nation's social, economic and religious conditions are taken into account within the education system (Oyaid, 2009).

Article 1 of the Saudi Education Policy highlights the role of education in aligning learners with the Islamic faith, encouraging religious morality, working towards the goals of the country as a whole, and ensuring that societal needs are met. At the individual level, education in Saudi Arabia is intended to provide learners with broad knowledge and new skillsets whilst also guiding their behaviour in a productive direction (Al-Hamid, Ziadeh, & Al-Otaibi, 2007). From a religious perspective, the aims are to familiarize learners with Islamic ideology and beliefs, provide them with a full understanding and interpretation of Islam and its texts, and encourage them to embrace and share the teachings of the faith. Finally, on a societal level, Saudi learners are taught to contribute in terms of culture, the economy and in strengthening their local community (UNESCO, 2010). The policy provides guidance for all education types and stages, the curricula and courses taught within the system, the education and administration models adopted, the relevant organisational bodies, and all other relevant topics (Elyas & Badawood, 2016).

## 2.3. **Managerial and Administrative Structure**

The Ministry of Education, and the Technical and Vocational Training Corporation (previously known as the General Organization for Technical Education and Vocational Training) are the core authorities in charge of overseeing the Saudi education sector (Sack, Jalloun, Zaman, & Alenazi, 2016). Other bodies – including the Ministry of the Interior, the Presidency of the National Guard, and the Ministry of Defence and Aviation – are responsible for offering access to various educational services from nursery school right through to college and university (UNESCO, 2010). However, it is the Ministry of Education that creates and dictates the curricula, lesson plans and educational structure that all enrolled students must follow (Alharthi, 2017). The Saudi Arabia's main governing body in the education field is the Supreme Committee for Educational Policy, which was founded in 1963 (UNESCO, 2010).

## 2.4. **The Ministry of Education**

The Ministry of Education, founded in 1975, is responsible for all levels and types of education for both male and female students in Saudi Arabia. The Ministry oversees adult and higher education, special education, junior college education and teacher training (Ministry of Education, 2019).

The Ministry of Education oversees 42 districts within Saudi Arabia. In each district, a local district office serves as a connection point between the Ministry of Education and the schools within that district. The Ministry of Education is responsible for all fundamental areas of Saudi Arabia's national education policies, including the provision of textbooks, materials and equipment, as well as school maintenance, repair and new school construction (Oyaid, 2009).

Upon the establishment of the Ministry of Higher Education 1975, all responsibilities related to higher education were transferred from the Ministry of Education. However, in 2015, the Ministries of Education and Higher Education were merged into one entity: the Ministry of Education. In addition to organising and monitoring higher education establishments in Saudi Arabia, the Ministry is responsible for managing foreign educational offices, international academic partnerships and student scholarships. Saudi Arabia currently has 25 accredited (public) universities, nine private universities and 34 private colleges (Ministry of Education, 2019), with most students undertaking bachelor's degrees in the arts or social sciences (typically involving four years of study) or medicine, engineering or other sciences (typically requiring five years of study). Most school teachers are recruited from universities and teachers' colleges (Oyaid, 2009).

## 2.5. **Saudi Education System Organisation**

The Saudi Arabian education system has a greatly centralised administrative structure, with the Ministry of Education having a department responsible for developing and setting the national curriculum, and for curating the body of textbooks used in schools. All public and private schools in Saudi Arabia must provide students with specific textbooks for each grade level and subject. The textbooks prescribed by the Ministry of Education form the entirety of what students are taught – and tested on – in school (Al-Hamid et al., 2007; Oyaid, 2009). In the Saudi schooling system, students are taught over two 18-week terms, with the first 16 weeks of each term dedicated to teaching and learning tasks, the last two to assessment (Al-Ajlan, 2000).

End-of-term grades are based on a combination of final exams and coursework, representing 60% and 40% of the final grade, respectively. Students who do not meet the required grade level must retake their exams in order to progress to the next grade for each subject (Al-Hamid et al., 2007). However, primary school children are no longer given end-of-year exams, instead being continually assessed for academic performance throughout the school year as part of the changes made to the Ministry of Education's new curriculum (Oyaid, 2009).

Children have the opportunity to participate in the general education system in four different stages (Al-Hamid et al., 2007). The first stage is preschool, attended by children aged 3-5 years old (non-mandatory). The second stage, which marks the beginning of compulsory education, is primary school, for 6–12 years old children, which lasts for a total of six years. The third stage is intermediate education, which lasts for three years and is attended by those aged 12-15 years old. Finally, compulsory education ends with secondary school, which also lasts for three years, and is attended by students aged 15-18 years old (Al-Hamid et al., 2007). All education institutions apart from international graduate research institutions and King Abdullah University for Science and Technology (KAUST) University are single-sex (Al-Ajlan, 2000; Alrashidi & Phan, 2015).

### 2.5.1. Preschool

As noted above, preschool education is non-compulsory in Saudi Arabia and does not represent a stage of formal education. The Saudi government has, however, provided funding and technical support to a number of private preschools across the nation. The key aims of preschool education are to tackle behavioural issues and problems and address risks; to help children develop their unique personalities, preferences and creative problem-solving skills; to help children learn about their environment and the basic rules by which they should live; to teach children essential Islamic values; to nurture children's physical, emotional and cognitive development by providing a 'home away from home'; and to build children's sense of morality. Preschool education is also designed to help prepare children to enter the formal school system at the age of six (Al-Hamid et al., 2007).

### 2.5.2. Primary School

The purpose of primary education is to teach children more about cultural norms and values whilst providing them with the skills and knowledge to guide them in the right direction in later schooling and work life. Arabic, Islam, science and culture represent the core topics contained within the school curriculum. Students' progression through the grades depends on their performance in end-of-year exams. In order to progress to intermediate education, students must receive their Elementary Education Certificate by passing an exam at the end of their final year of primary school (Al-Ghamdi, 2019).

The fundamental aims of primary school education are to help children learn essential physical skills and abilities along with numeracy, literacy and language skills; to teach respect for national leaders and those in authority, along with a sense of patriotism; to provide children with an age-appropriate sense of social duty and human rights; and to encourage children to develop an interest in learning, in spending their free time well, and in acquiring new skills and knowledge that will help them in their future education and eventual careers. Primary school education is also geared towards sharing the teachings of Islam, encouraging a sense of belonging to the faith, and helping children to adopt core Islamic values and teachings (Al-Hamid et al., 2007).

### 2.5.3. Intermediate School

Intermediate school is the second compulsory stage of education, following primary school. Hakeem (2012) explains that the intermediate school curriculum is primarily focused on physical education, art education, English, science, maths, social studies, Arabic studies, and Islamic studies. The key aims of intermediate education are to guide, encourage and fine-tune students' skills and cognitive abilities; to encourage children to think scientifically and seek further information; and to provide children with essential knowledge and academic understanding, knowledge and skills. Intermediate school education also aims to teach students to engage in independent study of religious texts to encourage participation in religious events; to develop their sense of Islamic values and belief; to encourage children to maintain the strength of the Islamic nation; and to support students in building their awareness of religious duty and engagement in the Islamic community (Al-Hamid et al., 2007)

### 2.5.4. Secondary School

Once students have received their Intermediate Education Certificate, they are able to begin secondary school, which is compulsory and lasts for three years (ages 15-17/18). During the first year of secondary school, all students follow the same curriculum and must pass their examinations at the end of the school year in order to move to the next grade. During the second and third years, students are able to specialise in technical, arts or science classes, which they are assessed on at the end of each school year (Al-Ghamdi, 2019; Oyaid, 2009). The specialist subjects available to students differ based on gender; female students are only able to specialise in arts and sciences, while male students can specialise in applied/technological sciences, natural sciences, social sciences, administrative sciences, Arabic, or religious sciences (Oyaid, 2009). Additionally, Dar Al-Tawheed Secondary School, the Quranic Secondary Schools, Imam Mohammad Bin Saud Islamic University, and various others, are religious schools offering secondary education (Lavonen, Byman, Juuti, Meisalo, & Uitto, 2005a).

Secondary education can also be provided by specialist health, technical, agricultural, commercial and industrial institutes offering three-years courses. Female teachers can also be trained in specific secondary schools. Students who graduate with a Secondary Education Certificate after passing their end of year examinations are then able to move on to university or other forms of Further/Higher Education if desired.

The secondary education system is designed to meet a number of key aims. Firstly, Saudi secondary schools aim to further students' Islamic knowledge and values, providing them with insight into the human race, the creation of the world in which we live, the existence of heaven, and so on. Secondary education in Saudi Arabia also teaches students to be able to teach Islamic ideology and values to others and to develop a sense of religious pride. On an academic level, secondary school students are taught to utilise credible methods and strategies, to reference and research academic books and other sources of information, to perform systematic analysis, to develop their scientific problem-solving skills, and to take a keen interest in research. The curriculum is designed to nurture students' individual skills, abilities and talents and guide them in the right direction, according to the principles of Islamic education. Secondary school students also learn how to use their free time to the greatest effect, allowing them to develop as individuals whilst contributing to their local community. Students of this age are strongly encouraged to seek further information and awareness, to engage in independent reading, and to develop their academic skills and performance to prepare them for further education (Al-Hamid et al., 2007; Oyaid, 2009).

## 2.6. Science Education in Saudi Arabia

Very few published reports exist, detailing the background behind Saudi science education. Over the space of almost a century, since the General Directorate of Education the precursor to the Ministry of Education was founded in 1926, science education has been a formal part of Saudi curriculum as part of the country's development strategy.

It is reported that prior to the establishment of the General Directorate of Education, the primary school curriculum did not include any form of science education (Alosaimi, 2013). Indeed, science was also not initially part of the secondary school curriculum, but emerged in 1937, when biology, chemistry and physics were introduced to the curriculum. In 1962, the curriculum was amended to include geology as a formal subject (Al-Hussain, 1983).

Until around 1965, the more developed and longstanding education systems and policies of neighbouring Arab nations, particularly Egypt, served as the main inspiration for the Kingdom of Saudi Arabia (KSA) (Alosaimi, 2013). Universities were also unavailable in the Kingdom, with students encouraged to study abroad after being taught using the textbooks and curricula of surrounding Arab nations.

According to Alghanem (1999), the science textbooks selected for primary and secondary education were chosen by Ministry of Education employees from Egypt. Science textbooks – aimed at primary, intermediate and secondary school students – were then created by the American University of Beirut's Educational Centre for Science and

Mathematics in 1975. Ministerial Decision No. 1095/17 led to the establishment in 1984 of the National Committee for Science Education (NCSE) which still supports and provides guidance to the Ministry of Education's Educational Development Organisation.

The American University of Beirut's intervention in the Saudi science curriculum has been described as the catalyst for the most significant reform of the nation's science education system (Alosaimi, 2013). However, many science educators protested that the changes were inappropriate for Saudi students. Today's science curriculum is the responsibility of the Ministry of Education's Department of Curricula, which employs various science experts and specialists to curate and assess the textbooks from which students learn. Science textbooks are usually tested in a small number of schools in order to gain feedback, then re-tested in more schools for further feedback, before eventually being rolled out in schools across the nation (Alosaimi, 2013).

### 2.6.1. Science in the Saudi School System

As Alghanem (1999) explains, science is considered a core subject throughout primary, intermediate and secondary school in Saudi Arabia. Children are taught to follow a straightforward, logical thought process by learning about fundamental aspects of science, including animals, plants, the environment and human health. Subsequently, students are taught more advanced science in order to help them acquire the knowledge needed for the next stages of education.

Science is provided as an overall programme during intermediate school, though it includes subjects such as astronomy, geology, physics, biology and chemistry. Intermediate school students are taught from two textbooks (one for experiments and practical tasks and the other for academic learning and theory). The intermediate school science curriculum focuses on providing learners with a foundation of scientific knowledge to help prepare them for secondary school (Alosaimi, 2013).

Once students progress to secondary school, they learn science through four textbooks and four different programmes: geology (for boys only), biology, physics and chemistry. At this age, science is taught in a more advanced manner and students are informed about international progress and developments in science. Secondary science education is therefore much more thorough and extensive than science education during the earlier years.

Whilst other areas of the world are more learner-focused, Saudi science teachers tend to adopt the traditional approach of providing textbooks and information that students must learn (Alhammad, 2015). Therefore, Saudi students are not often taught to develop their critical thinking, independent learning or research abilities. Instead, they passively receive information and are assessed based on memorisation of textbook and lesson content, rather than on knowledge, creative ability or independent thinking. Thus, Saudi students tend to struggle when asked to present their work to the class, to solve problems and use logic, to provide explanations and perspectives, or to demonstrate creative or critical thinking (Alhammad, 2015).

### 2.6.2. Science Education Reform Efforts in Saudi Arabia

The significance of science in the Saudi education system stems from its role as a core part of the curriculum, as well as its associations with higher education, scientific research, scientific discovery and technological advancement (Sarjou, Soltani, Afsaneh, & Mahmoudi, 2012). Well aware of the role of education in national development, the Saudi government is taking steps to build a generation of information-loaded citizens who can drive the nation to succeed in the global environment (Alarfaj, 2015). Consequently, the amended Mathematics and Science Curriculum was introduced in 2009. This update included the introduction of science textbooks published by McGraw-Hill (an American publishing house), translated into Arabic and adjusted to suit different grade levels in Saudi Arabia (Almazroa & Al-Shamrani, 2015). As highlighted by Obeikan for Research and Development (2010), the new curriculum stresses the need for Saudi Arabia to adopt more modern teaching and learning methods (Almazroa & Al-Shamrani, 2015). Specifically, Saudi Arabia is now moving towards teaching styles that encourage creativity and student participation whilst taking students' preferences, abilities and learning styles into account. Textbook and curriculum content is a major factor in the quality of science education. If educational decision-makers can gain greater insight into the perspectives and requirements of learners in relation to technology, science, the environment and school science curriculum, students are more likely to be provided with a science education that effectively equips them for the ever-changing realities of the greater world (Almazroa & Al-Shamrani, 2015).

As Hargreaves and Shirley (2009) argue, learners' needs must be taken into account when developing the curriculum, and the content provided through the school system should effectively represent the needs of the students. The researchers also highlight the importance of students' participation in educational decision-making. However, at present, neither individual students nor Saudi society are being fulfilled by the curriculum taught in schools (Alnahdi, 2014). Al-Sadan (2000) also points out that there is a problem with making education mandatory yet not allowing students any input in what they learn, or how they learn it. Students are also restricted by rigid timetables and many classes, which limits their ability to engage in other pursuits. Given this, future changes to the national curriculum must consider students' needs and best interests.

Coll and Taylor (2012) assert that the implementation of curricular changes depends greatly on teachers' abilities and attitudes towards reform. Whilst teachers of the past could make do with basic scientific knowledge, teachers must now have extensive knowledge of their field. Another issue, as raised by De Beer (2008), is the worry that teachers will only change what is needed in order to 'tick the box' of assessed change, and that they will carry on using traditional teaching methods, without genuinely embracing a new style of teaching. The entire education system depends upon teachers, and reform is in vain if it is not implemented wholeheartedly. Finland is highlighted by Sahlberg (2011) as an exemplar country both in terms of its education system and teachers, whilst others have highlighted the importance of teacher quality in the effectiveness of reform (Hargreaves & Shirley, 2009). Essentially, reform can only be successful if all relevant parties are behind it: that is, the government, schools, administrators, social programmes, students and parents.

In order for the necessary changes to be realised in Saudi science education, all elements within the system must be focused on. Therefore, it is essential that the notion of systemic reform is fully comprehended and that global changes are recognised in order to learn from other countries and support the success of reform (Alnahdi, 2014).

## 2.7. **Summary**

Saudi schools have similar science curricula, and all public schools work under one policy. Saudi students must study 12 years in public school in three stages: primary school, intermediate school and secondary school. The Ministry of Education, which devised the education policies according to the country's education goals, is responsible for both public and private schools, which are gender-segregated. Saudi students study science every year in primary and intermediate schools; however, in secondary schools, science is divided into four subjects: physics, chemistry, biology and geology, with geology for boys only. Science teaching in Saudi Arabia has been criticised for a traditional teacher-centred approach that promotes memorization over creativity and problem-solving. However, efforts are being made to reform science education, raising the issue of the value of students' opinions in informing future policies and practices.

# Chapter 3: Literature Review

## 3.1. Introduction

By means of a review of literature, this chapter seeks to develop an understanding of three broad constructs pertinent to the pursuit of the research aims outlined in Chapter 1. It begins with an exploration of culture. Following discussion of the concept of culture, and how it is formed and transmitted, salient features of the Saudi culture, such as the influence of religion, are explored and an illustrative comparison with two other patriarchal Muslim societies, Turkey and Malaysia, is presented. This is followed by sections addressing the concepts of attitude, which is addressed in the ROSE questionnaire, and of interest, a dimension of attitude which is a particular focus of this research.

Since the current research seeks to investigate Saudi Arabian students' attitudes and interests toward science and technology, these topics will be covered in detail. Therefore, attitude definition, attitudes toward science, and factors that influence these attitudes will be discussed. Since interest in a topic is the focus of the current research, The definition of interest, students' interest in science, students' extracurricular activities and gender will be considered here.

At the end of this chapter the implications of the literature for the current research will be identified.

## 3.2. Culture

Culture is one of the sources from which education derives its components, orientations and goals (Barakat, 2016). Culture shapes people's perceptions of themselves and of the world around them and distinguishes one society from another, so it is likely to influence Saudi students' perception of the science, in and out school, and may help in interpreting the reasons for their perceptions and explaining differences between the views expressed by Saudi students and those of other societies. Therefore, the current section will discuss it as follows.

### 3.2.1. The Concept of Culture

One of the differences between societies is the culture that gives each society its particularity; it is the society's background in members' worldview, as well as their past and memory. Culture is a concept commonly employed in social science studies (Kasapoğlu & Ecevit, 2004). The English anthropologist Edward Burnett Tylor defined culture as "taken in its wide ethnographic sense ... that complex whole which includes knowledge, belief, art, morals, law, custom, and any other capabilities and habits acquired by man as a member of society" (Tylor, 1871, p. 1). Tylor thus defined culture as an expression of the universality of a person's social life, characterised by its collective dimension. Since it is acquired, it does not stem from biological heredity.

Culture is a complex concept that encompasses the ways that social life affects and informs our experiences. To quote the sociologist and cultural theorist Stuart Hall:

> Culture, it is not so much a set of things—novels and paintings, or TV programs or comics—as a process, a set of practices. Primarily culture is concerned with the production and exchange of meanings—the 'giving and taking of meaning' between members in a society or group… Thus, culture depends on its participants interpreting meaningfully what is around them, and 'making sense' of the world, in broadly similar ways (Hall, 1997, p. 2).

Hence, Hofstede defined culture as a "The collective programming of the mind which distinguishes the members of one group or category of people from another" (Hofstede, Hofstede, & Minkov, 2005, p. 3).

Focusing on a nation's culture means talking about people's faith, principles, regulations, history, heritage, and their interactions with other cultures, since they affect and are affected by other cultures (Alkhatimi, 2007). Culture forms and grows cumulatively in human memory from several components, including knowledge, beliefs, arts, literature, ethics, laws, norms, traditions, mental perceptions, historical, linguistic and environmental legacies that shape people's vision and way of thinking.

From the above, it can be seen that culture has two dimensions: first, an abstract dimension embodied in ideas, perceptions, values and attitudes. Second, a tangible dimension embodied in behaviours and practices that are a product of the first dimension (Mukhtaria, 2018). Hofstede (2011) divides this tangible dimension into four components by which cultural values are manifested and transmitted: Firstly, there are the collective processes of 'rituals', which have social significance for a culture, even if they are not practically essential for the attainment of the requisite aims. Indeed, such rituals are an end in and of themselves. Religious and social rituals, showing deference to people or welcoming them, are instances of rituals. Secondly, there are mythical, actual, deceased or living 'heroes' who may convey ideal and exemplary conduct or features that a culture values. Thirdly, there are objects, images, acts and words that provide 'symbols' within a culture, which only individuals within that culture comprehend the meaning of. Fourth, there are underlying 'values' that can only be deduced from the behaviour and concepts of individuals.

The same author developed a framework for understanding intercultural difference in values and their relationship to behaviour, based originally on a survey conducted between 1978 and 1983 involving more than 11,00 IBM employees across fifty-three countries. He identified four major dimensions of differences among societies in patterns of thinking, feeling and behaviour. Two others were subsequently added, but the first four are the most discussed. They are:

Power distance is "the extent to which the less powerful members of institutions and organizations within a country expect and accept that power is distributed unequally" (Hofstede et al., 2005, p. 521). In a large power distance society, children are taught to obey those in authority, such as parents and teachers, while in a small power distance society, children are treated more as equals.

Uncertainty Avoidance is

> the extent to which a society feels threatened by uncertain and ambiguous situations and tries to avoid these situations by providing greater career stability, establishing more formal rules, not tolerating deviant ideas and behaviours, and believing in absolute truths and the attainment of expertise (Furnham, 2005, p. 594).

Collectivism versus individualism

> Individualism pertains to societies in which the ties between individuals are loose: everyone is expected to look after himself and his or her immediate family. Collectivism as its opposite pertains to societies in which people from birth onwards are integrated into strong, cohesive ingroups, which throughout people's lifetime continue to protect them in exchange for unquestioning loyalty (Hofstede, Hofstede, & Minkov, 2010, p. 92).

Masculinity vs Femininity concerns the extent to which values such as solidarity, concern for the vulnerable, service, upholding friendly individual relationships and upholding wellbeing—linked to the female's position in the majority of cultures—are surpassed by those values predominantly connected to males' position in almost all societies, for instance rivalry, success, performance and dominance. There may be wider distinctions between male and female roles in certain societies compared with others, although all societies are characterised by some variation. 'Performance' societies are those where individuals are in 'hard' circumstances, with 'masculine' principles pervading and a significant distinction in female and male roles. Such hard values will even characterise females, although to a lesser degree than males. 'Welfare' societies are those where individuals are in 'tender' circumstances, with 'feminine' principles pervading and somewhat less distinction between the roles of males and females. Tender principles will even characterise males within a feminine society. It is apparent that male norms vary to a greater extent across cultures than female norms, given that there is wider variation in female and male values within specific masculine societies (Hofstede, 2011). Although Hofstede's work has been criticised on methodological grounds (McSweeney, 2002) other authors (e.g., Trompenaars ,1993, Schwartz , 1994, 2006) have identified relatively similar cultural distinctions, and Hofstede et al.'s (2010) dimensions have been validated in subsequent independent studies (listed by Hofstede et al., 2001).

### 3.2.2. Formation and Transmission of Culture.

People learn culture through associations with others, and thus it is not inherent, but rather a product of social existence that is passed on between generations and across geographical locations (Tengku & Sepideh, 2012). Personality and culture are connected through social development, during which the structures, principles and norms of a particular community are imported to members. Vygotsky's (1978) sociocultural theory, for example identifies how symbols, language and other aspects of culture are internalised via general experiences of socialisation, for example engagement in cultural and social activities, while children's comprehension and interpretation of the world is guided by more experienced members acting as cultural representatives (Vygotsky, 1978).

Many cultural concepts are acquired early in life, from sources such as parents, relatives, school, or religious traditions. These basic cultural concepts are further developed through interaction of the individual with his community. Important roles in socialisation are played by family, school and the media.

<u>The family</u> plays a major role in teaching children behaviour, customs and social values; what is considered right and wrong, good and bad, acceptable or unacceptable, their

rights and duties, how to deal with others and how to please the group as well as the family. The family decide what children eat, what they wear, the type of education they receive and the religious doctrine and political opinions to which they are exposed (Fayyad, 2015).

The school is the official social institution that carries out the function of transmission of culture via education. Children enter school with many social norms, values and trends inculcated by upbringing in the family. As their social circle expands in an organized form, they learn new social roles and behaviour (Maturi, 2016). According to Nakpodia (2010) and Gervedink Nijhuis, Pieters, and Voogt (2013) educational curricula have to be rooted in a society's culture, so that there is synthesis and complementarity between them. Juszczyk and Kim (2017) argue that students must be introduced to their culture from a young age, so that it can develop as they grow, and subsequently be passed on to the next generation. As a result, there is no such thing as a natural curriculum or a culturally neutral one, since every curriculum is drawn up on the basis of culture and political authority (Juszczyk & Kim, 2017).

The Media, today play an important role in the process of socialization and education, especially with the digital explosion taking place. The child learns via the media and communication; children are exposed to a wider range of experiences and skills, social relationship and attitudes, gradually modifying social values (Fayyad, 2015).

The strong influences of these forces do not mean, however, that culture is unchanging. Culture differs from one generation to another over time; it is dynamic (Verdu-Jover, Alos-Simo, & Gomez-Gras, 2018). Cultural change may come from many sources, but mainly through contact with other cultures, inventions and internal adaptation. Acceptance of change is not easy. While some societies welcome change, others put obstacles in the way of development and social change (e.g., through isolation), resulting in slow change or stagnation (Mukhtaria, 2018). However, today, isolation is more difficult, because of exposure to new ideas through international business and study, technology and the media. This could lead to cultural differences between generations, or educated and uneducated, urban and rural, those who have access to technology, and those who do not.

In the light of the foregoing insights, the next section examines the Saudi cultural context, and its impact an education and employment.

### 3.2.3. Cultural Context in Saudi Arabia

Saudi Arabia's society is highly religious, traditional, conservative and family-oriented, being significantly influenced by the Islamic and Arab heritage. However, the culture of Saudi Arabia experienced rapid change from the 1970s onwards, when the country, which was previously impoverished, drastically transformed into a rich commodity producer (North & Tripp, 2012).

A traditional feature of the structure in Saudi society is the distinct roles assigned to the genders. Whilst some have attributed the marginalised status of women in Saudi Arabia to Islam, others have identified cultural and social constructions of gender roles that have played a role in the development of Saudi's national identity along with reinforcing state control (Al-Rasheed, 2013; House, 2012; Kucinskas, 2010). Under patriarchy, traditional societal roles and the concept of male superiority and authority, men and women are typically allowed different levels of participation in public environments (e.g. restaurants, schools and so on). It is common for women to remain relatively isolated from the outside world, engaging only with family members and performing their role as housewives (Hamdan, 2005).

Thus, girls grow up under the constraint of many rules and restrictions, while boys enjoy significantly more opportunities to assert their independence. Upon reaching adulthood, every Saudi female's life must be strictly supervised by a legally recognised male guardian, who could be her father, her husband, or a close male relative. Women in Saudi Arabia must be accompanied by a male guardian if they wish to leave the house (Alsubaie & Jones, 2017). They also need a legal male guardian's approval to be granted bank accounts, legal documents and a passport. Moreover, until recently, women were prohibited from driving, so their access to education and work was dependent on a male relative or employment of a foreign driver (Tailassane, 2019).

As it is men who hold all the authority and influence in patriarchal society, women are made to conduct their lives in a socially acceptable way, which mainly centres around caring for children and looking after the home (Joseph, 1996; Sabbagh, 1996). This is broadly reflective of the role of women in other similar societies who are seen as being wives and mothers, whose role is not only to care for the home and family but also to ensure that the future generation of children are raised with the same expectations (Joseph, 1996).

Social constructions of gender in Saudi Arabia are reflected in attitudes to education and employment. Thus, "the purpose of educating a girl is to bring her up in a proper Islamic way so as to perform her duty in life to be an ideal and successful housewife and good mother" (Doumato & Posusney, 2003, p. 35). Men and women are naturally channelled to different programmes of study, consistent with what society perceives as their natural characteristics (Lörz, Schindler, & Walter, 2011). When looking for work, men and women seek circumstances that fit with what is expected of them. Women will, for example, look for situations that will leave them available to care for their children within certain hours. Men will seek courses that will help them obtain high-income careers, enabling them to fulfil their role as the family's financial provider (Evrikleia & Maria, 2007). Women are viewed as more sensitive, frail and easy-going, so considered best suited to managing the home and caring for the children. Men, on the other hand, are perceived as being balanced, powerful and in control and, therefore, better suited to being the providers and guardians of the family (Alwedinani, 2016).

This situation is evident in other countries, but particularly noticeable in Saudi Arabia (Alwedinani, 2016). One clear indication is that in subject areas such as humanities, women far outnumber men, yet science-related subjects are always male- dominated (Parker, Ashencaen Crabtree, Baba, Carlo, & Azman, 2012).

#### 3.2.3.1 Education in Saudi Arabia

Since Saudi cultural and societal norms highlight the differences between males and females, intermediate and secondary education is gender-segregated (Alghamdi, 2019). Consequently, male and female students attend different educational establishments that tailor their courses and approaches to the gender of their students, based on societal constructions of masculine and feminine interests and roles. For example, boys study physical education, while girls study home economics, and depictions of male and female in textbooks reinforce stereotypical gender roles (Abalkhail & Allan, 2015). Thus, within the school environment, female students are prepared for their future roles as married women with children, whilst male students are prepared for careers in science, research, and so on (Al-Hamid et al., 2007).

The gender difference becomes more obvious in secondary school than it is in primary and intermediate school, particularly during the last two years of study. During the first year of secondary school, all students follow the same curriculum, which includes English, mathematics, science, Islamic studies, computer science and administration/office management. In the last two years in secondary school, students choose one of the following majors: “administrative and social sciences or natural science or Shariah & Arabic studies” (Alghamdi, 2018, p. 12). However, students’ choices are limited based on their gender. Male students can choose to specialise in science and technology, administrative sciences, social sciences, or Islamic law, whilst female students can choose arts and humanities or sciences (but not geology, which is for boys only) (Al-Hamid et al., 2007).

When the Arabian Gulf States began to teach traditional science subjects, such as physics, chemistry and biology, in high school, they used imported American textbooks. These were not amended to make them relevant to the local culture or to make it easier for teachers and students to relate to the content (Alghamdi, 2018). It has been argued that science education should be linked to Saudi culture, and that this could help to narrow the enrolment gap in science subjects between boys and girls (Alghamdi, 2018), since there is evidence that attitudes students have to science are affected by their sociocultural backgrounds (Al-Balushi & Ambusaidi, 2015).

In line with Saudi Arabia’s high Power Distance, education is predominantly traditional and teacher centred, with predominant use of textbooks and rote learning (Alhammad, 2015). Therefore, Saudi students are not often taught in a manner that develops critical thinking, independent learning or research abilities; instead, they passively receive information that they then memorise in order to pass tests. Saudi teachers also focus on assessing students based solely on textbook and lesson content rather than on a combination of students’ knowledge and creative ability or independent thinking. Thus, Saudi students tend to struggle when asked to present their work to the class, to solve problems and use logic and to provide explanations and perspectives (Alhammad, 2015). It has been suggested that this approach results in negative attitudes toward science (Ali et al., 2013), and it is reported that some students would prefer to learn ideas from the environment around them, rather than solely from science textbook (Al-Balushi & Ambusaidi, 2015).

#### 3.2.3.2 Employment in Saudi Arabia

In the early years, the Saudi economy relied on traditional activities such as agriculture, grazing, fishing, commerce, and provision of services for pilgrims (Alabdulatif, 2006). Following the discovery of oil and resulting increased revenues, the Saudi government increased infrastructure expenditure, building new facilities which led to an increase in the demand for manpower (Fathy, 1993). In view of the scarcity of Saudis with the required competences, this need was met by recruiting employees from overseas (Shimon, 2014).

However, the government started at the same time to expend Saudi education, in addition to initiating overseas scholarships (Alabdulatif, 2006).

These measures have resulted in the emergence of graduate Saudi youth with scientific qualifications, who are able to fill administrative and educational positions which are mostly in the government sector (Alabdulatif, 2006), and are popular because they offer high financial return and job security compared to jobs in the private sector (Albanna, 2012). Also, with the availability of higher education, a cadre of graduates with bachelor degrees emerged, who were proud of their achievement, and sought jobs that set them apart from others in society. In the collectivist Saudi culture, academic success and a prestigious job reflect on the reputation of the family and community. Therefore, working in manual or inferior jobs became undesirable for Saudi youth and their families (Almadhari, 1999; Fathy, 1993).

However, Shimon (2014) notes that the perceptions of Saudi youth towards job are changing due to many factors, including changes in the labour market, saturation of the government sector, the enacting of regulations and laws which regulate the relations between employee and employer in the private sector, including minimum wage rates, the expansion in technical and professional education, in addition to the Saudization policy, requiring employers to substitute foreign expatriates with qualified Saudi competent citizens in some fields. Thus, many youths will now work in jobs which they would not accept before.

Changes in opportunities for women have, however, been slower. Saudi Arabia is considered one of the strictest Islamic countries, and conservative cultural attitudes towards women's education and careers resulted in a delay in girls' formal education, and more limited educational opportunities (Alsharif, 2019).

One factor limiting women's employment opportunities is gender segregation, which is applied not only in the education system, but also in most service sectors, such as banks. According to Alzahrani (2011) Saudis believe that separation will protect girls from harassment and also preserve their purity, a number of parents refuse to allow their daughters to work alongside men and indeed, many male and female students themselves reject mixed workplaces (Alqahtani & Omar, 2020). However, other voices in Saudi Arabia are calling for a lowering of these restrictions, and some now allow female family members to work in mixed workplaces, such as hospitals. This is more common among upper class educated families (Almunajjed, 2010; Alsalloom, 2015).

Recently, reforms have been undertaken in order to empower women and increase their participation in the labour market, leading to a strong debate over the role of women in society, as some Saudis fear that the changes run the risk of eroding traditional values within Saudi society (Alsalloom, 2015).

Male domination in the fields of engineering and architecture (Hamdan, 2005) has resulted in Saudi females, according to a survey Almunajjed (2010), being channelled into studying such subjects as Islamic studies, humanities, the arts, mathematics, chemistry, physics, biology and education (Alwedinani, 2016). However, opportunities for women have increased, allowing them to enrol in higher education in various subjects previously open only to men. For example, the industrial and electrical engineering majors are now open to women at King Abdul-Aziz University. Women are also now able to study in fields such as architecture, with courses available at private universities. A lessening of the restrictions on women in the workplace has enabled woman to work in many fields, as lawyers, bank tellers, salespersons and waitresses. Nevertheless, equality still does not exist; women comprise only approximately one-fifth of the workforce (Alhareth, Alhareth, & Dighrir, 2015).

Saudi Arabia's gender equality ranking on a global scale has consistently been below that of most other countries. In 2006, out of 115 countries, Saudi Arabia scored 114th on the Global Gender Gap. Although by 2017, Saudi Arabia's score had improved, still it ranked 141st out of 149 countries. This is reflected in the fact that 81.6% of working-age men were formally employed in Saudi Arabia, compared to 23.4% of working-age women (Abramowitz, 2021).

### 3.2.4. The Influence of Islam on the Saudi society

Islam shapes all areas of Saudi culture and society, with Shariah law and the Qur'an forming the foundation upon which the Saudi monarchy rules (Al-Atawneh, 2009), consistent with high Uncertainty Avoidance; religion offers absolute truths that provide certainty and clear rules for every situation. As Albugami and Ahmed (2016) highlight, the influence of Islamic values and beliefs can be seen to permeate every area of citizens' daily lives, with education being perceived as a major element of religious responsibility, regardless of gender. In Saudi society, the Qur'an provides a multifaceted and interwoven framework that provides citizens with a common moral code for everything from extended family structures and interpersonal relationships to tribal communities (Oyaid, 2009).

Religious studies are offered by one in every three primary schools in Saudi Arabia, representing over 50% of the national curriculum when combined with Arabic studies (Prokop, 2003). Islamic studies can also be chosen as a major in the higher education system, with courses being offered by one-third of the universities (Palmer & Palmer, 2007). The Saudi education system is designed primarily to guide students on the right path through the teachings of Islam (Nevo, 1998).

The emphasis on science as both a matter of faith and a field of study is highlighted by the Commission of Education Policy in the Saudi education system's science curricula. As Almuhesin (1999) explains, it is stressed that Almighty God is responsible for creation and the precise and spectacular state of the natural world. Islam asserts that research should be carried out with scientific objectivity, interpretation, and sound reasoning, and that rather than being contradictory to religion, science and religion are intimately and unquestionably intertwined.

According to the teachings of Islam, the acquisition of knowledge is an obligation imposed upon every Muslim, whether male or female. The Holy Qur'an, the religious book sacred to Muslims, explicitly states that men and women are equal, since both sexes share one origin and, therefore, have equal rights (Alsaleh, 2012). Islam states that women have an essential role to play within society, contrary to common beliefs, and the Prophet Mohammed (PBUH) emphasised that women and men have equal rights, including the right to work (Alsaleh, 2012).

However, there are substantial gaps between the teachings of the Qur'an and the manner in which it is practised (McDonnell, 2017). Therefore, it is important to separate religion and culture (Tailassane, 2019). Hamdan (2005) states that certain Muslim countries, such as Saudi Arabia, have deeply rooted cultural customs that deny women equal rights, and observers do not separate the cultural traditions from the religious principles, simply concluding that Saudi customs are part of the country's Islamic foundations. This issue is a complex one for Saudi women and has emerged from a range of social, political, and religious tensions and clashes.

### 3.2.5. A Comparison of Saudi Arabia with Malaysia and Turkey

"Religion is used primarily as a proxy for patriarchal preferences or the pervasiveness of traditional culture" (Braunstein, 2014, p. 61). Patriarchy is a system that ascribes women a subordinate position under the control and dominance of men. To ensure that men have power over women, a range of social customs, traditions, and roles act together, making it clear to women what they may and may not do and what men expect of them (Sultana, 2012). Various views on what makes up justice and equality between the sexes on issues come from the Holy Qur'an and the Hadith, which may be interpreted and applied differently in different countries (Noor & Malim, 2008).

Since this research compares Saudi students' views on science with those of students from other countries, it is interesting to compare Saudi Arabia with two other predominantly Muslim societies, Turkey and Malaysia. According to Jihad (2011) in "a widely accepted typology, relations between state and religion can be broadly divided into three categories" (p.5) : first, systems with an established religion such as Saudi Arabia, second, systems with strict separation between state and religion such as Turkey, and third, mixed systems such as Malaysia. In addition, these countries (Saudi Arabia, Turkey and Malaysia) differ in the scores on Hofstede's cultural dimensions: Power Distance, 95, 66 and 100; Individualism 25, 37 and 26, Uncertainty Avoidance, 80, 85 and 36, and Masculinity, 60, 45 and 50 respectively (Hofstede Insights, 2021). These cultural values, in turn, may influence students' attitudes towards scientific subjects. The following sections compare Saudi Arabia with Turkey and Malaysia in political, social, and educational terms.

#### 3.2.5.1 Political Structure

Saudi Arabia, the largest country in the Arabian Peninsula, is an absolute monarchy, where the king has ultimate power over legislative, executive, and judicial decisions, and he presides over the Council of Ministers. The 2019 Freedom House survey of global freedoms stated that Saudi Arabia's absolute monarchy limits virtually every type of political right and restricts civil liberties, and this absence of democracy and political freedom explains why Saudi women's rights continue to be limited (Tailassane, 2019). In contrast, Turkey, a Muslim state that lies partly in Europe and partly in Asia, is a republic with power vested in a secular representative parliamentary democracy. The citizens elect their president who, in turn, appoints the prime minister. Turkey gave women political rights including the right to vote, early in its history, before other Muslim countries in the Middle East, Asia, and Africa. Malaysia is situated in Southeast Asia, and its population is made up of Malay, Chinese, and Indian communities, as well as a minority of foreigners. The country's political system involves a federal representative democratic constitutional monarchy, in which women have the right to vote.

#### 3.2.5.2 Social Structure

The three countries are all patriarchal and predominantly Muslim. While Islam does not favour one gender over another and teaches justice and equality for all people, in the Muslim community, the patriarchal system dominates and is justified in religious and cultural terms, based on the belief that men are stronger and wiser than women (Salim, Nurdin, Sekarningrum, & Prengki, 2017). Islam recognises physical differences between men and women and gender differences in terms of performance and qualities, and in so doing, Islam differentiates the roles played by the genders in society. In Muslim society, the role of the man is to engage in the outside world and be productive, protecting and financially supporting the family, while the woman has a complementary role within the home, where she is responsible for bringing up the children and being a wife.

However, the three countries compared here exhibit different interpretations of male and female roles and relationships, reflected in their different scores on the Masculinity Index. Saudi Arabia is a highly gender-segregated country, which separates women and men who are not blood relations or linked by marriage at all social events, gatherings, and work environments. At the time when the current study's data were being gathered, women were still forbidden to drive in Saudi, the aim being to prevent women from leaving the home unaccompanied (Tailassane, 2019). Rules that prohibit women obtaining a passport, legal documents, or a bank account, without the approval of a legal male guardian, are justified by reference to Islamic principles.

The same is not true of Turkey, although it is also a patriarchal Muslim society, where male control is visible in many features of social life (Cinar & Ugur-Cinar, 2018). The influence of the revolutionary views of Mustafa Kemal Ataturk saw women being allowed to vote, the eradication of polygamy, and a higher public presence for women. Nevertheless, these radical changes did not dismantle patriarchy, for as Salim et al. (2017) note, a woman's primary role is still considered to lie in the domestic domain as wife and mother. It has been said that Turkish women may have been emancipated, but they are still waiting to be liberated (Cinar, 2019).

In Malaysia, too, patriarchal values continue to have a strong impact on women's lives. Abdullah, Noor, and Wok (2008) describe Malay women as in a no man's land, caught between tradition and the modern world. While Malay women can engage in paid employment, they are still expected to look after their families and conform to traditional images of a woman. There are few female entrepreneurs in Malaysia, since women find it difficult to secure funding, combine work with family duties, or acquire support from their families (Selamat et al., 2016).

The 2020 Global Gender Gap report ranked Saudi Arabia 146th, Malaysia 104th, and Turkey 130th out of the 153 countries included in the survey. This demonstrates that women continue to have a lower economic, political, and social status than men in these countries, when compared to other countries with a similar economic standing (World Economic Forum, 2020).

#### 3.2.5.3 Educational Structure

Consistent with the country's high Power Distance the Saudi Arabian education system has a highly centralised administrative structure, with the Ministry of Education having its own dedicated department responsible for developing and setting the national curriculum. Saudi education aims to provide learners with broad knowledge and new skillsets whilst also guiding students' behaviour in a productive direction (Al-Hamid et al., 2007). High Uncertainty Avoidance is reflected in the concern to inculcate Islamic ideology and beliefs, to provide students with a full understanding and interpretation of Islam and its texts, and to encourage them to embrace and share the teachings of the faith (UNESCO, 2010). Islam is the bridge between religion, citizenry, and education in Saudi Arabia, and it is the foundation and heart of all education. The Saudi Ministry of Education (1969) states that the goal of Islam is to create an intelligent civilisation, founded on the message of the Prophet Mohammed (PBUH), which will lead to happiness in this life and in the afterlife. The Islamic curriculum is mandatory for all students, whether they are attending public schools, private schools, or international schools. The subjects covered include: the Qur'an, the Hadith (the sayings of the Prophet), the Tawhid (the declaration that there is only one God), and the Fiqh (which looks at how religion applies to everyday life). Students also take subjects such as Tafseer (the study of the Qur'an's meaning) and Tajweed (how to read the Qur'an).

According to Baki (2004), the Saudi education system buttresses the country's social order and traditional customs, since women and men are taught that the subjects they take and the activities they do depend on their gender and on society's expectations for their behaviour. It has been argued, from the perspective of social reproduction theory, that all institutions in Saudi Arabia, including its education system, are shaped by patriarchy (Alwedinani, 2016). Saudi Arabia's higher education institutions act as agents for the patriarchal system by mirroring societal norms and segregating subjects according to gender. For example, only men are encouraged to study aviation, which is traditionally a male activity, while women are taught hairdressing, cooking, and textiles, in line with their domestic roles.

In Turkey, the Ministry of National Education is responsible for the country's education system. According to The Constitution, all citizens have a right to receive education (Polatcan & Polatcan, 2015). The declared aim of the education system is to produce broad-minded, productive, and happy individuals who have a national consciousness and come together to build a united state, creating a prosperous society through their abilities and skills. All Turkish children must attend school for 12 years: four years of primary school, four years of elementary school, and four years of high school. The starting age for school is 60 to 66 months old (Gün & Baskan, 2014).

In addition to general public or private schools, at elementary and secondary level there are so-called by Imam Hatip religious schools, while high schools include general high schools, schools specialising in teacher training, Science, Social Sciences, Fine Art or Sport and vocational and technical schools. The term *higher education* covers every educational institution that offers secondary education or a minimum of two years of higher education (Baysu & Agirdag, 2019).

In 2015, the Turkish Ministry of National Education launched a project to raise awareness of the need for gender equality among parents, students, and educational staff (Cin, 2017). Durakbaşa and Karapehlivan (2018) state that, when compared to the averages in other Organisation for Economic Co-operation and Development countries, Turkey has a fairly balanced distribution of genders across higher education disciplines. Moreover, highly educated professionals include a significant percentage of women, which implies gender equality. However, a visible gap between the genders is reflected in high levels of illiteracy and low rates of schooling and vocational skills among women in rural Turkey and in low socioeconomic classes.

In Malaysia, the federal government is responsible for the overall education system, but states and federal territories have their own education departments that monitor and organise education in their sectors. The declared aim of education in Malaysia is to produce holistically integrated people, who have an emotional, physical, intellectual, and spiritual equilibrium, which is further enhanced and developed by their piety and shared belief in God (Al-Hudawi, Fong, Musah, & Tahir, 2014).

Children start primary school at the age of six and remain there for six years. Since Malaysia is a multinational federation, the Malay, Chinese, and Tamil communities receive primary education in their own language (Kenayathulla, 2015). Secondary education, for ages 12 to 17 years, lasts for five years. For the first three years, students have to take at least eight subjects, including the Malaysian language, English, science, history, geography and mathematics. Optional subjects include Islamic studies, moral education, life skills, European languages, and mother tongue studies. After these three years, they sit for the Secondary Education Assessment Exam. Successful students can apply for the second part of their secondary education, including two-year field-based courses in which schools offer academic, technical, vocational, and religious education (Polatcan & Polatcan, 2015). Higher education in Malaysia is provided by higher education institutions, technical schools, and public and private universities.

Until the 1960s, Malaysian society believed that women should stay at home and carry out their domestic duties or, if educated, should choose a so-called feminine occupation, such as teaching or nursing (Ariffin, 1992). This attitude has changed over time; in 2010, women made up 60.1% of undergraduates attending public universities (Lim, 2019) However, Karim (2009) notes that gender stereotyping has remained, and even at the tertiary education level, women are more likely to take an arts course than specialise in Science, Technology Engineering, and Mathematics (STEM) subjects. In 2019, United Nations International Children's Emergency Fund (UNICEF) found that Malaysian women are more likely to study the arts, science, or technology than their male peers, but they do not enrol in large numbers for technical and vocational courses.

In summary, Turkey and Malaysia share many similarities: they are democratic republics where women have the right to vote, and there is a clear separation between the state and religion. In contrast, Saudi Arabia is a monarchy based on religious and tribal affiliations, Islam plays a major role in shaping every element of social and political life (Alkhidr, 2011), and the legal system is founded on Sharia law. Although all three societies maintain that women should be responsible for the home and children, Saudi women face greater challenges and more gender-based discrimination in many areas of their lives. The education systems in all three countries are centralised and based on a transition from elementary schools to higher education. In Turkey and Malaysia, the education systems allow for genders to mix, and religion is an optional subject. In contrast, Saudi Arabia has made the study of religion mandatory at every educational level, and every school is a single-sex institution.

## 3.3. **Attitudes**

This section takes as its point of departure the literature on the impact of student perceptions of, and attitudes towards, science and technology in influencing their approaches to studying in this field, particularly in the upper levels of schooling.

As Guenther and Weingart (2016) have detailed, a new paradigm emerged in the 1970s which held that scientific and technological innovation lay at the heart of positive social and economic outcomes for nations. A significant element of that push was a renewed focus on science education, and advances in this field were also sought, with a particular focus on innovative approaches to teaching and learning (Kenar, Köse, & Demir, 2016). While it has long been seen as an important factor, it is since this paradigm shift that scholars have increasingly focused on the role of student motivation or ‘attitudes’ in influencing learning outcomes (Potvin & Hasni, 2014). As Lado (2011) has observed, student perceptions of science and technology as a human endeavour have also come into focus, with the underlying assumption being that those perceptions and attitudes play a crucial role in shaping students’ decisions about whether or not to pursue studies in this field. Other scholars have argued that attitudes towards science and technology are not in any sense ‘innate’ and that positive approaches can be actively cultivated (Kenar et al., 2016). School is a critical context in this regard; in particular, the periods of formative education when childhood attitudes are most obviously being formed. In this regard, as Lado (2011) has found, student engagement in science and technology studies can be strongly influenced by teaching methods in classroom instruction at the primary education level and how teachers engage students’ attitude in the subject is critical.

### 3.3.1. Attitude Definition

Attitude can impact upon individual behaviour, and, consequently, a wide range of research has been applied in this area. The primary focus of this work has been on seeking to define attitudes and discussing how these definitions may be influenced by the setting in which they are adopted. While numerous definitions have been advanced, Bennett (2005) has proposed that a psychological approach is the most effective method by which to gain an in-depth understanding of attitudes.

According to Jain (2014) attitude can be described as “the affect for or against the psychological object” (p.2). Essentially, this author was seeking to evaluate attitude as a concept. Although this definition was at a late stage and it focuses on attitudes’ emotional impact, nevertheless, it highlights that there are challenges associated with arriving at a consensus on what attitudes constitute. In an early perspective on attitude, Allport (1935), described attitude as the appearance of individual behaviour arising from the combined effect of mental processes and various subjective experiences. As a result, he defined attitude as “a mental or neural state of readiness, organised through experience, exerting a directive or dynamic influence upon the individual’s response to all objects and situations with which it is related” (p. 810). Despite being first advanced over eight decades ago, Saleh and Khine (2011) believe that this definition has been used and impacted upon numerous researchers and strategic approaches in this area.

Allport’s Allport (1935) definition of attitude centred on mental activity, while a later example put forward by Eagly and Chaiken (1993) suggested that attitude primarily focuses on psychological tendencies. The definition they proposed contains a combination of a number of different concepts;

> an Attitude is a psychological tendency that is expressed by evaluating a particular entity with some degree of favour or disfavour. Psychological tendency refers to a state which is internal to the person, and evaluating refers to all classes of evaluative responding, whether overt or covert, cognitive, affective or behavioural. (Eagly & Chaiken, 1993, p. 1).

Generally, the majority of researchers appear to agree that

> Attitude is a state of readiness, a tendency to respond in a certain manner when confronted with certain stimuli. Most of an individual’s attitudes are usually dormant and are expressed in speech or behaviour only when the object of the attitude is perceived.... Attitudes are reinforced by beliefs (the cognitive component) and often attract strong feelings (the emotional component) which may lead to particular behavioural intents (the action tendency component) (Oppenheim, 1992, p. 174).

Referring specifically to science, Kind, Jones, and Barmby (2007) suggested that attitude toward science can refer to an individual's feeling about science, founded on his or her own knowledge and belief about science.

Three key components, namely cognitive, affective and behavioural have been identified by Barmby, Kind, and Jones (2008), as exerting a significant impact on the general attitude held towards science. These components have been described in further detail, as follows, by Reid (2006):

1. Cognitive factors refer to knowledge, opinions and thoughts held in relation to a specific object.
2. The affective component focuses on feelings (positive or negative) evoked by the object, positive or negative.
3. Behavioural aspects are objective in nature, also involving the triggering of action tendencies.

Gardner (1975) argued that attitude always involves a particular "attitude object", which can elicit individual reactions. He highlighted that attitude towards science refers to opinions and visual impressions which emerge arising from exposure to diverse experiences and influential factors, within various contexts. Essentially, Nieswandt (2005) defines attitude as the extent to which an individual is favourably disposed or otherwise, in this specific case to the subject of science. According to Crawley and Koballa (1994) a positive or negative attitude towards science may be induced, depending on the individual's feeling about science.

To conclude, attitude towards science is a reflection of both the emotional response a student exhibits to it, as well as his or her overall level of knowledge. These factors will, in turn, impact upon his or her behavioural response to science. Therefore, multiple factors typically impact upon students' attitudes towards science, which can be induced by their experience either inside or outside school activities (Bennett, 2005; Raved & Assaraf, 2011). Consequently, it is worth differentiating between these two groups of factors, which affect students' attitudes. The following section will therefore discuss this difference in students' attitudes towards science and technology and attitudes towards school science.

### 3.3.2. The Diversity in Students' Attitude Toward Science and Technology

Although students' attitudes toward science often show distinctions and variety, the common attitude toward science and technology is typically positive (Sjøberg & Schreiner, 2010). Nevertheless, other research (Hussain & Akhter, 2016; Sarwar, Naz, & Noreen, 2011) has emphasised the variation in science and technology attitudes among students. Consequently, there are some studies that have focused on science's perceived social significance among students, while others have investigated students' attitude toward science with regard to their educational programme. Whereas students' attitudes towards school science are formed by their daily experiences in school, attitudes towards science in general are formed by their experiences outside the school.

### 3.3.3. Attitudes Toward Science

The Relevance of Science Education (ROSE) project examined students' attitude towards science, and it found that young people were favourably disposed towards science and technology (Sjøberg & Schreiner, 2010). The authors attributed this to the belief, commonly held by this cohort, that these subjects promoted healthier lifestyles, along with making daily living less demanding and more enjoyable. Similarly, Jenkins and Nelson (2005) found that students displayed an overall positive attitude towards science, which they considered to be both interesting and beneficial. Additionally, the National Foundation for Educational Research (2011) found that when students were asked about science's ability to improve human wellbeing and strengthen technological progress, they tended to answer positively. For example, economic progress, as well as the identification of cures for cancer, HIV/Aids and other ailments, are associated positively with science by learners (Jenkins & Pell, 2006).

The economic growth levels within a country have been identified by Sjøberg and Schreiner (2005) as a key determinant in the selection of science and technology as a career option for its young people. Among the major problems developing countries inevitably face are improving overall living conditions, promoting economic growth and enhance existing health and welfare support systems. Enhancing material living standards is clearly of both public and political concern, with science and technology being regarded as providing a mechanism to further advance these objectives. Hence, being gainfully employed within the science and technology sector is seen as a positive achievement, both from a subjective perspective and in terms of significantly contributing to the wider society. Sjøberg (2002a) noted differences in attitudes between developing and developed countries, whereby in the former, young people characterised scientists as 'heroic'. Conversely, in developed countries, younger people do not necessarily regard scientists or engineers as heroic or as role models worthy of emulation.

Sicinski (2000) suggested that individual expectations associated with economic development are inherently linked with the advantages deemed to be associated with science and technology. Late modern societies are generally regarded as post-materialistic societies, which promote the values of democracy, environmental protection, self-actualisation and care for others (Inglehart, 2018). In Western society, the demand for places on courses in medicine, biology and environmental studies continues to remain high, with a larger proportion of females enrolling, as opposed to male students. This trend could signal that young people living in developed nations are of the opinion that the major problems modern society have to contend with are health and environment-related. Thus, gaining knowledge in these areas provides a greater prospect of subsequently engaging in worthwhile employment.

However, according to Nelkin and Elias (1996), sometimes the media can play a very powerful role in presenting science in a sensational manner. Some such examples include publishing news items which are orientated in a specific direction, presenting contentious issues as undisputed fact and portraying scientists as superior and completely detached from daily life. Christidou (2011) asserts that the level of interest, perceptions and attitudes towards popular science held by the general public, as well as young students, are largely shaped by mass media, print media such as magazines, the film industry, and the Internet, amongst others. Similarity, Reiss (2004) has argued that students' attitudes towards science are also influenced by conditions external to the school setting, such as cultural factors, the media, government-led policies, overall technological skill proficiency levels and the national economy.

### 3.3.4. Attitudes Towards School Science

Students' attitudes towards school science are shaped on a day-to-day basis by the school curriculum. In addition, the content-specific pedagogical approach adopted influences both the level of exposure students have to the subject within the school, as well as their attitudes towards school science (Reiss, 2004). Similarly, Kind et al. (2007) have identified that important determinants of attitude to school science include the science classroom environment, science content and attributes of the science teacher. The approach that science teachers adopt when teaching, as well as their manner of interaction with their students, are two of the factors on which students rate their teachers as positive or negative, enjoyable or boring and interesting or uninteresting.

Research has shown that students perceive a significant disparity between science-in-society and science-in-school, which impacts on their attitude towards school science (Christidou, 2011). They believe that, as a subject, school science is unattractive, as it fails to include topics that are of interest to students. Consequently, it does not offer a forum through which to demonstrate their creativity, along with being viewed as somewhat separated from real life situations. As a result, studies have found (McSharry, 2002; Siegel & Ranney, 2003) that this has led students to claim that science lacks practicality and has little social application in daily living.

In addition, Bennett, Hampden-Thompson, and Lubben (2011) have identified that student attributes also influence attitude to science within school settings, for example, age, gender, socioeconomic group and ethnic background. Multiple studies have examined the impact of gender on participation in science, technology, engineering and mathematics (STEM), whereby relatively fewer females select these subjects, most notably physics, but also mathematics and physical science. Furthermore, research has found that male students attending co-educational schools are more inclined to study physics, as compared to their single-sex school counterparts. Conversely, a greater percentage of female students attending all-girls schools, as opposed to co-educational settings, select physics as one of their A-level subject choices (Bennett, Lubben, & Sharpe, 2013b).

Butt, Clery, Abeywardana, and Phillips (2010) proposed that students have a difficulty in identifying the relationship between science and their daily activities. As the Wellcome National Foundation for Educational Research (2011) related, students' lack of enthusiasm for science is usually associated with the lack of a link between the science curriculum and real-life application. As result of that, during the first years of secondary education, a strong decrease in positive attitude toward science is noticeable, as is increasingly apparent in the existing literature. The severest fall in positive attitude toward science has been found from 11 to 14 years of age, although from 11 to 16 a general fall was observed (Bennett & Hogarth, 2009). Further still, science's lack of significance to individuals' daily activities and its challenging nature are typically emphasised.

Consequently, it has been suggested that the association of ethical issues and practical contexts with the science curriculum may give science greater relevance to students' lives (Murray & Reiss, 2005). The perception among young students that science is challenging or uninspiring has an effect on 40% of them, according to Wellcome Trust Monitor's research (Butt et al., 2010). In particular, the Wellcome National Foundation for Educational Research (2011) found that physics was considered 'very boring' or 'boring' by 50% of students completing the survey (Oversby, 2005). Moreover, the perception that one's daily activities are not affected by the kind of technology and science knowledge learnt at school, a lack of encouragement of inquisitiveness, poor careers guidance, alongside a lack of interest of school science compared to the majority of subjects, were found in the global research included in the ROSE report (Sjøberg & Schreiner, 2010).

Students' educational choices are affected by their attitudes toward science and technology, which can vary considerably, given that they are shaped by the extrinsic and intrinsic variables outlined above. The variables affecting students' attitudes towards science and technology are discussed in the following section.

### 3.3.5. Influences on Attitudes

Technological developments are occurring today at an increasing rate as funding for science and the frontier of our scientific understanding and technological knowledge constantly expand. This pace of change in the contemporary world poses a set of distinct challenges for the teaching and learning of science. In particular, there is the challenge of how studies in science and technology are integrated with other fields such as history, geography, mathematics, English and other languages. Indeed, as Narmadha and Chamundeswari (2013) find, the breadth of subjects under study today is greater than it has ever been. For this reason, students' attitudes play an increasingly important role in predicting students' choice of study programme, including in the fields of science and technology.

It was mentioned previously that teachers can play a very important role in influencing the attitudes of their students in relation to science and technology studies. At the same time, a range of other crucial factors – including students' personal experiences and individual motivations and objectives – are strongly associated with attitudes to studying science and technology (Fazey & Fazey, 2001; Jenkins & Nelson, 2005). Moreover, a growing body of research has catalogued a wide range of other influences on students' attitudes toward science, including macro-variables such as culture and, especially, gender. Environmental elements, such as the quality of science teaching, the impact of the attitudes of friends and family and other role models, have also been identified (Mutua & Sunal, 2004; Okonjo, 2000; Okwach & Abagi, 2005; Osborne, Simon, & Collins, 2003). Nieswandt (2005) finds that the curriculum can have a significant impact. A study by Rana (2003) identified three key variables – the socioeconomic status of parents, the self-concept of students, and gender – to be the key determinants of student attitudes to science education. As Anwer, Iqbal, and Harrison (2012) recently discussed, the range and number of factors that influence students attitudes' to science is thus extensive and complex.

Potvin and Hasni (2014) undertook a meta-analysis of 228 studies on student perceptions of and attitudes towards the study of science and technology. They found seven emphasized teacher qualities – particularly teacher enthusiasm, encouragement, and support – as the preeminent aspect. A further six studies focused on what Potvin and Hasni (2014) labelled 'meaningful learning', including aspects in the classroom such as 'hands-on', 'inquiry-based' learning (two studies), effective laboratory conditions (two studies), and learning environments that encourage critical thinking (one). One of the studies found that even among students that believed science and technology to be socially beneficial, very few believed scientific learning through the media or textbooks was enlightening or enjoyable. Five papers that emphasized the challenges associated with science teaching and learning and knowledge acquisition – excessive note-taking, memorization, formulaic teaching methods, and written exercises – but this did not mean that students were opposed to traditional methods such as examinations over more contemporary methods of assessment.

Given the multiplicity and complexity of causal factors, each of these above-mentioned influences will be discussed in further detail below.

#### 3.3.5.1 Gender

Gender is a major contributor to student attitudes to science and technology studies (Akcay, Yager, Iskander, & Turgut, 2010). The majority of research conducted on the impact of gender on science learning attitudes focuses on students in middle and high school (Hacieminoglu, 2016). Osborne et al. (2003) draw attention to the growing amount of research that has illustrated conclusively gender differences in science education attitudes.

Among these many studies, Sofiani, Maulida, Fadhillah, and Sihite (2017) find that while both genders have positive attitudes toward science and technology in general, it is boys that demonstrate a more pronounced proclivity to studying these fields (Smith, et al., 2014). The generally more positive attitudes of boys towards science and technology studies over girls were confirmed by (Jebson & Hena, 2015).

At the same time, some studies have found no gender impact on attitudes toward science and technology studies. An example is Reddy's study (2017) of students' attitude towards science and the influence of gender. He surveyed on 547 students, studying in Grade 7, from an urban area of Gauteng Province (South Africa). Another example is Sofiani et al. (2017), who investigated 77 secondary school students' attitudes towards science and the gender influence on students' attitude in Bandung, Indonesia. Both studies concluded that gender did not play any role in the students' attitude toward science.

Likewise, a study that was done to compare mixed- and single-sex classes found no significant differences in student attitudes toward science (Brown & Ronau, 2012). In contrast, another study found that teenage girls reported more positive attitudes to learning science than boys (Else-Quest, Mineo, & Higgins, 2013). However, in their study on the impact of live simulation on middle-school students' enthusiasm for science in three USA states, Chen and Chen and Howard (2010) found that boys generally showed higher levels of interest than girls, although simulations had a positive effect on both genders in general. Moreover, in a study by Çepni, Taş, and Köse (2006), to explore the effect of Computer-assisted Instruction Material in classroom instruction in Turkey, involving two different 11th grade classes taught by the same teacher, the researchers found that the use of computer aids in classroom instruction had no discernible effect on interest in science for students of either gender.

Thus, the previous studies suggest that gender may be one among several factors influencing students' attitude toward science, but the results are conflicting and inconclusive.

#### 3.3.5.2 Students' Experiences and Characteristics

An additional set of 'internal' factors influencing student attitudes, as mentioned, is individual personality and life experience. Glogowska, Young, and Lockyer (2007) found that self-determination and a commitment to pursuing a professional career in science influenced students' attitudes toward the field significantly. The authors also pinpointed a range of other individual personal circumstantial factors, including financial resources and motivation to find employment, health and well-being, and the encouragement of family and significant others as crucially important. Another study found that particular aspects of student behaviour – such as work and study techniques and coping strategies, as well as motivation to succeed, were crucial determinants of perseverance and long-run success in the study of science and technology (Suresh, 2006).

#### 3.3.5.3 Teachers and Teaching of Science and Technology

Students' attitudes toward science are also affected by the standard of technology and science instruction they receive. Raved and Assaraf (2011) found that with regard to remembering and understanding science knowledge, varied practical supports and diverse teaching practices are prominent aspects of strong science classes, which promote enthusiasm and enjoyment. Furthermore, negative effects on students' attitudes toward science have been associated with reliance upon textbooks and traditional pedagogical approaches (Ali, Yager, Hacieminoglu, & Caliskan, 2013). It has been suggested that a traditional lecture-based format, with the teacher speaking to a group of students to convey information and learners simply listening and completing homework, is the standard approach for the majority of classes, rather than the adoption of an array of instructional techniques (Raved & Assaraf, 2011).

Christidou (2011) explained that the practice of teaching science in a manner distanced from students' daily life is common among science teachers, which has a detrimental impact on students' attitudes, in the same way that instructional techniques, textbooks and curricula can have negative impact. Ultimately, if ethical quandaries and familiar contexts from daily life are drawn on to provide science education, this may strengthen the curriculum (Murray & Reiss, 2005). For example, the practical utility of science to daily activities was a particular reason for over 50% of Year 9 learners believing that learning science would be beneficial for them after they left school (Bennett & Hogarth, 2008).

Another influence on students' perceptions about the difficulty of science (and their attitudes towards it) that has been identified is the declining level of direct teacher support that comes as students advance through school and become more academically independent (Rice, Barth, Guadagno, Smith, & McCallum, 2013). The support of teachers as students' progress from middle school to high school is crucial, and teachers remain a vital source of positive and engaged classroom behaviour in this regard, especially in relation to mentoring for independent study habits in science and technology (Ahmed, Minnaert, van der Werf, & Kuyper, 2010; Barth et al., 2011). Furthermore, students' attitudes toward science are affected by the characteristics of the teacher (Mihladiz & Duran, 2014; Raved & Assaraf, 2011). As Butt et al. (2010) noted, almost 52% of young students explained that a bad teacher undermined their enthusiasm for studying science, while 47% of such students explained that an effective teacher was inspiring, based on a Wellcome Trust Monitor questionnaire.

To summarise, beneficial or detrimental effects on students' attitudes toward science and technology may be influenced by a number of variables related to pedagogical approaches and educators, beyond the issues with text-based learning and curricula.

#### 3.3.5.4 Parental Influences

Lado (2011) and Mokoro, Wambiya, and Aloka (2014) are representative of the varied literature that has identified a relationship between parental effect and children's attitudes toward science. Saleh and Khine (2011) also identified that positive or negative perceptions and decisions associated with science are significantly affected by both parents' approaches. They found that young learners of both genders would be supported in their positive attitude toward science and pursuit of science education by most Turkish parents. However, in the UK, fathers were found to have less effect on students' attitudes toward science than mothers (Breakwell & Beardsell, 1992). It is also apparent that girls receive less maternal support than boys do, for pursuing science education (Lado, 2011).

Rice et al. (2013) found that parents – through their approach to supporting, encouraging and modelling positive expectations – play a major role in their children's academic self-perception and choices of subjects for study, and the majority of students identify with their parents´ wish and adopt it as their own. A number of studies have explored the influence of parental attitudes and behaviours on students' attitude towards science and technology. Cao, Bishop, and Forgasz (2007), for example, conducted research in China and Australia that investigated the influence of parents on students' learning in maths and science. Another study explored parental attitudes and the effects of ethnicity on students' attitudes toward studying science in the USA (Alrehaly, 2011). An important piece of research by Oloruntegbe (2012) looked at the influence of parents in the development of positive associations with science in their children through parental engagement in 'everyday' scientific aspects at home and in the local neighbourhood. A study on Nigerian lower-secondary school students examined the link between parental literacy levels and their children's educational attainment in science (Oludipe, 2009). Nigerian children were also the subject of Oluwatelure and Oloruntegbe (2010) looking at parental engagement in their children's biology and chemistry studies and how this influenced learning outcomes in these subjects.

Encouraging and supporting children while doing their homework, as well as visiting museums and libraries in order to facilitate enthusiasm for science education, are ways in which parents can contribute positively in their children's attitude toward science (Perera, 2014). Sun, Bradley, and Akers (2012), in the Hong Kong context, investigated variables affecting science attainment, by means of a multi- level analytical technique and PISA data. They found both father's and mother's attitudes towards science to be a statistically significant factor impacting other student and school variables. Children's subject selection and their attitudes have been found to be considerably affected by parents in numerous existing studies. From the above cited evidence, parents can be identified as a significant variable, among a number of other crucial variables affecting students' perspectives.

#### 3.3.5.5 Culture

Saleh and Khine (2011) found that in various states, pursuit of science-related professions such as farming, forensic science and health, as well as students' general attitudes towards science, are impacted by culture. Indeed, the impact of culture has been attested by a number of studies. For example, learners' decisions on which subjects to pursue during their education, as well as their perspectives of technology and science, were assessed in relation to the effect of national culture in Hofstede and Hofstede's (2001) renowned research. Additionally, it has been found that compared to developing countries, more positive perspectives of science are held by learners in Africa, with the effect of national culture being significant (Jenkins & Nelson, 2005). Given that relatively few scientists emerge from the African continent, this result may seem paradoxical.

Moreover, learning of science subjects can be influenced by local culture, which remain relevant to and influential on students' life away from the school. Alshammari, Mansour, and Skinner (2015) found that greater benefit from science education is acquired by learners when their daily activities are reflected in and related to the syllabus they are learning. Thus, the pursuit of scientific knowledge may be in contention with the comprehension of science that learners have in Saudi Arabia, due to the specific cultural and social context (Alhammad, 2015). Additionally, learners' perspectives of science education in Kuwait have been found to be affected by a lack of connection of the curriculum to the Islamic religious tenets underpinning the culture and society (Alhammad, 2015).

Ultimately, students' perspectives of and attitudes toward science and technology education have been found to be shaped by the structural factors of culture and gender, across a number of studies. Thus, as Jones, Howe, and Rua (2000) found, with gender typically being powerfully constructed by culture, particular subjects such as engineering, mechanics, science and technology have also traditionally been 'gendered' as more preferable for women or men to pursue, or more inclined to reflect their interests.

Additionally, career ambitions have been found to be affected by a number of motivational variables, of which gender differences are posited as relevant by various discriminant studies. Koul, Lerdpornkulrat, and Chantara (2011) identified that in terms of career choices, gender roles as shaped by culture are an important consideration. Nevertheless, in a study in Turkey by Örnek (2015), pursuit of science or science-based careers by women and men was not found to differ significantly. Therefore, Örnek (2015) proposed that an interrelationship existed in terms of the effect on science and science-related careers from culture and gender. Thus, as the existing literature has identified, attitude is fundamentally shaped by culture as one of a number of variables affecting students' attitudes towards science.

## 3.4. **Interest**

Recent empirical evidence has indicated that learners' interest in a topic can promote their level of academic attainment by elevating their cognitive engagement and affective state. Schraw, Flowerday, and Lehman (2001) demonstrated that intrinsic motivation is positively influenced by interest, while Harackiewicz, Tibbetts, Canning, and Hyde (2014) reported on the positive association between academic attainment and learner interest. In their analysis of the influence of learner interest, Krapp and Prenzel (2011) cited its beneficial effects on previous knowledge synthesis and attention levels, as well as capabilities ranging from recognition, persistence and academic motivation, to recall and effort.

This study examines the views of students and their interest in science. The following sub-sections include definitions of interest and a review of the literature which investigates students' interest in science, their extra-curricular activities and gender differences in interest in science.

### 3.4.1. Interest Definition

There is no definitive definition of 'interest' in the literature. Different researchers place different meanings on the word. Prime suggestions are curiosity, enjoyment and motivation (Silvia, 2006; Swarat, Ortony, & Revelle, 2012). The meaning of the term "interest" typically depends on the context, with definitions commonly linking it to terms such as attitude, curiosity and motivation (Ramsden, 1998). Some researchers consider 'attitude' and 'interest' to be equivalent terms (Schreiner, 2006; Sjøberg & Schreiner, 2004), while others have suggested that the latter is a type of the former (Osborne et al., 2003). That is to say, interest is sometimes viewed as a subordinate concept, namely, as a type of attitude marked by a particular object area. However, other scholars view attitude and interest as distinct (Gardner, 1998).

Yet, interest has a vital role to play in stimulating learning. Personal motivation is connected to personal interest (Uitto, 2014). Some researchers (Hidi, 1990) consider that the process and outcomes of mental health activities are highly stimulated by interest. Although there is close similarity between interest and motivation, they are differentiated by the fact that motivation is intrinsic and derived from a self-generated inner drive, whereas interest refers to 'a person's interaction with a specific class of tasks, objects, events or ideas' (Logan & Skamp, 2013), namely, external stimuli.

The psychological effect of connecting or reconnecting with material objects, ideas or incidents over a period of time as an aspect of interest has been defined by Hidi and Renninger (2006) as a 'motivational variable'. Defining interest as a content-specific motivational characteristic (Schiefele, 1992) leads to definite choices for specific subject areas (Schiefele, Krapp, & Winteler, 1992). Other researchers such as Schraw and Lehman (2001) have defined interest as voluntary involvement in an enjoyable cognitive activity.

Interest derives from a relationship between the individual and an object (Schiefele et al., 1992), which can be a tangible or a material item, an idea or an issue conceived externally. It is complex and multifaceted, bearing cognitive and affective dimensions (Hidi & Renninger, 2006; Krapp, 2002). Interest can be considered individual or situational: "individual interest refers to a person's relatively enduring predisposition to reengage particular content over time as well as to the immediate psychological state when this predisposition has been activated" (Hidi & Renninger, 2006, p. 113). Individual interests lead to preferences for particular activities or subjects of knowledge (Bergin, 1999), which evolve slowly but can prove to be enduring. A positive affect and persistence can be constructive elements of the learning process and may result in the benefit of supplementary knowledge (Swarat et al., 2012). Gradually, individual interest can be absorbed into and form part of a person's subconscious ethical code. It has been postulated that people maintain a programme of individual interests within themselves, which are activated when a person is faced with a situation that relates to a particular interest. The particular individual interest is mobilised, which in research is termed 'actualised individual interest' (Schraw & Lehman, 2001).

Conversely, "Situational interest refers to focused attention and the affective reaction that is triggered in the moment by environmental stimuli, which may or may not last over time" (Hidi & Renninger, 2006, p. 113). In addition, Silvia (2008) defined situational interest "as momentary feelings of curiosity, fascination, and enjoyment triggered by an environment or task" (Nye & Rounds, 2019, p. 13). Positive benefits from situational interest are only likely to happen if the same procedures are conducted over time, when long-term interest may be generated and lead to increased knowledge, long-term interest, a change in values and increased positive feelings (Swarat et al., 2012).

Interest for students begins with situational interest situations, in which repeated involvement with an object, or a particular subject develops interest that creates a more positive interest. This in turn develops into individual interest. The key to this progression is to select a subject or topic that generates personal meaning and assists in the change of emphasis from situational to individual interest (Hulleman & Harackiewicz, 2009).

This research study maintains that interest is an exploration-related emotional state and is connected to learning and attention; this means that interest may depend on, for example, the way the subject is taught, the subject's technical content, or whether the learner enjoys the subject.

### 3.4.2. Students' Interest in Science

A key function of science education is to encourage students' interest in the subject and provide additional support for the overall aims of the discipline. The finding of a study by Rutherford and Ahlgren (1990) indicate that the content and conduct of teaching practices often do not take into consideration the interests and experiences of students, creating an atmosphere of pointlessness in their lives. It was found that a major reason for the lack of interest in school science was its apparent disassociation with events in everyday life. The evidence indicated that, as students matured, they increasingly lost interest in the subject and considered it to be even less relevant to their needs. They also reported that they found a significant disparity between science as learnt at school and science as applied in society (Barmby et al., 2008; Osborne et al., 2003). Proposals for restructuring science curricula (Jenkins & Nelson, 2005) are aimed at promoting science-related subjects to raise student interest levels and respond to their concerns. It has been established that enabling students to develop their own interests encourages them to pay greater attention for longer time spans and display their own creative initiatives (Pintrich & Schunk, 2002). This generates interest in planning future career choices (Kahle, Parker, Rennie, & Riley, 1993; Maltese & Tai, 2010).

The ROSE project established that fifteen-year-old students were not motivated by school science when compared to other subjects, which they considered to be more interesting (Sjøberg & Schreiner, 2010). A number of factors could contribute to this lack of appeal: the difficulty in understanding complex formulae and concepts, the mathematical content of chemistry and physics and the requirement to memorize a wide range of facts and figures for examinations (Collins, 2010; Osborne & Collins, 2001). The frequently misconstrued idea that physics is a complicated subject has influenced enrolment choices and performance for students of physics (Bamidele, 2004). Belief that a subject is difficult leads to an overall negative approach. Quite naturally, students prefer to opt for subjects in which they feel they have the prospect of achieving good results (Williams, Stanisstreet, Spall, Boyes, & Dickson, 2003).

The human connection between subjects and teaching was found to be beneficial in teaching at all levels in secondary schools (Uitto, 2014). Uitto's (2014) study in Finland revealed biology as the preferred choice of subject in upper-secondary schools. Approximately half of the students interviewed considered biology to be an interesting subject, although different areas of biology were met with varying levels of interest. Health issues, human and cell biology and gene technology were subjects reported to be particularly interesting (Uitto, 2014). Personal experiences of human biology and health and safety issues mean that these topics were of particular interest to ninth-grade students, according to the Program for International Student Assessment (PISA) survey conducted in 2006. Conversely, students were not interested in subjects with which they had little or no personal experience (Bybee & McCrae, 2011). These findings were supported by the results of the international ROSE project. It was reported that ninth-grade students considered human biology and health issues to be the most interesting topics of biology (Trumper, 2006; Uitto, Juuti, Lavonen, & Meisalo, 2006). They showed little interest in farming or plant-related subjects (Trumper, 2006; Uitto et al., 2006). Teaching on ecology, evolution, gene technology, human and cell biology and health was more favourably received than studies on living organisms and environmental protection (Baram-Tsabari & Yarden, 2011; Uitto, 2014).

A student's interest in a subject was the deciding factor in his or her decision to choose the subject for study at the high school level (Hofstein & Mamlok-Naaman, 2011). A study of students' reactions to studying chemistry conducted by Reiss (2000) generated many negative observations. Particular specialised studies, such as learning about molecular masses, may enthuse some students intellectually, but the majority view was that these subjects were incomprehensible and had no application to everyday life. Osborne and Collins (2001) in their focus group study, reported that both genders stated that certain intangible subjects and microscopic studies bore little relation to student needs and were both remote and pointless. Topics that generated greater interest involved more practical activities and senses, such as 'mixing chemicals' and experiencing 'smells and colours' combined with what students termed an 'element of danger' (Osborne & Collins, 2001).

There are many indications that physics is considered to be a difficult, uninteresting and relatively impractical subject (Erinosho, 2013). Students showed a marked preference for chemistry or biology (Angell, Guttersrud, Henriksen, & Isnes, 2004; Lavonen et al., 2005a). A UK-based survey determined that students were not interested in physics as they perceived it to be a difficult discipline (Williams et al., 2003), and they were unlikely to achieve satisfactory results from the tasks undertaken (Barmby & Defty, 2006). Studies indicate that students initially enter secondary schooling with an equal liking for biology and physics, but, thereafter, their liking for biology takes precedence and their interest in physics declines. The reason stated is that they found biology to be interesting and physics to be boring (Angell et al., 2004). But the underlying reasons for finding physics uninteresting revert back to the belief that the subject both is difficult and has no practical application (Erinosho, 2013). However, interest is reportedly shown by both boys and girls in some areas, particularly those related to space and the universe (Osborne & Collins, 2001; Williams et al., 2003).

It has been suggested by Krapp and Prenzel (2011) that levels of interest in science subjects are derived from the manner in which lessons and knowledge are presented and taught in school programmes. Students reported that their interest levels were raised when teaching involved interactive and practical activities and innovative teaching methods (National Foundation for Educational Research, 2011). Involving students in the modelling of abstract concepts was one method for creating more interest in lessons, according to the Wellcome Trust Monitor (Butt et al., 2010). Research on interest has focused on differentiating between the interest shown for different subjects and topics within those subjects and interest in the relevance of a subject for practical application. According to the Science and Scientists (SAS) study, the context in which a subject is offered determines the attractiveness of the subject's content (Sjøberg, 2000b). He observes, for example, that 'music' is a far more attractive subject than 'acoustics and sounds', and 'rainbows and sunsets' is a more promising title when compared with 'light and optics.' These differences are evident in a study by Cerini, Murray, and Reiss (2003) in which chemicals in the body and drugs raised far more interest than a presentation about chemicals in industry. Applying lesson content to everyday situations such as those related to the human body, or those that focus on particular phenomena or contain social relevance, raises interest levels.

There is a commonality between the findings in the literature, even when conducted using different methodologies, which has validity across different cultures and education systems (Sjøberg & Schreiner, 2004). There was a noticeable difference in the subject interest of students from different countries disclosed in the findings of a SAS study (Sjøberg, 2000b). However, the general opinion is that there is little difference in the areas of science that interest students from different countries. A survey by Hagay et al. (2013) conducted in 600 schools across four countries (Portugal, Turkey, England and Israel) verified this observation. Students from all nationalities were interested in similar science issues. It was observed that religious and national factors and gender differences influenced the results from country to country. From this, it can be deduced that cultural issues have an effect on student interest levels.

### 3.4.3. Students' Activities Out-of-School

As a general rule, it is recommended that teaching should utilise a child's experience and interests. This process, to be of value, needs to match the personal curiosity and the social environment of a child (Sjøberg, 2002c). Interest in STEM is stimulated through a number of out-of-school sources (Henriksen, Jensen, & Sjaastad, 2015). Popular science and popular culture generally help establish and maintain interest as well as formulate young people's ideas of science and scientists. According to Stocklmayer, Rennie, and Gilbert

(2010), settings associated with science, such as museums, and popular science articles in the media help develop and stimulate interest in science and technology. A Finnish survey (Lavonen et al., 2008; Uitto et al., 2006), conducted by science educators in 2003 on 3,626 secondary school pupils, to record their out-of-school experiences in the sciences—biology, physics and chemistry— revealed some significant correlations with students' interest in certain science topics.

A logistic regression model was used by Dabney et al. (2012) together with the calculation of prototypical odds ratios with the aim of establishing the relationship between out-of-school science activities and STEM career interest in universities. The investigators posed two major research questions:

1. What is the correlation between varying forms of out-of-school activities?
2. What are the particular forms of out-of-school activities that could be connected with STEM career interests in universities?

The main issues that generated university career interest in STEM were found to be out-of-school activities related to science and mathematics, earlier middle school interest in the same subjects and gender, all of which were found to have a significant effect on STEM interest.

Out-of-school experiences add to and strengthen knowledge gained in the classroom, according to the research (Bell, Lewenstein, Shouse, & Feder, 2009; Bybee, 2001). Most studies looking at such experiences have centred on out-of-school activities such as field trips and visits to science museums under teacher supervision (Falk, Dierking, & Adams, 2006; Rennie & McClafferty, 1995). The most benefit was gained from those scientific field trips that were related in subject matter to the school curriculum. Nature featured prominently in studies undertaken by Swedish student teachers, in which natural activities such as fishing and collecting berries helped to heighten the sense of belonging and that of identity (Danielsson, Andersson, Gullberg, Hussénius, & Scantlebury, 2013). Another survey (Baker & Leary, 1995) was conducted among girls in grades 2, 5, 8 and 11 in the USA to establish what had induced them to select science. Those girls who were most positively motivated cited extracurricular experiences such as studying science at home, reading about science and viewing science-based television programmes as contributory incentives towards a positive view of science.

There is a wide range of differences in experiences among students attending science classes. There are variations among students in the same class, in the same school and of the same nationality. There are major differences in children from different countries (Sjøberg, 2002c), added to which, there are possible systematic differences between boys and girls. Societal values, culture and the economic environment lead to different out-of-school experiences (Korkmaz, Thomas, Tatar, & Aktas, 2017a). Previous investigations have confirmed that these differences influence the results of studies related to science (Korkmaz et al., 2017a). There is a need to evaluate out-of-school experiences to ascertain those that are most beneficial and, where necessary, to adapt science programmes and science classroom settings.

### 3.4.4. Gender and Interest in Science

An increasing number of studies have been conducted to compare interest in scientific subjects between boys and girls. The predominant view is that boys have a greater interest in science subjects (Baran, 2016) than girls do (Christidou, 2011). Observations indicate that girls tend to prefer biology (Britner, 2008; Joyce & Farenga, 1999; Osborne & Collins, 2001; Tamir, 1991), and find physics unappealing. Generally, physics and technological studies (and, to a certain degree, chemistry) are the domain of boys (Potvin & Hasni, 2014). Some research has indicated that gender choices are made because of subject content. Specific childhood experiences tend to direct children towards particular disciplines in the field of science rather than science as a whole, and these preferences can be influenced by social change (Sjøberg, 2000a).

The involvement in and viewpoint towards science for sixth-grade students have been examined (Jones et al., 2000). In a survey to establish students' understanding of science and scientists, involving 437 respondents, views on scientific subjects of interest, out-of-school experiences and considerations for future employment were examined. The results showed considerable gender differences in respondents' experiences with and views on science, which influenced perceptions of science courses and possible choice of careers. Boys were more involved with the practical aspects of science from their contact with mechanical and electrical items such as electric toys, microscopes, batteries, fuses and pulleys. Girls were familiar with more domesticated activities such as knitting and sewing, bread-making and gardening. Understandably, there was a greater incidence of boys being interested in cars and computers, atoms and atomic bombs and x-rays and similar technological equipment. Girls' interests focused on healthy eating, the weather and rainbows, animal communication and the subject of AIDs.

However, there were areas of similarity in interest for both boys and girls. The results showed that what interested girls could also be of interest to boys, but the reverse was not apparent. Those areas that were significantly interesting to girls were, in particular, human biology, fitness, health and diet, diseases and their treatment, plant life and animals, astronomy and outer space and light and sound. These were also found to be of interest to boys, although to a lesser degree than to girls (Christidou, 2006; Osborne & Collins, 2001). The findings of the ROSE project Sjøberg and Schreiner (2010), established definite gender differences. In general, male students were interested in matters of a 'technical, mechanical, electrical, violent, spectacular or explosive nature', whereas, exclusively, female students were interested in matters of a more human nature, health and medicine, beauty and the human body, aesthetics, ethics, and topics of wonder and speculation that included an interest in the paranormal (Sjøberg & Schreiner, 2010).

The findings were interesting in that the differences often diverged with older students, possibly as the result of the pending choice of career (Potvin & Hasni, 2014). Girls may apprehend the supposed pressure on young women, in particular, to balance a career in science with raising a family. Research assessing the opinions of girls regarding the pursuit of science-orientated careers shows. Many have preconceived ideas about science that turn them against scientific careers. This is particularly noticeable among young girls who have the idea that science is an exclusively male-orientated domain. The idea that success in science requires total dedication to the discipline (Christidou, 2011; Gilbert & Calvert, 2003). This is at odds with the female ideal of family life and the workplace being a congenial environment, contributing to the low number of females who choose careers in science (Christidou, 2011).

## 3.5. **The Implications for the Current Research**

The literature review suggests that students' attitudes in science have many dimensions and are impacted by various factors which all contribute to some extent to the cognitive, affective and behavioural components of such attitudes (towards science) shown by students. Also, there are many reasons why students may not choose to study science, for example, views of science as a subject, early experiences of learning the subject or a belief as to what kind of person would wish to study science. Researchers find this issue very important for further examination, as seeing why a subject is not chosen can reveal interesting findings. One reason given for science not being chosen as a subject and negative attitude towards science is how difficult and complicated it appears to be (Anwar & Bhutta, 2014; Bennett, Lubben, & Hampden-Thompson, 2013a; Guido, 2013). A subject is not likely to be taken up if it is viewed as uninteresting, (Tseng, Chang, Lou, & Chen, 2013), or if it is seen as non-stimulating or lacking excitement (Hofstein & Mamlok-Naaman, 2011).

According to Osborne et al. (2003), students' voluntarily enrolment in science courses and future careers are determined attitudes towards science. Hence, an understanding of student attitudes toward science could lead to instructional and curriculum changes that may support and enhance students' learning of difficult subjects such as science and technology (Tseng et al., 2013). Sociologists (Osborne et al., 2003; Reid, 2006; Toplis, 2012) have advocated that more work needs to be done to explore students' attitudes in order to improve the quantity of people signing up for science.

Moreover, students' attitudes may vary according to a variety of factors. Gender is one of the factors that may play a major role in people's attitudes in general. Therefore, feminists strive to understand why the sexes have unequal power in society (Mertens & Ginsberg, 2009). Literature suggests that the differences between men and women are may be due to nature, nurture, or a little of each (Marini, 1990). The nature theory suggests that women and men have set, unchangeable physical and biological characteristics, which is why they behave differently in various situations. The opposing view is that it is the environment children grow up in, and what they see happening around them in their community and society, that shapes their views, attitudes and behaviours. Empirical study has focused on the extent to which gender differences in, for example, competitiveness and risk aversion can clarify variation in outcomes. Also, there is a focus on the impact of gender stereotypes on subject decisions where it is revealed that women are overrepresented in the social sciences and underrepresented in the scientific areas (Alwedinani, 2016; Lörz et al., 2011; Parker et al., 2012).

A wide range of literature has discovered how students' views can provide opportunities for students to become active participants in their education, including making decisions about what they want from their studies and how their education is assessed. In the subject of science, from students' views, educators can see why students find it interesting and what they hope to achieve when they leave study for the 'real world'. This will help teachers shape the best method for teaching (Bishop & Denley, 2007). Basu, Barton, and Tan (2011) saw this as important and stated that what students think leads them to act in a particular way. Going further than this, Rudduck et al. (1996) explained that paying attention to the views of students and young people could be used as a way of refining the way subjects are taught. The best person to ask about improving a subject is the person taking it, the student (Rudduck & Flutter, 2004), so listening more to what they have to say, and valuing their opinions would help facilitate their own learning and the experience of others.

This study focused on exploring Saudi students' attitudes towards science in order to understand student interest in learning science and identify the influence of gender on students' attitudes toward science and technology subjects. Research on students' attitudes has been reviewed as the starting point of the research and in order to decide on an appropriate form and shape for this study. Since students' attitudes are understood in terms of the tripartite model of attitude (cognitive, affective and behavioural domains) there is the opportunity to look deeper into what students really feel when they tell us they like subjects such as technology and science. Moreover, studies on culture guide this research to investigate how students' attitudes toward science and technology subjects are influenced by cultural norms, such as gender expectation.

This research investigates young Saudi students' attitudes toward science and technology in order to understand what students think about the form, content and purpose of science education and student interest in learning science. Thereore, it is key to listen to the views of students and hear what they have to say, including what they see as the problems in their education and what they believe can be done to improve this situation (Soohoo, 1993).

## 3.6. **Summary**

The aim of the chapter was to develop an understanding of three key themes that underpinned this study, contributing to shape the form of the study and interpret the outcomes. It began with the concept of culture, as a multi- layered and multi-dimensional set of values, norms and practices acquired through socialization that influence students' patterns of thinking, feeling and behaviour. Attention was focused on the particularities of the Saudi culture and its influence on education and employment and a comparison was made with Turkey and Malaysia, to highlight similarities and differences among these patriarchal, Muslim societies,

The present chapter also explored attitude, defining it as an individual's feelings toward science, founded on his or her own knowledge and belief about science. Moreover, it highlighted the three key components, namely cognitive, affective, and behavioural, exerting a significant impact on the general attitude held towards science. Research has emphasised the variation in science and technology attitudes among students. Students' attitudes towards science are also influenced by conditions external to the school setting, such as cultural factors, the media, government-led policies, overall technological skill proficiency and the national economy.

Moreover, this chapter discussed students' interest in science. It provided definitions of interest and reviewed studies that investigated students' interest in science, their extracurricular activities and gender differences in the interest of science. The insights gained helped to shape the structure of the current research and in turn the achievement of the research aims by answering the research questions through the data that has been collected, analysed, and then discussed. The research instrument and the research methods employed in the current research will be presented and discussed in the coming chapter.

# Chapter 4: Research Methodology

## 4.1. Introduction

The research's main goal was to investigate Saudi students' attitudes and interest regarding science and technology. The aim of the current study was to listen to the Saudi students' views regarding science and technology, thereby answering the main question of the present research, namely,

**What are Saudi secondary school student' views of science and technology?**

This chapter presents the methodology that underpinned the research, discussing the theories that were utilised and explaining how the present research related to them. It explains the development of the research instruments, the sampling procedure, the quantitative and qualitative data collection and analysis, and the relevant ethical issues. It ends by discussing the validity and reliability of the research instruments.

## 4.2. Research Approach

Inductive and deductive reasoning is employed by humans to gain an understanding of events (Gay & Airasian, 2003). In addition, researchers use theory, which may not always be evident in their research design but may be made evident in the results and conclusion (Saunders, Lewis, & Thornhill, 2012).

In the current study, the research questions arise on the basis of students' attitude and interest theories and the outcomes of the studies explained earlier (Bryman, 2012; Saunders et al., 2012). Therefore, an inductive approach did not seem to be appropriate for the current study.

The deductive approach signifies the most common perspective regarding the association between theory and social research, in which the research uses what is known about a certain domain and the appropriate theoretical notions so as to deduce alternative notions or premises (Bryman, 2012). In deductive research, the research starts with a general understanding and then goes on to more specific information (Killam, 2013). Hence, the researcher derived from the literature, a general understanding of students' attitude and interest towards science subjects, besides the effect of culture on that, and proceed to explore further influential factors of significance for the learning of science and technology. Therefore, the current research is deductive, because the researcher commenced with theory to generate research questions that were the basis of the data collection process for quantitatively testing the research propositions (Bryman, 2012; Saunders et al., 2012). The researcher also employed the ROSE questionnaire format to help in replication that would assure reliability of the study (Saunders, 2012).

## 4.3. Research Design

The research questions were to generate descriptive, exploratory, and explanatory answers (Saunders et al., 2012). The aim was to describe the Saudi students' attitudes and interest regarding science and technology in their own words. Johnson and Christensen (2010) mentioned that "educators sometimes conduct descriptive research to learn about the attitudes, opinions, beliefs, behaviours, and demographics (e.g., age, gender, ethnicity, education) of people" (p.366).

The current research examined the Saudi students' opinions and beliefs about science and school science in order to understand their attitudes and interest (Creswell & Poth, 2016). Based on the data that was collected through the ROSE questionnaire, mean values and percentages were examined to analyse and understand the students' attitudes and interest (Robson, 2002). Consequently, the study went beyond description to identify patterns and associations within the findings. Thus, the descriptive design assisted in attaining the research objectives (Abuallam, 2011), as it enabled the researcher to understand and synthesise the students' attitudes and perspectives regarding science and technology (Abuallam, 2011; Saunders et al., 2012). The methods used to investigate the perspectives of students will be further elaborated on in the next section.

## 4.4. Research Methods

There are three main types of research methods: quantitative, qualitative, and mixed methods (Williams, 2007). In the present research, the researcher employed a mixed methods data collection strategy to examine Saudi students' opinions, identify answers to the research questions, and achieve the research's aim of investigating their attitudes toward science and technology, as explained below.

### 4.4.1. Mixed Methods

The researcher considered that, rather than depending on the outcomes of a single method, the mixed-methods approach, using various sources of data, would be advantageous due to the quality and completeness of the data generated (Denscombe, 2014). Mixed methods enable the researcher to benefit from a variety of data sources (Creswell, 2014). This approach offered a more comprehensive view of the Saudi students' opinions, because the data generated by the different techniques were complementary. The quantitative and qualitative methods used captured different viewpoints that, when integrated, provided a deeper and more holistic understanding of the Saudi students' attitudes toward science and technology than could be generated by a single approach (Denscombe, 2014). The quantitative approach provided a numeric depiction of trends in the outlooks or opinions of the student sample (Creswell & Poth, 2016). By contrast, the qualitative enquiry employed extensive description to explain the participants' attitudes and interest through their experiences and the words they used to express them (Merriam, 2009).

Quantitative and qualitative techniques had different degrees of value relative to the research objectives. To provide a large volume of comparable data to inform schools, educators, and decision makers, a descriptive quantitative approach was employed, as the major component of the research, whereas the qualitative method was the secondary, complementary method for interpreting the students' attitudes and interest (Denscombe, 2014).

#### 4.4.1.1 Quantitative Method

A quantitative method using a survey strategy was employed to analyse Saudi students' opinions, interests, and attitudes regarding science and technology. The quantitative method employed descriptive statistics to describe general trends in the data, to classify the data, and present that data in tables and figures in a form which made it understandable. Thus, the researcher was able to use frequency distribution tables and mean scores to describe the students' behaviours and cognitions that would enable her to make probabilistic predictions and generalisations (Johnson & Christensen, 2012). Typically, there is a relationship between deductive research and a survey strategy, which is "most frequently used to answer "what", "who", "where", "how much" and "how many" questions" (Saunders et al., 2012, p. 176). By using a survey strategy, the researcher was able to gather information regarding the Saudi students' attitudes and interests regarding science and technology, linking them to reported events, activities, moral and personal experiences and behaviours (Wisker, 2007).

For collecting quantitative data, the research used a fixed, non-experimental, descriptive survey. According to Johnson and Christensen (2010), "Survey research provides a quantitative or numeric description of trends, attitudes, or opinions of a population by studying a sample of that population" (cited by Creswell, 2014, p. 296).

To achieve the research objectives, a small group was selected within the Saudi secondary school population (Creswell & Poth, 2016). Data were obtained from the sample by employing questionnaires directly delivered to participants in their schools. The use of such a survey made possible the study of a wide range of issues to define or describe any generalised features (Cohen, Manion, & Morrison, 2011).

The survey strategy is typically employed in education studies to explain an existing phenomenon (Cohen et al., 2011); hence, it was appropriate for this research, because it offered the logistical advantage of easy , cost-effective access to a large population. It also offers the benefit of anonymity. The researcher sought information pertaining to perspectives, attitudes, interests, and beliefs and aimed to precisely comprehend the group's interests. A one-shot survey design was employed, to obtain information from a single sample taken from the target population on a single occasion.

The quantitative method was the first and the main method used to describe the phenomena investigated, using the ROSE questionnaire. However, the quantitative method alone would not fully fulfil research the objective, so after the survey, diamond ranking was applied to focus group data, as explained below.

#### 4.4.1.2 Qualitative Method

Whereas the descriptive statistical techniques applied to the quantitative data collected via the questionnaire helped to explain a wide variety of aspects of students' attitudes and enabled the data to be tabulated and presented in graphical form (Evans, 2013), the questionnaires did not provide extensive information regarding the Saudi students' attitudes. Therefore, using the quantitative method alone would not have provided a full and deep understanding of their attitudes towards science and technology (Bryman, 2012; Cohen et al., 2011).

The objective of qualitative research is to comprehend the meanings accorded by individuals or groups to a social or human issue. The current research sought to understand the Saudi students' attitudes and interest regarding science and technology by listening to their views, and Maxwell (2013) suggested that qualitative research could help in attaining that goal. The qualitative method allowed the researcher to gain a deep understanding of various Saudi students' viewpoints, and offered extensive explanations of the procedures that took place, in their local context (Miles & Huberman, 1984). It also enabled uncover of unexpected events and influences that might offer new grounded theories with respect to the events in question. Qualitative techniques produce data that is considered to be natural, rather than constructed (Easterby-Smith, Thorpe, & Jackson, 2012) and Miles and Huberman (1984) mentioned that such data is "far more convincing to a reader – another researcher, a policy-maker, a practitioner" (p.15).

To obtain a deeper understanding of the students' attitudes and interests and support the management of sensitive issues (Johnson & Educational Management Development Unit. University of Leicester, 1994), focus group interviews incorporating a diamond ranking exercise was used to uncover common perspectives and develop more extensive interpretations of students' attitudes and experiences, which compensated for the deficiencies inherent in the quantitative technique. The next section will provide information about the research instruments and techniques used.

## 4.5. **Research Instruments and Techniques**

The difficulties involved in gauging affective factors of learning, such as interests, values, attitudes, feelings and motivation, are widely acknowledged, and the challenges have been recorded by researchers in various fields (Bennett, 2001; Gable & Wolf, 2012; Oppenheim, 1992). As previously mentioned, in the present research, quantitative and qualitative data were gathered to answer the research question. A questionnaire was used to collect quantitative data in order to understand student's views on science, while focus group interviews and diamond ranking were used to collect the qualitative data, to encourage debate and enable students to analyse and explain their thinking.

### 4.5.1. Questionnaire

The questionnaire is "the most commonly used descriptive method in educational research" (Cohen et al., 2011, p. 256). Researchers can collect information from people by posing questions directly or indirectly through a questionnaire (Gillham, 2007) which is "a self-report data-collection instrument that each research participant fills out as part of a research study" (Johnson & Christensen, 2012, p. 162). Furthermore, by using a questionnaire, a researcher can obtain data about participants' thoughts, feelings, attitudes, beliefs, values, perceptions, personalities and behaviour intentions (Johnson & Christensen, 2012).

Different types of questionnaires can be used, depending on the research aim, including closed, open, closed-and-open and photo questionnaires (Alassaf, 2010). Phellas, Bloch, and Seale (2011) recommended structured questions, in which the participants' answers are limited to a fixed set of responses, as too much diversity in responses can be an obstacle during analysis. Consequently, the present research used a closed questionnaire consisting of a list of questions answered by the participants on a 4-point Likert scale, ranging from 'Very interested' to 'Never interested' or 'Agree' to 'Disagree' (Bryman, 2012). The Likert scale offered participants the freedom to choose across the four ratings, which helped participants complete the questionnaire easily, quickly and with high reliability (Gay & Airasian, 2003; Oppenheim, 2000).

As with any data collection method, questionnaires have advantages and disadvantages (Gillham, 2007). Among their advantages, questionnaires can be convenient for the respondents and can reduce the possibility of bias (Bryman, 2012). Wallen and Fraenkel (2013) mentioned that researchers may distribute questionnaires simultaneously to a large sample, saving time. They facilitate study of problems in a realistic setting (Wimmer & Dominick, 2006), particularly in exploring attitudes, perceptions, beliefs and opinions (Black, 1999). Wimmer and Dominick (2006) highlighted the amount and variety of data that researchers can gather when employing questionnaires. Easterby-Smith, Thorpe, and Lowe (1994) stated that questionnaires "can provide wide coverage of the range of situations; they can be fast and economical; and, particularly when statistics are aggregated from large samples, they may be of considerable relevance to policy decisions" (p.83). Since the investigation of Saudi students' attitudes and opinions towards science and technology subjects, required questioning many participants in a limited time, a questionnaire was an effective method to gather data.

The researcher attempted to avoid the negative features of a questionnaire, such as being unable to ask further questions to gain an in-depth understanding, by conducting follow-up focus groups to clarify important points in further detail. A questionnaire can also produce unreliable data if the participants are careless or misunderstand the questions (Bryman, 2012). Therefore, the questionnaire in this study was administered by researcher herself (in girls' schools) or her husband (in boys' schools) to confirm both genders could understand the questions, answer any questions the participants had and encourage the students to answer all questions. Low return is one of the drawbacks of questionnaires; however, in this study, in-person administration helped to overcome this problem.

The questionnaire was adapted from the ROSE project, as an overview of earlier studies revealed no other existing research tool that could be used to gauge the attitudinal features of students' relationships with science (Sjøberg & Schreiner, 2004). The ROSE questionnaire and its adaptation for this study will be discussed in the following sub-sections.

#### 4.5.1.1 Development of Instrument

Previous projects to assess students' abilities in science include the Trends in Mathematics and Science Study (TIMSS), the Program for International Student Assessment (PISA) and ASPIRES, which aims to understand how young people's science and career aspirations develop during the 10-14 age period, particularly what influences the likelihood of aspiring to a science-related career. The Wellcome Trust Monitor is also designed to measure the public's awareness, interests, knowledge and attitudes in relation to science, in particular, biomedical research. While ASPIRES and the Wellcome Trust Monitor are used only in the UK, the Relevance of Science Education (ROSE) gathers and assesses information from young students across the globe regarding various factors that affect their attitudes towards science and technology, as well as their interest in these subjects. Factors explored in the ROSE project include the interests of students in learning about science and technology topics in varied contexts, aspirations for the future, priorities, optimism and pessimism regarding environmental problems, previous experiences and opinions regarding learning science in school, science and technology in the community and science and technology-related experiences outside of school.

The ROSE instrument was formulated in Norway using ideas obtained from international discussions, workshops and piloting amongst a group of science education researchers. The items of the ROSE questionnaire were designed over more than one and a half years, and its complete form was developed by the Norwegian partners of the ROSE team based on the additional suggestions of a global advisory team. The questionnaire was tested in various countries, including European and African nations, as the aim was to develop an instrument that could be employed in different regions of the world to encourage research collaboration and networking despite cultural restrictions and to encourage an informed debate regarding ways that science education could be made more appropriate and significant for students in a manner that values gender distinctions and cultural diversity (Sjøberg & Schreiner, 2004).

The ROSE questionnaire is not a test for assessing students' conceptual understanding of science content, but it is an instrument for collecting data about students' emotional and attitude identity in science and technology. It can be used to understand important aspects of students' attitudes towards science and technology at school and in life.

#### 4.5.1.2 Content of the ROSE Instrument

The survey form formulated by ROSE has a large number of components (see Appendix 1), with sections labelled 'A' 'C' 'E' 'F' 'G' 'H' addressing different topics or queries as explained below. Some questions were added to the questionnaire by the researcher on the first page to obtain background data about the participants, such as their gender, the neighbourhood where they lived, and their parents' occupations (optional).

##### 4.5.1.2.1. 'What I Want to Learn About' (ACE)

The collection of 107 items under this question are possible topics to learn about, each rated on a 4-point Likert scale from 'not interested' to 'very interested'. To avoid stress and confusion, the elements are categorised into three subject areas, sections A, C and E, which are collectively referred to as the ACE queries in this research.

The queries in these sections are based on the idea that numerous young students find science and its characteristics fascinating, even though they do not plan to become science experts or to pursue a scientific career. The purpose of these queries was to identify the types of problems that intrigue individuals, to investigate the ways that they differ and to identify specific arrangements to form solutions. These sections provide insight into how various subjects may or may not appeal to various groups of students, which could help in assessing how science syllabi may be composed to fulfil the requirements or concerns of the various factions of students.

Nevertheless, the limitations of the ACE queries should be kept in mind. The queries are concerned with *what* to teach (the subject), not *how* to teach (the procedure or technique applied). There are numerous techniques and procedures for teaching and studying, which can meet numerous informative needs, to encourage the students and hold their interest (Sjøberg & Schreiner, 2004). However, while teachers understand that the procedures and techniques of teaching are of great significance (Osborne & Collins, 2001), this research does not investigate whether a particular teaching method would be effective or not in holding the interest of students, when the ‘interesting’ matters are being discussed. Teaching ‘interesting’ issues does not ensure that a particular teaching procedure would be beneficial, but it is more logical to teach ‘interesting’ subjects instead of ones that fail to hold the interest of students and are considered boring.

This unit contains one question about music, but the researcher excluded this question because there is no music curriculum in Saudi schools and consequently students would not be able to provide their opinion.

#### 4.5.1.2.2. ‘My Science Classes’ (F)

This section elicited insights from students about their science classes, their inspirations for studying science in school, their confidence in their own abilities in science at school, what they gained from studying science and how they felt about the requirement to study science. This query was posed because factors such as self-assurance, behaviour, curiosity, viewpoints and inspirations are important aspects related to studying in a particular field. Respondents’ reactions offered an opportunity to define what students in Saudi Arabia believe they obtain from studying science in school. The question included 16 statements, each followed by a 4-point Likert scale that ranged between ‘disagree’ and ‘agree’.

#### 4.5.1.2.3. ‘My Opinions about Science and Technology’ (G)

This section investigated the viewpoints of students regarding the roles and purposes of science and technology in their society, as well as their expectations of science and technology. This question included 16 statements related to science and technology, each followed by a 4-point Likert scale that ranged between ‘disagree’ and ‘agree’.

#### 4.5.1.2.4. ‘My Out-of-School Experiences’ (H)

This section provides data regarding incidents or actions encountered by students outside school that piqued their curiosity and increased their interest in science, including significant events that encouraged studying science at educational institutions. The answers to this question would help teachers, curriculum makers and textbook authors understand and acknowledge the expectations of students regarding science and technology, as well as the ways that they differ between girls and boys. The question presented 61 statements about actions and events, each followed by a 4-point Likert scale that ranged from ‘never’ to ‘often’.

#### 4.5.1.3 Translation

Researchers who attempt to gather high-quality data with proper results must translate research instruments into the respondents' preferred language, particularly for a study that uses quantitative measures (Maneesriwongul & Dixon, 2004). Chapman and Carter (1979) stated that "One of the most important elements in undertaking educational evaluation and research projects involving the cross-cultural use of measurement instruments is the translation and validation of the instruments" (p.71). Maneesriwongul and Dixon (2004) refer to the translation's quality and the translated instrument's validation as critical to the quality of results. Since the researcher intended to use the ROSE questionnaire English edition to gather data from respondents whose first language is Arabic, the researcher had to translate the questionnaire from English to Arabic (see Appendix 1).

Translating an instrument from one language to another is a complicated process that is subject to cultural and linguistic variations (Yu, Lee, & Woo, 2004). Therefore, scholars suggest several translation techniques to achieve reliability (Maneesriwongul & Dixon, 2004). For example, Maneesriwongul and Dixon (2004) refer to the techniques suggested by Brislin (1980), which were (1) back-translation, (2) pretest, (3) committee approach and (4) bilingual techniques. In back-translation, the questionnaire is translated back to the source language after being translated to the target language, to verify the translation. A pretest procedure is a pilot study implemented after the questionnaire is translated to ensure that future respondents from the target language will be able to understand all questions and procedures. The committee technique is based on a team of bilingual people who can translate the questionnaire from the source language to the target language. Finally, the bilingual technique works by testing both the source and target language questionnaires among respondents who are fluent speakers of both languages to discover any different responses yielded in the two versions.

To translate the questionnaire from English to Arabic, the researcher followed the bilingual technique. She performed a translation and then sent it her friend who had earned his PhD in the UK. The researcher then sent the questionnaire to three specialists: a translator, a TESOL PhD and a PhD student in English Literature. The three specialists reviewed the questionnaire and corrected any ambiguity or mistakes. Note that the questionnaire was not sent to them at the same time. First, the researcher sent the questionnaire to the translator, then to the TESOL PhD and then finally to the PhD student.

### 4.5.2. Focus Groups

Focus group is a technique in which a group or, more frequently, a number of groups, of participants is gathered together to discuss a topic with the mediating support of a moderator. The moderator guides the conversation about the given topic while allowing a broad variety of ideas and attitudes to be expressed (Lunt & Livingstone, 1996). Focus group is currently one of the most popular instruments in social sciences, and the principal technique in qualitative investigations where a researcher aims to collect data through a group conversation. There are several reasons why focus groups are useful for researchers seeking to understanding students' attitudes and opinion. First, distinct from explicit-function group assemblies such as educational seminars, meetings of decision-makers, and group therapy sessions, they gather attitudinal information as data. Second, unlike nominal groups, Delphi groups, and other group interview scenarios, they provide a greater extent of interactive discussion. Third, they involve the researcher in the role of facilitator or moderator (Carson, Gilmore, Perry, & Gronhaug, 2011). Also, they can generate complex information in an economical and time-effective manner (Liamputtong, 2011); it would be difficult for a researcher to meet student respondents individually, and the students too may not have time for this. Therefore, this study used the focus group technique with Diamond ranking (see Appendix 2).

#### 4.5.2.1 Diamond Ranking

Diamond ranking is a well-known thinking technique (Rockett & Percival, 2002) that is widely used for extracting concepts and for assisting in debates. It is considered a thinking skills tool. Diamond ranking is a method used to extract implicit ideas and to facilitate debates or discussions. This technique has been applied with students in focus groups to explain and clarify their opinions, feelings and thoughts concerning a subject, and it is normally performed using pre-written statements (Rockett & Percival, 2002) The strength of diamond ranking is evident when students collaborate and researchers can observe how they make co-operative decisions (Christensen & James, 2008). Another benefit is that when students "…rank items, either statements, objects or images, and discuss the ranking choices, they are required to make explicit the over-arching relationships by which they organise knowledge, thus making their understandings available for scrutiny and comparison" (Clark, 2012, p. 223).

This research investigated young Saudi students' attitudes, feelings and thoughts toward science and technology in and outside school. The research participants were expected to be hesitant to speak because they were unaccustomed to expressing their opinions. Therefore, diamond ranking was an appropriate technique to encourage students to present their opinions toward science and technology subjects in Saudi schools.

Clark (2012) mentions that some scholars called diamond ranking 'Diamond 9's'. Based on previous research, the researcher prepared a list of nine statements regarding the importance of science and technology as well as why schools should teach these subjects to students. These statements included important science topics that enable students to develop the confidence, knowledge and skills to find answers to their own questions about the workings of the biological, chemical, physical and technological world; to become better informed citizens; to attempt to find solutions to problems arising from their own needs and experiences in daily life; to confidently participate in public debates and decision making regarding science; to appreciate the achievements of scientists and their research; and to value the scientific contributions and achievements of people from many different cultures.

The statements were written individually on square cards (see Appendix 2). A grid with nine squares in the shape of a diamond was also designed and printed on A3 paper. The squares were numbered from 1 for the least important to 9 for the most important. During focus groups with small groups of Saudi students, the researcher asked students to rank each statement according to its importance, relevance and significance, and to place the statement with the highest priority at the top of the diamond formation and the least important statement at the bottom. The second, third and fourth rows consisted of statements that were ranked with descending priority, and each row had two, three and two statements, respectively.

According to Clark (2012), diamond ranking is used with children and young people to enhance arguments and discussions regarding a variety of topics, so it was the appropriate tool to use to encourage the group members who participated in this research to engage in discussions and express their opinions and reasons behind ranking the statements.

## 4.6. **Sampling**

Schmidt and Hollensen (2006) advised researchers to formulate a sampling framework, which requires determining the sites where the study would be implemented. Therefore, the researcher should assess the local populace in terms of its relationship to the study and its appropriateness for achieving the specific research aims (Gay & Airasian, 2003). Matthew and Carole (2004) define a sample as “every possible case that could be included in your study” (p.149). The targeted sample represents the whole population (Alduhayan & Ezat, 2002). Gathering data from a sample rather than the entire population saves time and money. In addition, by carefully selecting the sample, a researcher might increase the response rate and receive greater cooperation from sample respondents, and the data provided by the sample will be equally accurate as data collected from a survey of the entire population (Bailey, 2008).

As the present research sought to investigate Saudi students’ opinions and attitudes towards science and technology, and because the researcher had limited time due to the regulations of the Saudi Ministry of Education permitting data collection from students within three months only, with a possibility of no more than a one-month extension, it was not practical to gather data from all of Saudi Arabia; therefore, the researcher selected only Buraydah city. Buraydah, in Qassim province, has students in the final year of secondary school who are studying the same subjects and curriculum in the same system and environment as all students in Saudi Arabia, which has a unified educational system.

To generalise the quantitative study results to the wider population, normally the sample should be extensive. However, the sample in a qualitative study is small because interpretation is more important in qualitative research, as opposed to generalising the result. For mixed-method research, Johnson and Christensen (2012) suggest four sample relationship criteria:

Identical relationship, which is when the same participants are used to gather both quantitative and qualitative data.

Parallel relationship, which means the sample will be from one population; however, the participants in the quantitative part are different from the participants in the qualitative part.

Multilevel relation, which occurs by selecting participants from different levels in the population to gather quantitative and qualitative data.

Nested relationship, which occurs when choosing a second phase sub-set from participants who participated in the first phase.

In the present research, the nested relation was used to gather data. All participants in this research participated in the questionnaire, and their quantitative data was extracted. Some participants then volunteered to participate in focus group interviews to deliver qualitative data. There were four members per interview and two groups per class. The present research's target population, from which the sample was drawn, consisted of all students who were studying in the science path in the final year (year three) of Buraydah secondary schools; the ROSE questionnaire was designed for students studying in the final year of secondary school.

Scholars do not agree on how to determine a sample's size. Alassaf (2010) and Alashari (2007) recommend determining the proportion of the sample to the population at 1%, 5% and 10% to achieve confidence levels of 99%, 95% and 90%, respectively. However, Kerlinger and Lee (2000) believed there are no clear methods to determine sample size because it can be affected by other elements, such as the research aims and topic or the study population's nature and economic situation.

This research's population was approximately 7000 students in the final year of secondary school, and the students were distributed among 142 schools for boys and girls around Buraydah city. Data were collected from 20 schools, including 10 boys' schools and 10 girls' schools; all schools in Saudi Arabia are single sex. In total there were 671 participants in the quantitative questionnaire. However, the researcher excluded 61 participants whose questionnaires were incomplete. Therefore, the actual participants were 610 (Tables 4-1 and 4-2). Of these, 80 were involved in the focus group interviews.

Table 4-1 The number of questionnaires distributed and excluded in girls' schools.

| School | Number of participants | Excluded | Actual |
|---|---|---|---|
| 1 | 38 | 5 | 33 |
| 2 | 39 | 4 | 35 |
| 3 | 21 | 1 | 20 |
| 4 | 32 | 2 | 30 |
| 5 | 32 | 1 | 31 |
| 6 | 30 | 5 | 25 |
| 7 | 43 | 1 | 42 |
| 8 | 16 | 0 | 16 |
| 9 | 23 | 1 | 22 |
| 10 | 39 | 5 | 34 |
| Total | 313 | 25 | 288 |

Table 4-2 The number of questionnaires distributed and excluded in boys' schools.

| School | Number of participants | Excluded | Actual |
|---|---|---|---|
| 1 | 43 | 0 | 43 |
| 2 | 42 | 0 | 42 |
| 3 | 37 | 0 | 37 |
| 4 | 43 | 0 | 43 |
| 5 | 28 | 0 | 28 |
| 6 | 61 | 27 | 34 |
| 7 | 33 | 6 | 27 |
| 8 | 36 | 0 | 36 |
| 9 | 20 | 3 | 17 |
| 10 | 15 | 0 | 15 |
| Total | 358 | 36 | 322 |

## 4.7. **Gathering Data**

Upon receiving approval from both her supervisor and the University of York for a field trip, the researcher immediately prepared to gather the data. She requested a letter from the Saudi Cultural Bureau, asking the General Directorate of Education Qassim (GDEQ) for their assistance with the field trip, and received approval from the GDEQ to implement the study in their schools.

After the researcher arrived in Buraydah, Saudi Arabia, on 21 February 2017, she delivered the letter to the GDEQ on 22 February 2017 to obtain approval for visiting the schools. This process took five working days[1], and approval was issued on 28 February 2017. The researcher visited the first school, a girls' school, the same day.

The researcher acquired a list of Buraydah schools and contacted the school principals to obtain permission and schedule appointments for visiting. She then asked the relevant teachers -who were teaching science subjects- to sign a permission form. One full day was spent in each school and some schools were visited twice. Overall, the researcher spent six weeks collecting data from the girls' schools, at a rate of two schools per week, with one week's delay for the half-term holiday.

The researcher usually met the participants in their classrooms. In Saudi schools, students stay in their classrooms unless the teacher requires them to go to the laboratory for an experiment, so the researcher had to visit more than one classroom in a single school. In

1 . The weekend in Saudi Arabia is Friday and Saturday.

the classrooms, the researcher described the purpose of the study, then explained the questionnaire and the instructions for completing it. Next, the researcher distributed the questionnaire and answered any questions the students asked. The researcher remained in the classroom until the participants finished the questionnaires; a process taking between 45 and 60 minutes.

After the completed questionnaires were collected, the researcher invited four volunteer students to participate in a focus group. The researcher conducted two discussions per class, meaning that, if the school had two classes, four discussions were performed with eight participants. Initially, the researcher explained the purpose of the discussion, explained with the diamond ranking task, explained the sentences that were printed on the cards, and asked students to appoint a coordinator to manage the discussion while the researcher took notes. Before the discussions started, the researcher asked the participants if they had any objection to being recorded. The discussions usually took between 15 and 20 minutes, during which time the students discussed their views about the importance of teaching science and technology in schools. When the participants finished their discussions, the researcher documented the school's name and the group's code, then photographed the resulting diamond after the participants had ranked the cards.

When the researcher was collecting the research data in 2017,[1] the Saudi regulations prohibited males and females from attending or visiting the same schools; thus, females could not, or struggled to, collect data from boys' schools, and males could not collect data from girls' schools. Therefore, the researcher's husband helped the researcher to collect the data from the boys' schools. Since the researcher's husband held a PhD, he possessed sound knowledge of data collection and dealing with participants and questionnaires, although the researcher trained him on how to conduct the discussions during the diamond ranking activity.

To collect data from the male participants, the researcher's husband started by contacting the head teachers at the schools identified by the researcher, to schedule the school visits. He visited 10 boys' schools; the first visit was on 15 April 2017, and he visited two schools per week, so he spent five weeks collecting the boys' data.

Initially, he met with the schools' head teachers, who checked the approval letter and asked about the nature of the data that he wished to collect. The meetings usually took about

1 . Currently, and before submitting the thesis, a number of changes to Saudi regulations have affected women.

20–30 minutes. Then school principals gave their permission for one of the science subject teachers to organise the ROSE questionnaire data collection from science pathway students. The teacher introduced the researcher's husband to the students, then left the classroom. Since schools have two year twelve classes (the third year in Saudi secondary schools), the data was collected from the two classes separately. Initially, he met the students, described the purpose of the study, and informed the students that the data collection would be confidential, assuring them that the questionnaire did not request any information that would breach participant privacy; it would only use a code to refer to the school name. Thereafter, students were advised of their right to leave class or raise objections if they did not wish to participate in the study. Before he distributed the questionnaire, the researcher's husband gave the students an opportunity to clarify uncertainties and ask questions.

He then distributed the questionnaires to the participants, discussed how to answer the questionnaire, and explained the questionnaire sections to them; if they had any questions, he answered them. He stayed with participants until they had all completed the questionnaire. Some students raised concerns about items they did not understand, such as items asking about horoscopes (the reasons for their concerns will be discussed in the findings and discussion sections), but he clarified the meaning of these items and explained why there was no conflict between the items and their beliefs. When he collected the questionnaires from the participants, he wrote the school's code on the papers, then placed them in a case provided by the researcher.

Participants were asked to volunteer to participate in the diamond ranking activity before they completed the ROSE questionnaire, and their names were noted. As mentioned previously, the groups comprised four participants and also two groups per class. The researcher's husband agreed with the school principals to conduct the diamond ranking activity in a different room, so the activities were done in different places depending on the availability of space, with some of them conducted in classrooms, and others in science laboratories or school libraries. He explained the activity and the diamond ranking statements, and also asked the groups to appoint a coordinator to organise the discussion. He then provided nine statements printed on blue cards and a sheet of A3 paper with a pyramid containing the numbers one to nine, on which the blue cards were arranged, depending on their importance to the participants, as explained earlier. The group members were asked if they had any objections to their discussions being recorded, but all the group members gave their permission for the recording. The participants conducted their discussions while the researcher's husband took notes and, in some cases, facilitated the discussion by asking the students questions. In addition, he tried to encourage all group members to provide their views and participate in the discussions, which helped to extract the widest possible range of views and opinions regarding science and technology. When the groups had organised their statements, finished their discussions, and completed the activity, their pyramid diagrams were photographed for use in the analysis. In some groups, the members had different opinions about the importance of the diamond-ranked statements, which necessitated arranging the statements in the pyramid twice and photographing them to capture the variation. A note was made, explaining that there were two opinions in that particular group. The audio recordings were saved in a mobile device under the school's code and group number.

At the end of the day, the researcher's husband transferred the audio files containing the group discussions to a computer, saved the diamond ranking pyramid photographs in a folder with the school's code, and placed the case containing the participants' questionnaires in a special box. All this information was later handed to the researcher.

The data collection was completed on 20 May 2017, when the last focus group discussion was completed. The researcher then commenced the analysis. The next section will explain the procedures employed to analyse the quantitative and qualitative data.

## 4.8. Data Analysis

This section explains the procedures employed to narrow down and organise the quantitative and qualitative data, which helped the researcher to answer the research questions . Normally, data analysis follows long after the data collection, but in the current research, the quantitative and qualitative data was analysed earlier due to the instruments that were applied (the ROSE questionnaire and the diamond ranking) and the clear aims of the research (Bryman & Bell, 2011). As the researcher collected the quantitative and qualitative data, various statistical tests were applied to obtain descriptive data and thematic analysis conducted, in order to elicit various types of information that would answer the research questions.

### 4.8.1. Quantitative Data

This section presents the techniques that were employed to analyse the descriptive data collected from the Saudi students and investigate their attitudes and interest toward science subjects. The descriptive data was managed and analysed using IBM SPSS (Statistical Program for the Social Sciences) and Microsoft Excel software (Saunders et al., 2012). To enhance confidence in the correctness and accuracy of the data entry procedures, the researcher entered the data into SPSS herself, in accordance with the guidelines of *The ROSE Handbook* provided on the website of the ROSE project (Sjøberg & Schreiner, 2004). Since the questionnaire employed four-point Likert scales, responses were coded on a scale of one to four, according to the Likert scale order, so a value entered in the first-choice box was coded as 1, a value entered in the second-choice box was coded as 2, and so on. The researcher also used the code X to refer to the questionnaire page and added the page number (e.g. X1 referred to page 1 of the questionnaire), which made it easier to recognise the questionnaire's page number in the SPSS file (Sjøberg & Schreiner, 2004).

The demographic information was also coded for use in the SPSS software, where it was coded 1 for a boy and 2 for girl, with additional codes for the parents' occupations. The number 9 was used to represent missing data, that is, any item that was not responded to by participants, or where more than one choice or category was selected for one item. Any questionnaires that were not fully completed, or which were completed incorrectly, were excluded. However, the 61 questionnaires excluded and responses coded 9 were retained for future use in tracing possible mistakes at a later stage if necessary (Sjøberg & Schreiner, 2004).

To ensure quality and avoid mistakes, the data was properly cleaned. The data cleaning procedures involved checking any mistakes in the Likert scale codes (e.g. a code entered twice for one choice), and whether there were any differences between the cell code and the question number, a cell with missing a code, or one cell with more than one code. All completed questionnaires were coded by the researcher to make it easier for her to spot errors.

When all the data had been entered, but before the researcher started the statistical tests, she reviewed the SPSS file to check all the data that been entered, and she solicited her husband's assistance in checking the questionnaires while she read the codes from the SPSS file. The time that the researcher spent on entering data, for 204 items and four additional background questions, was 60 days, plus a further 15 days for reviewing, so the total time taken was 75 days.

After ensuring that the data had been entered correctly and checking the data integrity, the researcher began the statistical analysis and interpretation of the results (Khalil, Baker, Mustafa, & Mohmmed, 2011). The researcher used the following SPSS statistical techniques:

- Cronbach's alpha coefficients were employed to measure the research reliability across a number of items. Clusters were used to investigate the internal consistency within numbers of science topics that were grouped according to their appropriate science discipline. It should be noted that the test was done both before and after the data collection.
- A simple descriptive statistical test used proportions and mean values to explain the sample information, with the strength of the students' interests and attitudes being measured by values ranging from one to four, as follows:
  - Mean values between 3.23 and 4 indicated strong interest and agreement.
  - Values between 2.6 and 3.24 indicated moderate interest and agreement.
  - A value of 2.5 was considered to be 'neutral', meaning that the students neither agreed nor disagreed with the ROSE statement.
  - Values ranging from 1.75 to 2.49 indicated little interest and agreement.
  - Values from 1 to 1.74 indicated complete lack of interest and agreement.
- Chi-squared tests were used to investigate the statistical significance of differences in two stages. The first stage explored the statistically significant differences between girls' and boys' interest and attitudes toward science and technology by comparing the two samples' mean value for each section. The second stage identified gender differences for individual items. The significance of differences in means between the boys' and girls' scores; was based on the P-value. If this was greater than 0.05, it meant that there was no statistically significant difference, but if the p value was less than or equal to 0.05, it meant that there was a statistically significant difference.

Statistically significant differences between Saudi students and their peers from other countries who participated in the ROSE project were not calculated in the current research, but they are reported using graphical representations.

### 4.8.2. Qualitative Data

Because qualitative data involves large amounts of information, it can pose challenges for researchers in terms of analysis (Bryman & Bell, 2011). In this study, challenges arose from the clarity and explicitness of the language used and its inherent nuances. The researcher extracted the relevant information and constructed explanatory narratives in order to interpret and understand the social phenomena (Walker & Myrick, 2006). The current research collected data from 32 focus group discussions to interpret and understand how the Saudi students perceived science subjects and explore the reasons underlying their interest and attitudes regarding science and technology. The data that was collected was classified and managed through the use of themes and categories, which allowed the researcher to form concepts and theories (Walker & Myrick, 2006). The following are the procedures followed to manage the qualitative data:

- All the discussions with both girls and boys were audio recorded, so the researcher listened to all the recordings and noted any sound problems or interruptions in the discussions.
- All the audio files were transferred from the iPhone that had been used to record the discussions to the MacBook that the researcher used. The operating systems for the two devices were compatible, which made the transfer process quick, easy, and accurate.
- In the beginning, the content of the girls' discussions was transcribed by the researcher. It took a long time to produce a full transcript, because the researcher transcribed it first by hand, and then using Microsoft Word; therefore the researcher spent approximately six weeks on transcribing 17 discussions. Due to time constraints, the researcher used a professional third party to transcribe the 15 boys' discussions. The third party provides academic services in Saudi Arabia and has been used by number of postgraduate Saudi students to produce transcripts for them. The transcription carried out by the third party contained full details, include timing, unclear words or speech, momentary pauses, mumbling, laughter, and all other utterances in order to present a full record of the boys' discussions. They provided the transcripts as Microsoft Word files, with coloured fonts to distinguish between participants. The different coloured fonts were assigned to specific group members.
- Each transcript completed by the researcher or by the third party was reviewed by the researcher and compared with the original audio file to verify its authenticity; therefore, the researcher became immersed in each discussion's details, which enhanced her understanding of the information captured.
- The analysis of the discussions was carried out as follows:

The analysis depended on the order of the diamond-ranked statements in the pyramid. It was carried out by identifying the statement that was placed at the top of the pyramid by the largest number of groups, reflecting its importance to these group members. Then the statements identified by fewer groups were identified sequentially, down to the ones identified by only one group.

In the current research, thematic analysis was employed, using themes identified from the ROSE questionnaires and the literature review. These were identified and classified into relevant categories drawn from the participants' discussions. The researcher classified data with similar subject matter under one theme and gave it a specific font colour, so that quotations linked to the importance of teaching science were coloured blue, quotations regarding the teacher were coloured green, and quotations that talked about particular science topics had different colours depending on the science subject, with physics topics coloured brown, biology topics coloured red, and so on. The classified statements helped to establish categories and led to the formation of themes (Scott & Howell, 2008; Walker & Myrick, 2006).

The ROSE sections (A, C, E, F, G, H) were used to classify the quotations and create themes, which were then checked against the students' responses to the ROSE questionnaire. This helped in interpreting and understanding the students' attitudes and interest; for example, statements relating to diseases are linked with ROSE items concerning diseases in the research findings and discussion. The themes expanded on the students' views, as the focus groups gave them the opportunity to say more than the questionnaire allowed, to justify their answers to the ROSE items.

The next stage in extracting quotations involved translation of the Saudi students' discussions from their Arabic mother tongue. The researcher translated all quotations from Arabic into English with the help of two of her daughters who had grown up in the UK and had mastered the English language and then gave the translations to a professional English translator to check for accuracy. Proofreading was then carried out by a professional proof-reader.

### 4.8.3. Linking the Quantitative Data with the Qualitative Data

Since the present research contained two types of data, which had been collected to fully answer the research questions, the researcher had to link the qualitative data with the quantitative data to produce a single data set. This was done after the researcher analysed the quantitative data using the quantitative analysis techniques and the qualitative data using the qualitative techniques (Sandelowski, 2000). Sandelowski (2000) stated:

> For example, constant comparison, qualitative content, and narrative analysis techniques are used to analyse discussion data, whereas one or more statistical techniques are used to analyse data from instruments. The results of the qualitative analysis of qualitative data and of the quantitative analysis of quantitative data are then combined at the interpretive level of research, but each data set remains analytically separate from the other (p.252).

The following are the techniques used to organise and link the quantitative data with the qualitative data:

- Since the ROSE sections A, C, and E were linked to interest in science subjects, they answered research question one. Since these sections contained many items, which would have made the analysis and discussion chapter very long, the researcher condensed them according to the Saudi science subject divisions: physics, chemistry, and biology.
- Each of these science subjects comprised a number of relevant topics; for example, the biology section contained topics relating to the human body, plants, and animals, while the physics section covered light, electricity, technology, and other topics. Consequently, the quantitative data was analysed and discussed in relation to the qualitative data according to the divisions mentioned previously.
- As mentioned earlier, the section answering the research questions would have been extremely large, so the researcher condensed the information into three subjects, and separated section H into a separate chapter for the same reason.
- Since the limited items in sections G and F answered research questions three and four, the researcher analysed and discussed each item individually and matched it to the qualitative data in order to interpret the participants' choices in the ROSE questionnaires and also to discover their opinions and views regarding science and technology.

## 4.9. **Ethical Issues**

According to the ethical guidelines provided by the University of York, the researcher paid attention to all possible ethical issues associated with the whole research process. The researcher considered ethical issues in the earliest stage of the data collection (Bell, 2005), and obtained a letter from her supervisor addressed to the researcher sponsor, approving the research, as shown in Appendix 4. Based on the approval, a letter was issued by the sponsor (the Saudi Cultural Bureau) to the General Directorate of Education in Qassim to seek approval to apply the study in their schools (Appendix 5). When the General Directorate of Education in Qassim gave its permission, the researcher travelled to Saudi Arabia to collect the research data from the schools in Buraydah city. The researcher also obtained an approval letter from the General Directorate of Education in Qassim, addressed to the schools' head teachers (Appendix 6).

Neither the participants nor anyone else who contributed to the research was harmed by the research (Saunders et al., 2012). An explanatory sheet prepared by the researcher described the research purpose, and its aims and importance, giving brief information about the researcher. In addition, it stressed that of participation would reflect positively on the education system in Saudi Arabia, since it provided a channel for students to express their views regarding science and technology. This was delivered to the head teachers and the teachers of participants (Appendix7).

The researcher also emphasised, for students who participated in the questionnaire survey, the importance of providing honest answers. The researcher informed the involved students about the importance of the study and their rights in answering the questionnaire. They were advised that they could withdraw at any time without harmful consequences, that their information and their answers would be kept strictly confidential, and that the researcher would simply record the school name on the questionnaire.

Ensuring the discussion participants' confidentiality was one of the main concerns during the data gathering discussions (Kent, 2000; Silverman, 2013). In addition to the procedures mentioned previously, all discussion data that was collected during the focus groups was treated as confidential and the participants were informed that their input would be treated as such. They were informed by the researcher that their anonymity would be maintained at all times and their discussions would be coded anonymously by the researcher to hide their identities.

## 4.10. **Validity and Reliability of the Research Instrument**

The validity and reliability of the research instruments are the most significant issues in any academic research (Alduhayan & Ezat, 2002); therefore, the researcher endeavoured to ensure that the research instruments and data outcomes were valid and reliable, as the following sections show.

### 4.10.1. Validity

Research can be worthless if the instruments it uses are invalid; therefore, validity plays an essential role in effective research (Cohen et al., 2011).Validity has been defined as "the appropriateness, meaningfulness and usefulness of the specific inferences researchers make based on the data they collect" (Wallen & Fraenkel, 2013, p. 476).

The validity of the research may affect the inferences that are drawn from the results of data analysis, which means that the empirical evidence must support those inferences (Shadish, Cook, & Campbell, 2002). The validity of research can be ensured by following the proper academic research methods throughout the research process that leads to the generating of research findings, so Oliver (2010) considered validity to be a condition for results integrity for all types of research. The researcher concluded that the quality of the inferences would derive from the quality of the instruments used to conduct the research (Irfan, 2018).

The present research aimed to investigate Saudi students' attitudes and interest regarding science and technology by listening to their views regarding science and technology's importance in society and their plans and ambitions for the future. The researcher employed the ROSE questionnaire, which was designed to investigate students' attitudes toward science and technology in their own words and developed using a comprehensive process and involving a number of different actors. The ROSE organisation believes that the concepts that are most applicable are 'face validity' (the superficial appearance of the question) and 'cultural validity' (whether the cultural background of the students influences their understanding of the question), and they worked on addressing these types of validity in developing the ROSE instrument (Sjøberg & Schreiner, 2004). To do this, they began by having the questions and items evaluated internally and by their partners to determine whether these questions and items were useful, then they improved the items to ensure that their meanings were clear, simple, and unambiguously worded. During the questionnaire's development, the organisation listened to the views of students, teachers, and researchers from different cultural backgrounds, in an attempt to ensure common-sense face and cultural validity. All these efforts were made to ensure sufficient validity for most of the dimensions that they sought to investigate via the ROSE questionnaire; hence, the present research provided evidence for valid inferences by using the ROSE questionnaire to investigate Saudi students' attitudes and interest regarding science and technology.

### 4.10.2. Reliability

Another issue that concerned the researcher was whether the instruments were reliable, where reliability refers to the stability of the instruments over time (Punch, 2009) and their ability to generate similar results for the same test repeated under the same conditions (Oppenheim, 2000). Cohen et al. (2011) mentioned that "a reliable instrument for a piece of research will yield similar data from similar respondents over time" (p.200), but it is necessary to take into account that the period should not be too long, because the factors and circumstances may change, and should not be so short that respondents remember the answers from previous tests (Cooper & Schindler, 2003).

Research data reliability can be evaluated when the questionnaire items are examined for internal consistency, and the researcher should assess the internal consistency of the research items by checking and examining the extent of the correlation of these items with each other and with the total score. Researchers use a statistical test to verify the internal validity, which is called Cronbach's alpha and which examines the correlations between items in the scale and the total number of items (Kimberlin & Winterstein, 2008).

The current research used the ROSE questionnaire to enhance the Saudi students' expression of their views regarding science and technology. The ROSE organisation designed sections A, C, and E of the ROSE questionnaire to give students the chance to express their preferences regarding the science and technology topics they would like to learn about in school. These sections concerned the students' interest in science and technology subjects such as physics, biology, chemistry, and computer science, and these section items focused on different topics that linked to main subjects such as human biology, zoology (animal biology), botany, geology, meteorology, the environment, technology, medicine, and agriculture as applied sciences. These multiple items were designed to correlate with each other and shed light on students' interest in science subject areas. For the same reason, some of the science topics, in this research, were grouped according to the science subjects or disciplines that are taught in Saudi schools, which contributed to the present research instruments' reliability.

To examine the research instrument, the researcher employed the Cronbach's alpha statistical test using SPSS software. The researcher grouped the items into clusters that linked to specific science subjects, based on the Saudi science subjects in schools. Each group was assigned a code that referred to the name of the group: H referred to biology (human biology, youth and age, health and fitness), A to animals, P to plants, L to light, E to electricity, T to technology, U to space, C to chemistry, and G to Geoscience. Each group was composed of similar topics. A reliability analysis was applied to each cluster (group), using Cronbach's alpha to measure the internal consistency within the group, that is, the extent to which item in group measure the same underlying circumstances (i.e., the extent to which the items 'hang together'). The Cronbach's alpha values for the present research instruments ranged from 0.891 to 0.647 (for more details, see Appendix 3).

## 4.11. **Summary**

This chapter has presented and discussed the research methodology that was used to answer the research questions. Although the research questions focused on the Saudi students' attitudes and interest regarding science and technology, the Saudi education system does not encourage students to express their opinions, and the current research employed the best methods to address this deficiency with regard to science and technology subjects. The ROSE questionnaire was the best instrument, from among the quantitative methods, to help students to express their attitudes, interest, and views regarding science and technology. In addition, diamond ranking, qualitative method designed to encourage young people to express their views to adults, was employed during focus group discussions. Both of these techniques have been explained in this chapter. The research sample was discussed and was selected to represent male and female Saudi students who were studying the science pathway in year 12 (the third year of secondary school).

The data that was collected was mainly quantitative data, so it was analysed using SPSS software, because it enabled the researcher to conduct statistical tests such as mean value and chi-squared. The qualitative data was analysed thematically, and the researcher grouped the participants' quotations according to themes. The researcher paid careful attention to ethical issues when dealing with the data and participants. The following chapters will present the data findings and discussion, which will be divided and organised according to the answers to the research questions.

# Chapter 5: Answering Research Question One

**What is the students' interest in school science and technology?**

## 5.1. Introduction

Exploring and understanding students' interest in science is a significant issue. It enhances educational stakeholders' knowledge needed to determine, develop and evaluate the educational process, with the aim of enhancing students' achievement, hence the particular focus of this research on students' attitudes. This chapter investigates students' opinions of science subjects by analysing and discussing the data that were gathered quantitatively, via the Relevance of Science Education (ROSE) instrument, and qualitatively via focus groups. This is followed by an analysis of gender differences and a comparison of Saudi students' interests in scientific topics as reflected in sections A, C and E of ROSE, with those of students in other countries.

## 5.2. What I Want to Learn About

This section will provide data relevant for constructing science curricula that meet Saudi students' needs and aspirations. Sections A, C and E of the ROSE questionnaires were designed to give students the opportunity to indicate what science and technology topics they would prefer to learn about in school. While they investigate students' interest in various science and technology subjects such as biology, physics and chemistry in general, they also contain questions linked to various sub-disciplines of science and technology, such as human biology, zoology (animal biology), botany, geology, meteorology, the environment, etc. Moreover, various questions cover technology, medicine and agriculture as applied sciences. Other questions ask about horoscopes, mysticism and aliens as examples of unscientific or unproven phenomena. In responding to the questionnaire, Saudi students had the opportunity to indicate their interest in science and technology by answering the question 'How interested are you in learning about the following?' This section will analyse data collected from both boys' and girls' schools, with mean scores calculated for each item, by assigning a score ranging from 1 (never interested) to 4 (very interested) for students' responses. The middle point of the scale is a mean score of 2.5 which represents a 'neutral' position.

Sections A, C and E contain a large number of items, and the results could be presented in several ways. Here, the results have been organised to show the ten most interesting topics for girls and boys, then the ten least interesting topics for girls and boys, presented in four tables (Tables 5-1,5-2,5-3 and 5-4). The results are then divided according to the science subjects presently taught in the Saudi school system. Wherever an item does not link clearly to a school subject or to an area within a particular subject, the responses to that item are grouped according to the most closely related subject. Following presentation of the data gathered via ROSE, consideration is given to the reasons behind these interests by analysing and discussing the data collected from focus groups.

### 5.2.1. Results

Table 5-1 The most popular topics for girls, as extracted from ROSE sections A, C, and E

| N | Items | Frequency | | | | | | | | Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Very interested | | Interested | | Not Interested | | Not very interested | | |
| | | Count | % | Count | % | Count | % | Count | % | |
| 1. | A39. The ability of lotions and creams to keep the skin young | 174 | 60.4 | 77 | 26.7 | 27 | 9.4 | 9 | 3.1 | 3.45 |
| 2. | A40. How to exercise to keep the body fit and strong | 174 | 60.4 | 74 | 25.7 | 29 | 10.1 | 10 | 3.5 | 3.44 |
| 3. | A34. How it feels to be weightless in space | 170 | 59.0 | 70 | 24.3 | 42 | 14.6 | 6 | 2.1 | 3.40 |
| 4. | E10. How to perform first-aid and use basic medical equipment | 149 | 51.7 | 101 | 35.1 | 23 | 8.0 | 13 | 4.5 | 3.35 |
| 5. | C13. Why we dream while we are sleeping, and what the dreams may mean | 163 | 56.6 | 70 | 24.3 | 42 | 14.6 | 11 | 3.8 | 3.35 |
| 6. | A37. What to eat to keep healthy and fit | 151 | 52.4 | 90 | 31.3 | 29 | 10.1 | 18 | 6.3 | 3.30 |
| 7. | E8. Cancer, what we know and how we can treat it | 150 | 52.1 | 79 | 27.4 | 44 | 15.3 | 11 | 3.8 | 3.30 |
| 8. | C8. The possibility of life outside earth | 149 | 51.7 | 69 | 24.0 | 42 | 14.6 | 25 | 8.7 | 3.20 |
| 9. | C11. Life and death and the human soul | 136 | 47.2 | 88 | 30.6 | 32 | 11.1 | 24 | 8.3 | 3.20 |
| 10. | A7. How the human body is built and functions | 119 | 41.3 | 116 | 40.3 | 44 | 15.3 | 9 | 3.1 | 3.20 |

The results show that the top ten topics of interest for girls start with item A39 (The ability of lotions and creams to keep the skin young) which had the highest mean score (3.45), with 174 students (60.4%) responding ‘very interested’. Item A40 (How to exercise to keep the body fit and strong) scored a frequency of 170 (60.4%), but the mean value was 3.44. In response to item E10 (How to perform first aid and use basic medical equipment) 149, girls (51.7%) answered ‘very interested’, and the mean value was 3.35. Items A37 and C8 were of interest to girls, with mean values of 3.30 and 3.20, respectively. The mean value of item A7 (How the human body is built and functions) was 3.20, with 41.3 % of students responding, ‘very interested’. Most of these popular items are related to the self and, particularly, to health, mind, and well-being. As for item A34, which is concerned with aspects of astronomy, the frequency of ‘very interested’ responses was 170, with a percentage of 59.0 and a mean value of 3.40.

Table 5-2 The most popular topics for boys, as extracted from ROSE sections A, C, and E

| N | Items | Frequency | | | | | | | | Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Very interested | | Interested | | Not interested | | Not very Interested | | |
| | | Count | % | Count | % | Count | % | Count | % | |
| 1. | A40. How to exercise to keep the body fit and strong | 150 | 46.6 | 116 | 36.0 | 41 | 12.7 | 9 | 2.8 | 3.29 |
| 2. | A37. What to eat to keep healthy and fit | 143 | 44.4 | 114 | 35.4 | 42 | 13.0 | 17 | 5.3 | 3.21 |
| 3. | E10. How to perform first-aid and use basic medical equipment | 121 | 37.6 | 113 | 35.1 | 56 | 17.4 | 18 | 5.6 | 3.09 |
| 4. | C13. Why we dream while we are sleeping, and what the dreams may mean | 117 | 36.3 | 123 | 38.2 | 52 | 16.1 | 22 | 6.8 | 3.07 |
| 5. | A34. How it feels to be weightless in space | 125 | 38.8 | 87 | 27.0 | 70 | 21.7 | 34 | 10.6 | 2.96 |
| 6. | E40. Inventions and discoveries that have changed the world | 98 | 30.4 | 120 | 37.3 | 67 | 20.8 | 25 | 7.8 | 2.94 |
| 7. | E23. How my body grows and matures | 94 | 29.2 | 124 | 38.5 | 70 | 21.7 | 22 | 6.8 | 2.94 |
| 8. | E28. How to use and repair everyday electrical and mechanical equipment | 92 | 28.6 | 121 | 37.6 | 75 | 23.3 | 23 | 7.1 | 2.91 |
| 9. | E9. Sexually transmitted diseases and how to be protected against them | 92 | 28.6 | 112 | 34.8 | 74 | 23.0 | 26 | 8.1 | 2.89 |
| 10. | A7. How the human body is built and functions | 85 | 26.4 | 132 | 41.0 | 78 | 24.2 | 22 | 6.8 | 2.88 |

The results show that for boys, item A40 (How to exercise to keep the body fit and strong) scored the top mean value (3.29), with 150 students responding, 'very interested' and 116 students responding 'interested'. Item A37 (What to eat to keep healthy and fit) comes second in popularity with a mean score of 3.21. 143 students responded, 'very interested' and 114 students responded 'interested'. Items E10 and C13 were not significantly different because their mean value scores were 3.09 and 3.07, respectively. The mean value of item A34 (How it feels to be weightless in space) was 2.96, with 125 students who responded, 'very interested' and 87 students who responded 'interested'. The results also show that the items E40 (Inventions and discoveries that have changed the world) and E23 (How my body grows and matures) each had the same mean value of 2.94. Boys showed relatively high interest in learning about working on electrical and mechanical equipment, and the mean score for item E28 (How to use and repair everyday electrical and mechanical equipment) was 2.91. It can be observed that the last two among the ten topics most interesting to boys were sexually transmitted diseases and the functioning and building of the body; the mean values of items E9 (Sexually transmitted diseases and how to be protected against them) and A7 (How the human body is built and functions) were 2.89 and 2.88, respectively. Based on Table 5-2, it can be concluded that the most popular subjects for boys were related to health, the treatment of diseases and first aid.

Table 5-3 The mean scores for the 10 topics least popular with girls

| N | Items | Frequency | | | | | | | | Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Very interested | | Interested | | Not Interested | | Not very interested | | |
| | | Count | % | Count | % | Count | % | Count | % | |
| 1. | A47. How petrol and diesel engines work | 28 | 9.7 | 52 | 18.1 | 130 | 45.1 | 77 | 26.7 | 2.11 |
| 2. | C4. How cassette tapes, CDs and DVDs store and play sound and music | 27 | 9.4 | 66 | 22.9 | 129 | 44.8 | 64 | 22.2 | 2.20 |
| 3. | E33. Benefits and possible hazards of modern methods of farming | 61 | 21.2 | 133 | 46.2 | 57 | 19.8 | 32 | 11.1 | 2.21 |
| 4. | A17. Atoms and molecules | 39 | 13.5 | 66 | 22.9 | 103 | 35.8 | 78 | 27.1 | 2.21 |
| 5. | C9. Astrology and horoscopes, and whether the planets can influence human beings | 55 | 19.1 | 58 | 20.1 | 74 | 25.7 | 98 | 34.0 | 2.25 |
| 6. | E25. Plants in my area | 26 | 9.0 | 75 | 26.0 | 130 | 45.1 | 54 | 18.8 | 2.26 |
| 7. | E24. Animals in my area | 34 | 11.8 | 64 | 22.2 | 130 | 45.1 | 57 | 19.8 | 2.26 |
| 8. | C3. The use of lasers for technical purposes (CD-players, bar-code reader, etc.) | 37 | 12.8 | 65 | 22.6 | 121 | 42.0 | 63 | 21.9 | 2.27 |
| 9. | E17. How to improve the harvest in gardens and farms | 40 | 13.9 | 66 | 22.9 | 115 | 39.9 | 64 | 22.2 | 2.29 |
| 10. | E19. Organic and ecological farming without use of pesticides and artificial fertilizer | 40 | 13.9 | 57 | 19.8 | 136 | 47.2 | 53 | 18.4 | 2.29 |

Table 5.3 shows the ten items of least interest to girls. item A47 (How petrol and diesel engines work) was the least interesting topic for girls, with a mean value of 2.11, followed by item C4 (How cassette tapes, CDs, and DVDs store and play sound and music), with a mean score of 2.20. Items E24 and E25 scored the same mean value, 2.26, as did items E17 and E19, 2.29. It should also be noted that girls showed little interest in learning about atoms and molecules or astrology, as Table 5- 3 shows that both item A17 (Atoms and molecules) and C9 (Astrology and horoscopes, and whether the planets can influence human beings) scored mean values of 2.21 and 2.25, respectively.

Table 5-4 The mean scores for the 10 topics least popular with boys

| N | Items | Frequency | | | | | | | | Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| | | very interested | | Interested | | Not interested | | Not very interested | | |
| | | Count | % | Count | % | Count | % | Count | % | |
| 1. | A17. Atoms and molecules | 24 | 7.5 | 62 | 19.3 | 140 | 43.5 | 93 | 28.9 | 2.05 |
| 2. | E31. Biological and human aspects of abortion | 33 | 10.2 | 65 | 20.2 | 123 | 38.2 | 87 | 27.0 | 2.14 |
| 3. | E1. Symmetries and patterns in leaves and flowers | 37 | 11.5 | 58 | 18.0 | 141 | 43.8 | 72 | 22.4 | 2.19 |
| 4. | C9. Astrology and horoscopes, and whether the planets can influence human beings | 44 | 13.7 | 64 | 19.9 | 117 | 36.3 | 90 | 28.0 | 2.20 |
| 5. | E33. Benefits and possible hazards of modern methods of farming | 31 | 9.6 | 75 | 23.3 | 134 | 41.6 | 70 | 21.7 | 2.22 |
| 6. | A15. How plants grow and reproduce | 30 | 9.3 | 82 | 25.5 | 142 | 44.1 | 65 | 20.2 | 2.24 |
| 7. | A18. How radioactivity affects the human body | 32 | 9.9 | 83 | 25.8 | 142 | 44.1 | 61 | 18.9 | 2.27 |
| 8. | A12. Cloning of animals | 50 | 15.5 | 65 | 20.2 | 124 | 38.5 | 77 | 23.9 | 2.28 |
| 9. | A3. The inside of the earth | 18 | 5.6 | 107 | 33.2 | 141 | 43.8 | 53 | 16.5 | 2.28 |
| 10. | E4. The greenhouse effect and how it may be changed by humans | 31 | 9.6 | 86 | 26.7 | 131 | 40.7 | 58 | 18.0 | 2.29 |

Table 4 lists boy students' mean scores for the ten least popular topics. Item A17 (Atoms and molecules) was the least interesting topic for male students, with a mean value of 2.05 and 24 students responding, 'very interested', while 62 students responded 'interested'. Item E31 (Biological and human aspects of abortion) had a mean score of 2.14. The frequency of students who answered, 'very interested' was 33, while 65 answered 'interested'. Botany and pollution were not popular amongst male students, as they showed little interest in learning about botany and plants (E1 and A15), or environment protection (E33). Item C9 (Astrology and horoscopes, and whether the planets can influence human beings) had a mean value of 2.20. Male students were somewhat interested in learning about the cloning of animals and geology, as items A12 (Cloning of animals) and A3 (The inside of the earth) had the same mean value of 2.28. Boys were slightly more interested than girls in item E4 (The greenhouse effect and how it may be changed by humans), although it was still amongst the ten least popular subjects, and the mean value score was 2.29.

### 5.2.2. Analysis and Discussion

Chiappetta and Fittman (1998) claim that students find it more difficult to effectively understand biology when they are overwhelmed by too many different topics. This is because, when students are faced with large amounts of information to learn, they will often only have time to commit the information to memory rather than assimilate their understanding of each topic. When lessons and curricula are designed without considering students' interests and abilities, students are more likely to become disillusioned with the subject (Yüzbaşılıoğlu & Atav, 2004; Zeidan, 2010). Furthermore, Fraser (1998) has illustrated the integral connection between academic performance and students' perceptions within their scholastic environment. As such, waning enthusiasm for the sciences is related to excessive and unrelatable curricula, reduced opportunities to talk at length about particular subjects, limited creative input, and a lack of reference to the social and scientific context for each topic (Osborne & Collins, 2001).

Despite the conclusions of multiple studies in co-educational schools (Kerkhoven, Russo, Land-Zandstra, Saxena, & Rodenburg, 2016; Sjøberg & Schreiner, 2010) that secondary school boys are more interested in, and more positively inclined towards science and technology than girls are, this study found a different result. Boys and girls have almost identical interest in science topics (as shown in Tables 5-1 and 5-2). The interests and attitudes of boy and girls are alike in numerous developing countries such as Uganda, Ghana, Swaziland and Zimbabwe (Sjøberg & Schreiner, 2005). The Saudi boys and girls who participated in this research appeared to be interested in learning about most of the topics covered in the questionnaire. Furthermore, the mean scores indicated that girls had greater interest in science overall than boys: the mean score for girls was 2.75 while that for boys was 2.59.

These results contradict the findings of some previous studies in Australia, the United States, Taiwan, and Japan (Dawson, 2000; Evans, Schweingruber, & Stevenson, 2002; Weinburgh, 1995). A possible explanation may be that the stereotype of male-dominated science is less applicable in single-sex schools. As noted above in Chapter Two, the Saudi education system supports single-sex schools, so there are no mixed schools for any grades except preschool. Furthermore, boys are taught by male teachers and girls are taught by female teachers. The single-sex school system may influence Saudi students' interest in science, especially for girls who have a greater opportunity in this system to study the purportedly male subjects, such as maths and science, whereas their opportunity may be less in mixed schools. It is possible that female students may do better in single-sex schools, in terms of teacher-student and peer-group relationships, and this could inspire them to study science. Single-sex schools do away with competition with the opposite sex for the attention and time of the teacher. In addition, all the leaders and outstanding pupils in a single-sex class are females, and this could present other girls with strong and inspirational role models (Thompson & Ungerleider, 2004).

In contrast, school teachers and counsellors in co-educational schools shape their counselling and teaching practices in line with gender stereotypes, and this invariably deters female students from becoming interested, and taking an active part, in science classes. A number of studies have noted that the atmosphere teachers create differs according to the gender of the students studying science, and this is further reflected in the quite different, and gender-based, expectations and dealings they have with boys and girls (Park, Behrman, & Choi, 2018). Chetcuti and Kioko's (2012) study shows that there is a difference between single-sex and co-educational schools; it seems that girls who attend single-sex schools are more confident in studying science than girls who attend co-educational schools.

In their study in the UK, Bennett et al. (2013b) show it was more likely that boys in mixed schools choose physics compared with boys in single-sex schools, while at A level, more girls who came from single-sex schools opted for physics than girls who came from mixed schools. The results of the study suggest that girls in single-sex schools may be more confident to choose so-called male subjects.

The top ten items in Tables 5-1 and 5-2 show much similarity in the interests of boys and girls. Similarity is seen in five items related to human biology, astronomy and "topics about which science is uncertain". The tables also show many differences. It is interesting to examine closely where these differences lie, and whether they may be influenced by cultural constructions of gender and lifestyle, such as the possible career paths for boys and girls. These data are analysed and discussed in reference to the science subjects taught in Saudi schools, which are biology, physics, chemistry and geology.

#### 5.2.2.1 Biology

Boys and girls study the same biology topics in all Saudi schools: human biology, health and disease, zoology and botany topics. The ROSE questionnaire covers these topics. The discussion below presents the quantitative and qualitative data showing students' interest in biology according to these topics.

##### 5.2.2.1.1. Human Biology and Health

The students' interest in human biology was apparent in their responses to the ROSE questionnaire and in their focus group discussions, which are explored in this section. Human biology was a primary area of study in which the students expressed interest. The results indicate the students were particularly interested in issues that link to human health, such as a healthy diet and substances harmful to health. Participants responded particularly favourably towards two items that link to health and fitness: 'How to exercise to keep the body fit and strong,' with a mean score of 3.29 for boys and 3.44 for girls, and 'What to eat to keep healthy and fit,' with a mean score of 3.21 for boys and 3.30 for girls. Both items were amongst the top ten interests for boys and girls (Tables 5.1 and 5.2). The participants seemed interested in understanding and following ways to achieve and maintain a healthy body through diet and exercise. A possible explanation for the students' higher interest in these topics may be due to Saudi students' awareness of the importance of health and exercise.

The students mentioned that studying biology, especially the human body, helped them learn about diseases and treatment of diseases. Discovering medical cures through studying biology may help solve problems with chronic diseases facing Saudi society, such as cancer. The Saudi Ministry of Health reports that there are more than 14 thousand cancer patients in Saudi Arabia and 74% of those patients are Saudi citizens, which averages at 52.6 cases for every 100 thousand citizens, making Saudi Arabia one of the countries most affected by cancer. Breast cancer is the most common cancer (Alhadath, 2021), which may have influenced girls to be more interested in biology than boys.

One of Saudi Arabia's goals is to achieve a vital society by increasing the number of practitioners of sports and physical activities. The health statistics completed by the Ministry of Health in 2013 showed that the percentage of men practising physical activity in general was about 54%, and for women, only about 25%, leading the government to introduce initiatives for therapeutic use of physical activity (Ministry of Health , 2020). Also, girls' interest in health and fitness issues may be partially explained by studies showing that many young women are concerned about body image (Uitto et al., 2006). Before 2017, the Saudi government prohibited women and girls from physical education in schools and physical competitions in general. In addition, the prevailing social norms in Saudi Arabia do not allow women to go out to public places "without necessity," and the dress code for women in Saudi Arabia which is an additional obstacle. In public places, women are required to wear a black abaya, covering the woman from head to toe (Whitson, 2012).

Human biology attracted students with topics relevant to their own lives, such as treatment of diseases. Information collected by PISA in 2006 were discussed by Bybee and McCrae (2011), found that subjects related to students' own experiences were of more interest than those with which they had less first-hand experience. The International ROSE project has shown that teenagers in year nine were the most interested in both human biology and health in biology education (Trumper, 2006), which is consistent with this study.

Another item the participants expressed interest in learning about was 'Why we dream while we are sleeping, and what the dreams may mean,' with the mean scores being 3.07 for the boys and 3.35 for the girls, indicating girls were more interested in this topic. These aspects of biology are important because they are new and concern the unfamiliar (Osborne & Collins, 2001). Most participants, boys and girls, expressed a strong desire to learn about 'How the human body is built and functions', 'How babies grow and mature' and 'How my body grows and matures,' all of which are aspects of human biology.

The ROSE data in this research indicated that students were very interested in human biology, but the data did not explain the reason for this interest. Innes, Moss, and Smigiel (2001) in Australia maintain that it is difficult to judge and describe students' reality in the educational setting, without inviting the students themselves to provide accounts of how they view the experiences they are living. Adults do not always see or understand the subcultures to be found in every classroom. Therefore, focus group data were obtained to explore students' views about human biology. A number of participants explained why they were interested in biology; both boys and girls focused on biology in their discussions and talked frequently about aspects of biology that interested them. "Students who enjoy science are emotionally attached to learning the subject and consider learning to be meaningful" (Hampden-Thompson & Bennett, 2013, p. 5).

Human biology dominated the participants' discussion, indicating that it attracted students in several aspects, including the ability to help them understand their bodies and the functions of their organs. They were interested because it was relevant to them and to life in general:

> "Biology is about the human body." (B-B).

> "Biology is interesting; it is about the body and how it's built." (E-G 2).

Moreover, students noticed aspects of their bodies they had not been aware of previously because they lacked knowledge or were unable to understand their bodies. Studying human biology enabled them to understand and learn about their human experience.

> "There are things in life that we didn't know before [studying biology] such as … the human body, which helps us now to understand it." (F-B-1).

By studying human biology, they learned about the body and its functions, allowing them to identify the complex systems within the body and to understand various biological processes. The following quotations from a group of girls highlight their desire to improve their knowledge of the human body, agreeing with the results of the ROSE questionnaires.

> "I like biology because of the human body. I feel as though the human body is complicated; I prefer to learn about what's inside it and how the heart works and how it delivers the blood to the rest of the body." (E-G-1).

> "Through biology we can see and know what [is] inside the human body." (I-G).

"…and discover things [like] the way the human body works…." (I-G).

Moreover, Saudi students repeatedly mentioned they were interested in biology because of the focus on the human body and Baram-Tsabari, Sethi, Bry, and Yarden (2010) claim that teenagers' growing interest in human biology is partly related to the changes they experience in their own bodies during adolescence. This is distinct from adults who take an interest in biology due to issues relating to health or potential illnesses.

The participants also explained their interest in human biology by stating its advantage over other science-related subject as most of its content was relevant to their life experience. Although human biology concerns the human body, it also concerns the lives of people. People can see, feel and interact with the organs and functions discussed, making it easy for them to imagine the things they are learning about. Participants said, for example:

"Biology is about the human body…[it] is felt and seen." (B-B).

"Biology is more flexible, something tangible in life, talking about life and animals." (F-G).

Furthermore, some students expressed the belief that biology is the study of life and is essential to human society; they described it as including all aspects of humans' everyday life.

"Biology is the most important and links the most to everyday life." (C-B).

"It is easier, and you come across the things you learn in your everyday life." (F-B-2).

This suggests that academic interest in science occurs when the science connects with learners' everyday lives. Krapp and Prenzel (2011) argue that interest level and the course of interest development in science subjects depend strongly on the perceived attractiveness of the curriculum's content. In this study, the topics of human biology and health in biology attracted the interest of Saudi students, who mentioned that the subjects of the human body and health were easy and relevant in their lives. "The model of interest proposed by Hidi and Renninger (2006) predicts that various experiences and/or events will trigger Situational Interest and support the progression of that interest towards well developed Individual

Interest" (Darlington, 2017, p. 174). Consistent with that view, the students linked biology to medicine, the study of diseases and how to treat them.

Murphy and Whitelegg (2006) share this view that "perceptions of science subjects are closely linked to and influenced by what students find interesting and motivating" (p.21). Biology is often associated with medicine and in Saudi culture, medicine is considered to be a prestigious career (Sani, 2018). It offers some of the best-paid jobs in Saudi Arabia, and there is financial support for doctors' education. This is because Saudi Arabia is suffering from a shortage of graduates in the medical field (making the study of medicine a goal for many students), which is driving the Saudi government encourage and facilitate medical students (EasyUni, 2021). Sembawa, Sabbah, and Gallagher (2018) reported that female Saudi students of dentistry wish to build a successful career, and to become well-respected experts in their field. In addition, families encourage their children to study subjects leading to careers in the more prestigious and high-income sectors with the aim of improving the families' social conditions. It is reported that many parents aspire to having their children become doctors (Baqi et al., 2017). This could be one reason for students' interest in health topics.

According to constructivist theory, interest in science among students is predominantly driven by personal experiences (Harrison & Coll, 2008). This explains the success of human biology as a subject – it involves knowledge with immediate, transparent and unquestionable application. In this study, students were more interested in topics they found relatable and less interested in areas that did not seem to hold personal relevance. They believed that learning about human biology was important to knowing how their bodies were built, which they considered relevant and meaningful.

This finding was consistent with numerous studies showing that the more relevant the science curriculum is to students, the more interest it generates among them (Jenkins & Nelson, 2005; Murray & Reiss, 2005; Osborne & Collins, 2001). This may explain why human biology scored amongst the top ten items in the ROSE questionnaires, and why students discussed it so keenly in the focus groups. The current study agrees with evidence on the popularity of human biology in 57 countries presented by Bybee and McCrae (2011). In 52 of the countries addressed in the study, students favoured human biology over all other subject-areas, and all countries except Azerbaijan demonstrated a high rate of interest in human biology.

Furthermore, among ROSE items given high priority were several linked to increasing students' health knowledge, such as those about diseases, and five items achieved mean scores of over 2.5 for both boys and girls:

1- 'Cancer, what we know and how we can treat it' – boys 2.79, girls 3.30.
2- 'Epidemics and diseases causing large losses of life' – boys 2.76, girls 3.20.
3- 'What we know about HIV/AIDS and how to control it' – boys 2.74, girls 3.08.
4- 'Deadly poisons and what they do to the human body' – boys 2.86, girls 3.06.
5- 'Sexually transmitted diseases and how to be protected against them' – boys 2.89, girls 2.70.

The mean scores of these items show the importance of health topics to students, which is reflected, in turn, by their interest in biology. It appeared that students believed that research in health would improve humans' ability to treat diseases effectively, thus decreasing the health challenges people face. In their focus group discussion, participants expanded upon the relevance of biology, arguing that studying biology can improve health and lead to the discovery and treatment of diseases.

Both boys and girls in Saudi Arabia were interested in health, as noted in their responses to the ROSE questionnaire which demonstrate high (though varying) levels of interest in learning about diseases and how to treat them. The mean score for 'How to perform first-aid and use basic medical equipment' was 3.35 for girls and 3.09 for boys, indicating high interest compared with other items, and it was among the top ten items of interest to both male and female students. However, girls' scores for this item were higher than those of boys. In focus groups, students explained this interest by referring to the importance of helping others by learning how to use medical equipment:

"…as a human service, when you help a person and save their life." (F-B).

The results of this study showed that the participants' desire to help others was one of the reasons which positively influenced their interest toward biology. Miller notes that where female students are concerned, the principal impetus behind the choice to study science, biology, and medicine is a desire to contribute to society and assist those in need (Miller, Slawinski Blessing, & Schwartz, 2006). Also, Sani (2018) states that the fact students want to become doctors, in order to help other people and society in general, reflects the generous and charitable nature of Saudis. A motivation for studying biology, driven by the aspiration to help people, could be derived from Islamic values. To better understand the students' opinions, knowledge, interests and values, it is important to consider the socio-culture context. Islam is one of the main factors shaping culture in Saudi Arabia. One of the central principles of Islam is helping others. In the Quran, Allah says: "Help one another in acts of piety and righteousness." (Quran 5:2). In addition, in terms of Hofstede's cultural dimensions, Saudi Arabia is highly collectivist, which may explain the attitudes that are motivated by the desire to help society.

From another perspective, Rowland, Knekta, Eddy, and Corwin (2019) claim that the diversity of career opportunities open to students of life sciences is a primary attraction, as biology opens doors for students to enter the medical, conservation, academic, and other related fields. This suggests that long-term visions of particular career paths and other motivations may be of more importance to students than a specific interest in biology itself. This is often the case for medical students, for instance, who are frequently driven by the desire to help people (Pacifici & Thomson, 2011). In the Saudi context, Sani (2018) stated that participants claimed that studying biology would provide them with various job opportunities. Berkery, Morley, and Tiernan (2013) have demonstrated that women in Saudi Arabia are most likely to work in education or healthcare. Young Saudi women are more likely to choose education or healthcare at university as there are more opportunities of them to pursue a successful career in these sectors. The demand for doctors and teachers in Saudi Arabia ensures that there are sufficient career opportunities for those with the relevant qualifications (Alghamdi, 2018), and such fields are considered suitable to women's "nurturing" role.

The following statements were from groups who believed that studying science subjects is a significant factor in developing the field of biology related to disease treatment.

> "Biology will help in life with anything to do with the human body (such as disease treatment)." (G-B).
>
> "To me I think the most important things are diseases and how we can address them and the development of scientific skills; for example, cancer can now be treat[ed] scientifically." (H-B-1).
>
> "I believe that scientific subjects [are] related to biology [medical] now, the scientific fields are if not all mostly linked to medicine." (H-G).

#### 5.2.2.1.2. Botany

The Saudi school curriculum covers botany as a subject within biology. Despite the students' interest in biology, demonstrated in this research, they were not interested in botany; the mean scores of the items related to botany were lower than 2.5. Despite the importance of agriculture to the Saudi economy (it contributed $134 million to the Saudi gross domestic product in 2018, according to GAFS (2019) both boys and girls showed a lack of interest in a number of items linked to botany. For example, they were not interested in modern methods of farming, as indicated by the item 'Benefits and possible hazards of modern methods of farming', whose mean score was 2.22 for boys and 2.20 for girls.

Furthermore, two of the ten items, girls were least interested in (Table 5-3) were 'Organic and ecological farming without use of pesticides and artificial fertilizers' and 'How to improve the harvest in gardens and farms,' with mean scores of 2.29 for both items. Although these did not rank among boys' ten least interesting topics, the mean score for boys was 2.37 for both items. Also, students were not interested in learning about local or native plants; the mean score for 'Plants in my area' was 2.26 for girls and it was one of the ten topics of least interest to them, while for boys the mean score was 2.40 (although it was not among the ten least interesting topics for boys). Likewise, boys showed less interest in developing their knowledge about 'Symmetries and patterns in leaves and flowers', because the mean score for that item was 2.19, while girls were more neutral on this item, with a mean score of 2.50. However, one item among the ten least interesting topics for boys was 'How plants grow and reproduce,' with a mean score of 2.24 (the mean score of girls for this item was 2.29).

Supporting these ROSE results that the Saudi students were uninterested in botany, the focus group discussions indicated a belief that the study of plants was not particularly useful. Although participants considered biology in general as mostly tangible and related to their daily lives, botany was not an area of interest. One student said:

> "Plants are the ones that are useless." (F-G).

Although the participants appeared unaware of the benefits of plants, as the results showed, a number of them, especially among the girls, used alternative therapies derived from local or imported plants, such as herbs. This revealed a lack of connection between the topic they studied in school and the students' daily lives and community practices outside of school. As a result, the participants diminished the importance of these topics, which reflected negatively on their interest towards them.

Learning theories argue that "knowledge takes place at an existing cultural context, such as geographical location" (Anderson, 2006, p. 73). Perhaps the desert environment in Saudi Arabia and the urban area (in this study) influenced the students' interests. Saudi Arabia is considered one of the countries that are most vulnerable to desertification and salination, as 90% of the land is affected by a dry climate. Saudi Arabia has been fighting against desertification, and in 1998 the Saudi government signed the Fight against Desertification Agreement (ArabiaWeather, 2019). Nevertheless, education in schools has overlooked the importance of educating students about environmental problems such as this, which may have caused the students' lack of interest in botany topics.

Some students also expressed their annoyance about having to study botany, and suggested reducing its coverage in the biology curriculum. Because they were not interested in botany, they found it difficult to study.

> "Plants are the ones that we really struggled with; it would be better if there were less facts." (A-G).

Social theories of learning "emphasise that learning occurs as individuals engage in and contribute to the practices of their communities" (Murphy & Whitelegg, 2006, p. 7). In this study, students were not interested in botany because it did not seem relevant to practices in their communities. In urban areas, agriculture is not a likely or favoured career path. In any case, it' would presumably be less relevant for girls.

In addition, the large amount of botany content in the curriculum led the participants to believe that it is difficult, which reduced their interest in it. In Saudi Arabia, teaching follows a rigid national educational curriculum, whereby lessons rely upon the central role of the teacher and the textbooks provided by the government (Smith, Lancaster, & Johnson, 2019). Due to the vast array of educational content to be covered in a limited time, there is not always sufficient time to support teaching with practical examples or experiments, which means that students' knowledge and understanding of particular concepts can remain incomplete (Cimer, 2012). Among the causes of difficulty in the sciences, the nature of science itself and the teaching method in Saudi Arabia are clearly issues (Aldhahiri, 2012). In this respect, Saudi Arabia is similar to some European countries such as Finland; it is often the case that topics on botany and agriculture are less popular among students (Uitto et al., 2006). Moreover, Elster's study (2007) in Germany concluded that botany was not a priority for boys or girls in school. On the other hand, Saudi Arabia differs from other countries such as Ghana, where botany is perhaps more relevant and so more popular (Anderson, 2006).

#### 5.2.2.1.3. Zoology

Both boys and girls showed little interest in learning some of the zoology-related topics. For example, the mean score of the boys for 'cloning of animals' was 2.28, making this item one of the ten least interesting. The girls were not interested in it either, as their mean score of 2.43 demonstrates (although this item was not among their ten least interesting). In contrast, one of the girls' ten least interesting items was 'Animals in my area,' with a mean score of 2.26, but boys had a more neutral attitude towards this topic, with a mean score of 2.50. Moreover, this was confirmed by the focus group discussions, as a few participants expressed displeasure with the inclusion of zoology in the biology curriculum because they considered it irrelevant. As one student noted,

> "[Some]times they focus on unimportant subjects like animal subjects." (C-G).

Baram-Tsabari and Yarden (2008) showed that with increasing age, students' interest switches from zoology to human biology. Sjøberg (2002c) mentioned that zoology of animals in their immediate surroundings was one of the topics that students were not interested in studying in developed countries. The current study appeared to obtain the same result, although Saudi Arabia is a developing country. In Saudi Arabia, raising of animals occurs mostly in rural areas, whereas the region in which this study was conducted is urban. Thus, the environment may affect the students' desire to learn about animals. In Anderson's (2006) study it was found that there is a difference in students' scientific interests between urban and rural areas. This could explain why the current research's respondents believed these topics were irrelevant in their daily activities, unlike students in rural areas where they are closer to nature (Anderson, 2006).

### 5.2.2.2 Physics

Saudi students, both male and female, study physics as part of a separate curriculum in years 10, 11, and 12. Although Saudi students attend single-sex schools, the schools teach similar physics topics to both boys and girls. The ROSE questionnaire contained items relating to physics topics that Saudi students' study, such as light, electricity, sound and technology.

The data from the ROSE questionnaires and focus groups suggested that boys and girls alike were generally interested in physics, but there were differences in their interest in particular physics topics. The results showed the boys were more interested in technology, whereas girls were more interested in topics relating to sound, light and space. The following subsections will discuss these results.

#### 5.2.2.2.1. Light and Sound

These two physics topics stimulated male and female students' interest to varying degrees. Students were interested in learning about sound waves, as indicated by the mean scores for the items 'How the ear can hear different sounds' (boys: 2.79; girls: 3.03), and 'How loud sound and noise may damage my hearing' (2.70 for boys and 2.94 for girls), although these items were not among the top ten most interesting for girls or for boys.

The mean scores for other items suggested an interest in the study of light; this was corroborated by the focus group discussions, where some students explained that aspects of light and electricity are relevant to their lives, which made the study of these topics in physics interesting.

> "Phenomena in physics happen in front of us every day like the sun and sound. Physics is something you live it and is clear." (G-B-1).

Also, the item 'Why the stars twinkle and the sky is blue' had a mean score of 2.61 for boys and 3.03 for girls, suggesting students prefer these topics because they involve things they can see and recognise. It is clear that students enjoy learning about topics that are linked to vision, as the mean score for the item, 'How the eye can see light and colours' was 2.70 for boys and 2.87 for girls.

It should be noted, however, that boys appeared neutral towards items linked to the way rainbows are formed, despite rainbows being a visual phenomenon, indicating they were not interested in all viewable things. Girls seemed more interested in this topic; for the item 'Why we can see the rainbow' the mean score was 2.84 for girls, while it was 2.51 for boys, a close to the neutral point on the scale. Girls are interested in physics because it explains rainbows, as one girl said during a focus group discussion.

> "Physics is interesting; it explains rainbows and things." (G-G).

The results of the current research appear to conflict with Elster's (2007) finding that both boys and girls were interested in light and radiation, since boys showed opposite responses to items relating to light and radiation. The mean score for boys in response to the item 'How the sunset colours the sky' was 2.44, while it was 2.40 for 'Light around us that we cannot see (infrared, ultraviolet),' indicating that boys were not much interested in learning about these topics. The mean scores for girls, in response to these two items, were 2.82 and 2.57, respectively, suggesting they were more interested than boys are in light and radiation.

Moreover, girls expressed more interest in physics topics related to human bodies; for example, girls' mean score for the item 'How radioactivity affects the human body' was 2.74, while that of boys was 2.27. Also, for the item, 'How radiation from solariums and the sun might affect the skin,' the mean score was 2.69 for girls but 2.39 for boys, which suggests boys were not as interested in these topics as girls were.

In their review of prior research to understand students' attitudes towards physics, Häussler and Hoffmann (2000) refer to the role of context and content in students' attitudes. They suggest that context has a greater impact than content in terms of importance in students' interest in physics. Likewise, Sjøberg emphasized in Science and Scientists SAS that students' interest in a particular science content varies according to context. For example, Sjøberg found that "music" attracted much more attention than "sounds." Also, "rainbow" and "sunset" stimulated greater interest than did "light" and "optics" (Sjøberg, 2000b).

#### 5.2.2.2.2. Space

Space and the solar system were other areas of interest for students who participated in this research. A number of items in the ROSE questionnaire were related to space. Students indicated their interest in such topics as 'the possibility of life outside earth', with a mean score for the boys of 2.60 and for the girls of 3.20; 'rockets, satellites and space travel', with a mean score for the boys of 2.6 and for the girls of 2.73; and 'how to find my way and navigate by the stars', with a mean score for the boys of 2.84 and for the girls of 3.03. Moreover, one of the top ten interests for both the boys and girls was the item, 'how it feels to be weightless in space', with a mean score of 2.96 for the boys and 3.40 for the girls (Tables 5.1and 5.2).

The girls expressed more interest in topics related to astronomy, as indicated by the mean scores of items linked to astronomy being greater for the girls than for the boys, even though there was a lack of astronomy topics in their curriculum, perhaps even partly because of the lack of these topics, as they may have felt they had been missing something and were curious. According to their comments in the focus group:

> "We have simple things in science about space. I want to study what this planet has and what it is formed out of; we don't have these, like how stars are formed." (H-G).

The ROSE results also indicated the girls were interested in learning about the moon and the first landing on the moon, as the mean score for the girls was 2.69 for the item 'the first landing on the moon and the history of space exploration', while the boys expressed less interest in this item, as their mean score was 2.37. Moreover, there was a group of girls who participated in the focus group specifically because of their interest in physics and astronomy (they wanted to learn about stars and planets). The girls expressed a fascination with the Earth and the solar system, space exploration, and the formation of the planets.

> "I like physics and I want to learn more about planets and stars." (D-G).

> "I want to add an astronomy subject; I feel like it is an interesting subject, to learn about stars and space and black holes and things like that." (E-G-1).

Some students referred to gaining access to scientific information by watching science-related programmes on television, about such subjects as black holes:

> "I watch programmes about black holes and learn about them and enjoy watching them. I hope we learn about them in school." (E-G-1).

Krapp and Prenzel (2011) claim that students cultivate curiosity when they begin to learn science at a secondary level. Akram, Ijaz, and Ikram (2017) suggest that curiosity helps in increasing interest in scientific subjects. Saudi students were interested in physics because it helped them learn about space, which was unseen. The motivation for their interest was the desire and curiosity to explore stars, planets, and strange phenomena, such as black holes. The mean score for the item 'black holes, supernovas and other spectacular objects in outer space' was 2.62 for the boys and 2.97 for the girls; similarly, the item 'unsolved mysteries in outer space' had a mean score of 2.54 for the boys and 2.99 for the girls. A possible explanation for girls' interest in space might be Saudi culture. Because of gender inequality and male domination in Saudi Arabia (Al-Rasheed, 2013), men and women are typically allowed different levels of participation in public environments (Hamdan, 2005). Men are able to play sport, build many friendships and relationships, engage in public activities, go to work and earn an income. In contrast, women are monitored and often actively prevented from taking part in some activities (House, 2012). Due to the limited entertainment facilities for Saudi girls compared to boys (boys spend most of their free time outside the house, such as on road trips or in sports), girls search for different ways to spend their free time, such as watching scientific programmes.

Battrawi and Muhtaseb (2013) state that the social media are influential in students' lives, as they often draw students' attention to a variety of resources and the importance of knowledge and information. Watching scientific broadcasts leads to awareness and interest in scientific subjects, which may eventually lead to a desire to study science. Some students mentioned that they watched science programmes about space on YouTube to learn about science topics and enjoy them. "Enjoyment of learning in science explains the students' responses to science lessons, which are shown by the students' enjoyment of the science lesson and how strong is the students' desire to learn" (Astalini, Kurniawan, Kurniawan, & Anggraini, 2019, p. 7). The present study made clear that scientific subjects presented in the media enhanced the students' interest in studying science. The media were used as a visual instrument to convey reality, which promoted understanding of scientific topics. Therefore, they contributed positively to the students' interest in science subjects, because interest was affected by the students' understanding of the subject (Fisher, 1978). This study's results were consistent with the results of Lavonen, Byman, Uitto, Juuti, and Meisalo (2010) in Finland, and Jenkins (2006) in the UK, who found that the topics of astronomy, cosmology, and physics as they related to space drew interest from both girls and boys. In Turkey, Cakmakci et al. (2012) measured students' interest in a number of subjects by analysing the questions the students (at the primary level) posed about science, and astronomy emerged as among the most popular topics.

In the Saudi context, Islam is a major influence on the way science is taught (Alanazi, 2018). "The Quranic (Holy Book) view and the notion of Tawhid (oneness) hold that God creates the universe and everything in it. Accordingly, some scientific topics are often ignored because they contradict this religious tenet" (Sun Young & Alghamdi, 2020, p. 3).

This may explain why boys and girls agreed they did not desire to learn about astrology and horoscopes; this subject was among their ten least interesting topics. Students did not discuss the reason for this lack of interest in the focus groups, but the author believes it has to do with religion. People in pre-Islamic Arabia were superstitious and believed in stars and horoscopes, but Islam rejected such beliefs. Islam has prohibited astrology because it is based on illusions that, it is argued, have no truth. Similarly, the field of astrology has been rejected by the scientific community, as it is considered to be pseudoscience and not based on scientific fact (Zarka, 2009). As all students who participated in this research were Muslims, this is likely to have influenced their interpretations of the item; indeed, some participants expressed concern that certain items in the questionnaire asked about matters rejected by Islam, whereas the science curricula at all the Saudi educational levels are formed within the scope of religious belief (Alarfaj, 2015).

Another item of no interest to the students was 'ghosts and witches, and whether they may exist'. Muslims do not believe in the transmission of spirits or in spirits of the dead returning to life, so many Saudis do not believe in ghosts and evil spirits. Religion can positively or negatively affect people's interest in the sciences and science-related occupations. On the one hand it can lead to rejection of ideas that are contrary to religion. On the other, it can be seen as providing evidence and understanding of God's power of creation (Abdul Hamid, 2015). Thus, religious beliefs can be a significant determining factor in developing students' interest in science subjects. This is not due to a particular religious bias against science but rather due to the variety of influences that students encounter in their religious life (Glennan, 2007; Hagay et al., 2013; Irzik & Nola, 2009). Research has shown that students from Portugal, Turkey, England and Israel are likely to ask scientific questions about private issues, beliefs, and popular topics in the media, whereby religion constitutes one of the four main elements of students' interest in science (Hagay et al., 2013). Some researchers have pointed out that for students who consider science and religion to be in conflict, is not easy to change or improve their perceptions toward science (Abd-El-Khalick & Akerson, 2004; Mugaloglu & Bayram, 2009; Roth, 1997).

#### 5.2.2.2.3. Technology

In Manoa, Greenfield (1995) argues that technology is a common interest for boys, as boys are likely to be interested in learning practical skills and the way that devices work. The current study lends support to this argument, as technology-related items were among boys' top ten interests (see Table 5-2). The mean scores of items related to technology were high; for example, the score for 'How to use and repair everyday electrical and mechanical equipment' was 2.91 for boys and 2.61 for girls, whereas the score for 'How mobile phones can send and receive messages' was 2.87 for boys and 2.63 for girls, which suggests girls may be less interested in technology, despite encountering it in phones, tablets, games and computers. The mean score for 'How computers work' was 2.82 for boys but 2.50 for girls, while the mean score for 'How things like radios and televisions work' was 2.62 for boys and 2.36 for girls. Although the girls in this study reported more experience of technology than the boys, they showed less interest in learning about technology then boys, consistent with Chang, Yeung, and Cheng (2009). Previous studies provide possible explanation for this result. According to Jones et al. (2000) more girls than boys stated that science is difficult, and a subject that only suits boys. Also, Miller et al. (2006) added that girls find it difficult to forge emotional links between those subjects and the issues that matter to them. In the Saudi context, societal factors (e.g., the belief that hard and difficult labours are for men) appear to be the reason behind this result. According to Labour Law in Saudi, women work in all fields that are 'compatible with their nature', and it is forbidden to employ them in dangerous work or harmful industries (Bureau of Experts at the Council of Ministers, 2005).

The item 'how petrol and diesel engines work' did not seem to interest girls, as its mean score was 2.10 for the girls but 2.81 for the boys. A possible explanation for the boys' interest may be that in Saudi culture, jobs such as repairing electronic and electric devices are typically male fields. According to the Saudi government regulations, mechanical jobs are only available to men. Even in mechanical schools/colleges, only boys can be admitted (TVTC, 2018). Furthermore, jobs from which women are excluded because they are considered dangerous and harmful to women (Bureau of Experts at the Council of Ministers, 2005) include industrial work, power generation, conversion and transmission, and mechanics. Patriarchies expect women to be physically weak and gentle, while men are supposed to be physically strong and tough. Accordingly, demanding occupations are not considered suitable for women, due to their weak physique (Alwedinani, 2016). This is consistent with Vygotsky's (1962) view that social context influences how people think and how they are perceived by others.

Both the boys and girls expressed interest in the item 'how mobile phones can send and receive messages', but the mean score for the boys was 2.87, while that for the girls was

2.62, indicating the boys had higher interest. Neither group was interested in the item ‘how cassette tapes, CDs and DVDs store and play sound and music’, which had a mean score of 2.47 for the boys and 2.19 for the girls and which was one of the ten least interesting subjects for the girls. The reason behind these results may be that tapes were old technology and no longer used, and CDs and DVDs were also becoming outdated and rarely used at the time of the study; thus, the students were not interested and did not want to learn about these. According to Lavonen et al. (2010) “Boys’ interest is directed towards economic and technical aspects. However, these interests are not really knowledge-based, but more are a kind of curiosity and a general openness toward a new technology” (p.31). Elster (2007) in Germany and Oscarsson, Jidesjö, Karlsson, and Strömdahl (2009) in Sweden, conclude that girls are not interested in technology, whereas boys are more interested in technological innovations and modern technology. In Belgium, Ardies, De Maeyer, and Gijbels (2015) mentioned that females see technology as a male subject. These conclusions are generally supported by the present results.

#### 5.2.2.2.4. Electricity

Saudi schools teach electricity as part of physics, and boys and girls learn the same topics. The ROSE questionnaire contained items to identify the students’ interest in physics topics related to electricity. The item ‘how energy can be saved or used in a more effective way’ had a mean score of 2.79 for the boys and 2.55 for the girls, and the item, ‘electricity, how it is produced and used in the home’ had a mean score of 2.76 for the boys and 2.47 for the girls, indicating the boys were more interested than the girls in these topics. However, girls were more interested in scientific topics related to the human body, which may explain why the girls’ and boys’ responses were similar for the item, ‘the effect of strong electric shocks and lightning on the human body’, which had a mean score for the boys of 2.73 and for the girls of 3.06.

As mentioned above, the students seemed more interested in tangible topics, and electricity could be placed in this group. This can be explained by the nature of the geographical region in which the students lived. Due to the desert climate in Saudi Arabis, people cannot go without air conditioners in summer and heaters in the winter, since the temperature reaches over 48 degrees Celsius in summer and below zero in winter. They rely on electricity to complete basic household chores. In addition, the price of electricity was cheap at the time this study was conducted, due to government subsidies. For all these reasons, electricity was incorporated in students' daily activities, which explains their interest.

The focus group's findings supported the interpretation that the relevance of electricity to daily life was what made the topic interesting. The girls shared the boys' interest in electricity.

> "Electricity topics are the reality of life in physics." (E-G-1).

Both boys and girls (but the boys more so) were interested in energy and electricity topics, as shown by the item, 'new sources of energy from the sun, wind, tides, waves, etc.' In the focus group discussions, the boys explained they were interested in physics because it covered the themes of motion and electricity, which they wanted to know more about.

> "…want to learn more about how objects and kinetic energy rotates and how electrical energy is transferred into kinetic energy." (F-B).

Another factor is that Saudi Arabia has a collectivist culture, emphasising loyalty to the group and attention to the interests and needs of others (Darwish & Huber, 2003). In the focus group, some students related their scientific interests to their desire to contribute to efforts that could produce benefits for other people. Community service was a factor that pushed the boys to be interested in physics, so they could learn how to transform energy from the sun into energy for the benefit of people.

> "In Saudi the temperature reaches 50°; how can [we] turn the energy from the sun to something that everyone can benefit from?" (A-B).

Such a view appears to be consistent with the claim that "in situations when curricula allow a connection to be made with everyday life scenarios, students make the cognitive connection more quickly, which facilitates their learning of scientific concepts" (Malekan & Alghamdi, 2020, p. 1159). In a desert climate like Saudi Arabia, the sun plays a role in attracting the attention of Saudi students, as the sun shines most of the year, so students try to understand how to use it to produce energy, convert it, and use it in their lives.

The students also appeared interested in topics related to water and weather. The mean score for the item, 'what can be done to ensure clean air and safe drinking water' was 2.83 for the boys and 2.92 for the girls. The item 'clouds, rain and the weather' had a mean score of 2.69 for the boys and 2.93 for the girls. These indicated students' understanding of the importance of water and clean air in producing, green spaces and safe workplaces, improving people’s quality of life. With Saudi Arabia’s desert climate and lack of rain, its importance is keenly felt. From this perspective, the nature of the geographical location (desert) influenced the Saudi students’ interest in science.

Interestingly, neither the boys nor the girls expressed any interest in global warming, despite its importance. The item ‘the greenhouse effect and how it may be changed by humans’ was one of the ten least interesting topics for the boys (see Table 5-4), and its mean score for the girls was 2.38, indicating their lack of interest as well. Saudi Arabia is not a heavily industrialized country, and the government has not expressed much concern about global warming, an attitude which seemed to be reflected in the students’ knowledge about and interest in this subject. Therefore, the students did not have a strong awareness of climate change and its significance for the world. Neither were they much interested in ‘tornados, hurricanes and cyclones’, as the boys’ mean score was 2.33 and the girls’ was 2.48.

#### 5.2.2.3 Chemistry

Chemistry is taught in secondary school to both boys and girls, who choose to pursue the science path. The ROSE questionnaire included several items related to chemistry topics, which enabled the identification of the students’ attitudes towards chemistry.

The most interesting result for the chemistry topics indicated the girls’ interest in the subject as it links to cosmetics. The mean score for the item, ‘the ability of lotions and creams to keep the skin young’ was 3.45 for the girls, making it one of their top ten most interesting subjects (see Table 5-1). Skin could, of course, be interesting for boys as well as girls, but girls may consider their skin to be the most important feature of their beauty. This result reflects the culture of a society where beautification is for women but not for men. Therefore, girls take care of their skin and try to choose cosmetics that make the skin more vibrant, fresh, and attractive. Beauty was a priority for the girls in the study, as suggested by their mean score of 2.83 for the item ‘properties of gems and crystals and how these are used for beauty’. In contrast, the boys’ mean score for this item was 2.33, indicating their lack of interest. Similarly, other authors have found that beauty is one of the most significant interests for women as opposed to men (Anderson, 2006).

The item ‘deadly poisons and what they do to the human body’ had a mean score of 3.06 for the girls and 2.86 for the boys; this possibly reflects the finding discussed in the biology section, that the girls were more interested than the boys in the human body. This suggests that teachers could promote less popular subjects for girls, such as physics and chemistry, by drawing connections between the topics and human biology. As mentioned in previous studies in the literature, boys seem more motivated to learn about items like bombs, explosive chemicals, and weapons (Oscarsson et al., 2009; Sjøberg & Schreiner, 2010), but the present study found interest in such topics expressed by both the boys and girls. For example, the mean score for the item 'how the atom bomb functions' was 2.65 for the boys and 2.76 for the girls; this higher mean for the girls was surprising in light of the results of the previous work.

The results presented here demonstrate how the country's characteristics influence its education system. For example, the item 'how a nuclear power plant functions' had a mean score of less than 2.5 for all the students (2.47 for the boys and 2.30 for the girls), indicating a general lack of interest. Quite recently, Saudi Arabia has not been concerned with nuclear energy, since Saudi Arabia is a non-industrial country and has no nuclear power plants. In the focus group discussions, one group mentioned a lack of topics about nuclear energy in the curriculum, but they expressed not wanting to study it.

> "We don't study nuclear chemistry, but I feel like it's useless." (G-G).

The impalpable nature of chemistry makes chemistry concepts difficult to imagine, a difficulty that is reflected in the students' interest in this subject. For example, the mean scores for boys and girls for the item 'atoms and molecules' were 2.05 and 2.21, respectively, placing this item among their ten least interesting topics. Students in the focus groups expressed their difficulty in studying chemistry because it was intangible.

> "When they talk about atoms and oxidisation, we [ can] only imagine [them], we don't see them in reality, so it's really hard. (I-G).

> "Chemistry is hard because it's imaginative [sic]; we don't see anything." (J-G-1).

The educational environment influences students' interest in science. The content taught without relevance to everyday life led to a lack of interest. One way of viewing these findings is to conclude that students' limited experience of chemistry places them at a disadvantage for learning the concepts of chemistry. According to Hofstede, in cultures that have large 'Power Distance' (such as Saudi), teaching is teacher- centred (Hofstede et al., 2005) and there is a lack of student participation, which was reflected in this result. Saudi schools do not emphasise students' investigative roles and activities. Chemistry teaching tends to be disassociated from everyday life and teachers do not carry out practical experiments which can be applied to common substances students recognise (Sheikh, 2016). This creates a gulf between science and daily life, and any skills and knowledge of chemistry the students attain are seen as purely academic. As a result, students fail to see the processes by which chemicals interact in everyday substances, and do not fully grasp how chemistry can be used to find solutions to practical problems in their daily lives (Gendjova, 2007). Hyde and Jafeee (1998) point out that if students had regular, early experiences of chemistry, they would become more engaged and interested in the subject, and they would pursue this interest throughout their education. Constructivist-based studies have found that informal experiences of science are key to subsequent and thorough conceptual comprehension (Strike & Posner, 1992). Hence, the lack of extra-curricular activities in Saudi Arabia- due to the lack of financial capabilities, and the weak cooperation between parents and schools- may explain the students' inability to understand scientific concepts (Al-Shehri, 2017). In addition, "difficulties with specialized language may seriously impede the development of science understanding by Saudi students" (Kim & Alghamdi, 2019, p. 18). Alhammad (2015) and Hamdan (2006) state that the Saudi approach to science education continues to depend on traditional teaching methods, which rely on teachers expounding knowledge taken from official textbooks, and students absorbing and memorising the information. It has been suggested that science experiments play a significant role in ensuring students become engaged in the subjects, particularly if they find it difficult to understand scientific language and concepts (Kim & Alghamdi, 2019). Thus, the lack of such experiences may have contributed to Saudi students' lack of interest in chemistry.

Students in this study expressed that they were not interested in chemistry because it was not tangible, making it difficult for them to imagine the topics they were learning about. This finding is consistent with other studies which have suggested that students were uninterested in topics in chemistry that did not link to their reality (Barmby et al., 2008; Murray & Reiss, 2005; Osborne & Collins, 2001). However, when a subject is tangible and can be related to students' lives, this makes it more imaginable, thus increasing students' interest in that subject (Jenkins & Nelson, 2005). A common finding in such studies was the inability of students to connect the sciences taught in school to their experiences out of school. This may be why in this study, among the science subjects, chemistry appeared to be of least interest, and also why, where physics and chemistry were concerned, the students were more interested in the less abstract aspects of the subjects that could be observable through practical activities, as also reported by Christidou (2011).

#### 5.2.2.4 Geology

Since Saudi cultural and societal norms highlight the differences between males and females, boys' and girls' schools tailor their courses and approaches to the gender of their students, based on societal associations with masculine and feminine interests and roles. Thus, within the school environment, female students are prepared for their future roles as married women with children, whilst male students are prepared for careers in science, research, and so on (Al-Hamid et al., 2007). Geology is only taught to boys in Saudi schools; girls do not study it. The reason is that Saudi is a 'Masculine' society in which social gender roles are very different (Hofstede et al., 2005). Thus, geology does not correspond to the Saudi idea of the feminine nature, because of the difficulty of working in the geological field, which is thought to require men.

Nevertheless, the girls who participated in this research seemed to be interested in the subject. The scores for some items suggested the girls had a greater desire than the boys to learn about geology. For example, the item 'the inside of the earth' had a mean score of 2.65 for the girls and 2.28 for the boys; the item 'how mountains, rivers and oceans develop and change' had a mean score of 2.66 for the girls and 2.50 for the boys; and the item 'earthquakes and volcanoes' had a mean score of 2.76 for the girls and 2.47 for the boys. The reason behind girls' interest could be that, although they did not have the opportunity to study it in school at the time of this research, watching media programmes boosted their interest. They were interested in obtaining information about how the Earth formed and the composition of its layers, as they mentioned in the focus group discussions.

> "…geology, we need to learn about it, like how the earth was formed in the past." (A-G-1).

Perhaps the students' curiosity to know how the earth was formed in the past and to know the causes of earthquakes and volcanoes is what made them interested in geology, since curiosity helps in promoting students' interest in science (Akram et al., 2017). Moreover, it is possible that a lack of education is a cause for curiosity in science learning (Anderson, 2006). Sjøberg (2002c) suggested that a reason for the high interest in science expressed by female students in developing countries could be that "Girls in these countries often have less access to all sorts of education than boys have, therefore learning science may be seen as a very positive option." (p.92).

Although the boys were studying geology, they expressed neutral attitudes toward it. However, they did not mention any reasons to justify their response. According to Taskinen, Schütte, and Prenzel (2013) "Young people's interest in school science is the key variable to getting more students interested in science careers" (p.2), and the opposite may be true, as is the case with students in the current study. The scarcity of jobs in the sciences may be a reason why young people are reluctant to study or have an interest in science. In the Saudi context, only three main companies employ geologists in Saudi Arabia; they are Saudi Aramco, Maaden Company, and Civil Defence. This means there are few jobs available in geology, which may have undermined students' interest in it, since the authors suggest that the choice to study science can be predicted by its future relevance as well as future career opportunity (Osborne et al., 2003). However, other studies mention that the abstract aspects of geology could prove difficult for students (Mills, Tomas, Whiteford, & Lewthwaite, 2018). "More specifically, students often have incorrect or incomplete understandings about key ideas such as rock formation and classification" (Mills et al., 2018, p. 1502).

### 5.2.3. Gender Differences

This section will explore the gender differences in interest in science education. Chi-squared tests were conducted to investigate gender differences, if any, in students' experiences, interests, opinions, and future aspirations related to science in school. Table 5-5 shows the differences between the girls and boys, with a p-value less than 0.05 indicating a statically significant difference.

To analyse this section, the data were classified into groups based on the science subjects in the Saudi school curriculum. Each group was assigned a code that referred to the name of the group: biology content H (Human biology, young body, health and fitness), A (Animals), P (Plants), physics content S (Sounds), L (Light), E (Electricity), T (Technology), U (Space), chemistry content C (Chemistry) and G (Geology).

#### 5.2.3.1 Result

Table 5-5 Gender Differences

| Subject | Gender | | P |
|---|---|---|---|
| | Male | Female | |
| | Mean | Mean | |
| H | 2.73 | 2.99 | 0.003 |
| A | 2.55 | 2.58 | 0.787 |
| P | 2.34 | 2.36 | 0.797 |
| L | 2.5 | 2.76 | 0.005 |
| S | 2.63 | 2.61 | 0.968 |
| E | 2.68 | 2.64 | 0.809 |
| T | 2.69 | 2.44 | 0.041 |
| U | 2.56 | 2.86 | 0.015 |
| G | 2.47 | 2.67 | 0.062 |
| C | 2.55 | 2.66 | 0.415 |

Differences existed between the mean scores of the items related to human biology, towards which the girls showed more interest compared to the boys, as shown in Table 5-5; the mean value for the girls was 2.99, while it was 2.73 for the boys. The p-value of 0.003 indicated that the difference was statistically significant. Although the boys showed some interest in human biology, the results indicated that the girls had a markedly higher enthusiasm for learning about most of the contents of human biology. In contrast, there was only a single item of human biology, A9 'sex and reproduction', for which the result showed a statistically significant difference in favour of the boys, where the mean value was 2.79 for the boys and 2.58 for the girls, and the p-value was 0.029. Four items, A10 'birth control and contraception', A37 'what to eat to keep healthy and fit', E9 'sexually transmitted diseases and how to be protected against them', and E13 'how different narcotics might affect the body', showed no statistically significant differences (see Appendix 8).

There was no statistically significant difference between the interests of girls and boys in the topic related to animals. The mean value for the boys was 2.55 and for the girls was 2.58. The p-value was 0.787, which showed there were no gender differences. Neither the boys nor the girls showed any interest in the topic of plants, where the result for the mean value for the boys was 2.34 and for the girls was 2.36. The p-value was 0.797, which showed there were no gender differences.

Physics subjects include sound, light, electricity, and technology. The overall average of the two items related to sound in Table 5-5, shows no significant difference between the boys and girls. Gender differences did appear, however, in the mean values for each item. Item A43, ‘how the ear can hear different sounds’ was statistically significant in favour of the girls, with a p-value of 0.009, which was less than 0.05. As shown in Table 5-5, the overall mean value of the light items was 2.50 for boys and 2.76 for girls, with a p value of 0.005, which means there was a statistically significant gender difference in favour of girls in general.

For the four items related to electricity (see Appendix 8), the overall average showed no difference between boys and girls, as shown in Table 5-5. Item A33, ‘The effect of strong electric shocks and lightning on the human body’, however, did show a statistically significant difference in favour of girls. Although few topics are related to space in the curricula of Saudi schools, some students who participated in this research indicated an interest in space topics. Table 5-5 gives the overall mean scores on space items, which were 2.56 for boys and 2.86 for girls, with a p value of 0.015, which indicates a statistically significant gender difference in favour of girls. Conversely the boys appeared to be more interested in technology than girls; the overall mean value for the items related to technology for the boys was 2.69, while for the girls it was 2.44, which is less than the mid-point on the response scale.

There were no statistically significant gender differences in topics related to chemistry, and the p-value was 0.415. However, significant differences in favour of the girls appeared in some items, such as A32, ‘biological and chemical weapons and what they do to the human body’, where the p-value was 0.006, while for A39, ‘the ability of lotions and creams to keep the skin young’, the p-value was 0.000. Moreover, the p-value of item A2, ‘chemicals, their properties and how they react’, was 0.021. However, item A47, ‘how petrol and diesel engines work’, with a p-value of 0.000, showed a significant difference in favour of the boys.

As mentioned previously, in Saudi Arabia, geology is taught only in boys’ schools; therefore, girls do not have an opportunity to study this subject. Accordingly, Table 5-5 does not show any overall statistically significant gender differences; at 0.062, the p value was greater than 0.05. In contrast, four items (see Appendix 8) showed statistically significant gender differences in favour of girls, for example A3 ‘The inside of the earth’ and A24 ‘Earthquakes and volcanoes’.

#### 5.2.3.2 Discussion

Previous researchers argue that boys and girls have different interests in and attitudes towards science, and science careers (Jones et al., 2000). In this study, the girls tended to show a preference towards human biology and health more than the boys. This finding was not surprising because other studies also found that female students in secondary schools were more interested in biology than male students (Krapp & Prenzel, 2011; Osborne et al., 2003; Trumper, 2006; Uitto, Juuti, Lavonen, Byman, & Meisalo, 2011; Uitto et al., 2006). Girls may have had a stereotypical view toward the biological sciences, believing they were more suitable for females, possibly explaining their attraction to subject (Alghamdi, 2018). According to Sociocultural theory, the environment in which children grow up will influence how they think and the ideas they will contemplate (Scott & Palincsar, 2013). The social culture Saudi students live in may explain the gender differences in interest in science.

Social constructions of gender in Saudi Arabia are reflected in policies on women's education; as Doumato and Posusney (2003) highlighted, "The purpose of educating a girl is to bring her up in a proper Islamic way so as to perform her duty in life to be an ideal and successful housewife and good mother" (p.35). Therefore, men and women are naturally channelled to different programmes of study and courses, which are aligned with what society perceives as their natural talents. This, then, reflects on what young people choose to study at university. Being influenced by gender roles means that men and women both choose what to learn along the lines of what is expected (Lörz et al., 2011).

The results of the current research showed that girls preferred topics or disciplines that have relevance to prevailing constructions of their feminine nature, such that they were more interested in biology topics, especially topics related to medicine. Moreover, the culture of 'Collectivism' and 'Masculinity' (differentiation in roles) are reflected in this result, as helping others and improving society is a main motivator for women to enter science in general, and the biosciences and health fields in particular (Miller et al., 2006), and this is considered one of the roles of women in Saudi culture. In this case, it seems that the stereotype of the role of women is similar in most societies. The Saudi girls' situation seemed similar to that of girls in Israel and the USA, as reported by Baram-Tsabari and Yarden (2008) and Miller et al. (2006).

The results of the current study showed no statistically significant gender differences in topics related to chemistry and most of the physics topics, such as Electricity and Sounds. This may be due to the Saudi education system. As mentioned before, Saudi Arabia provides single-sex primary, intermediate and secondary schools (Al-Ghamdi, 2019), which may provide a suitable environment for learning science, especially for girls, as students do not need to compete with the opposite sex for teachers' attention and time. Also, in all-girls schools, leaders and top performers in all classes, including science, are female students, which may provide good female role models for other girls (Thompson & Ungerleider, 2004). Therefore, the results of this study did not show any differences in chemistry and some physics subjects. This contrasts with, for example, Finland, where Uitto et al. (2006) demonstrate that the study of chemistry showed gender bias, but female students were more interested in the context of human biology.

The results indicate that the girls were interested in physics, but they were attracted to physics topics that reflected their interests (Reid & Skryabina, 2003). For example, in this study, girls were more interested in space and light topics and less interested in technology than boys, with statistically significant gender differences in scores for these topics. The reason for the difference may be gender stereotypes, which are supported by Saudi culture and Islam. Girls are interested in beauty and the human body, while boys are interested in things and machines. It is worth noting that the stars and planets that illuminate the sky are considered as decorations for the sky in the Islamic religion. Also, natural phenomena of an aesthetic nature in the universe attract girls' attention more than boys, in addition to topics related to the human body, for example, 'The effect of strong electric shocks and lightning on the human body'. This interest is appropriate to the feminine nature, according to the view of Saudi culture.

In contrast, boys' interest tended more toward technology and machines, such as 'How to use and repair everyday electrical and mechanical equipment'. These interests also reflect the Saudi gender culture (Masculinity), which says men should be strong, smart, tough, and in control. This result is consistent with Osborne and Collins (2001), who referred to the difference between boys' and girls' interests, with girls being more interested in the topic of light, while boys are interested in cars. Other studies have also found that boys were attracted to technology topics and preferred to study practical skills, like how appliances function (Oscarsson et al., 2009), while girls are more interested in topics related to humans (Uitto et al., 2006).

From the present results, there are no statistically significant differences between girls and boys in interest in geology. Nevertheless, girls in this study preferred to study about 'the inside of the earth' and 'earthquakes and volcanoes', besides learning about the Earth's formation. As mentioned previously in the space section, the media may be a factor reducing the gender differences in the interest in science.

In conclusion, from the current study it was shown that there is a statistically significant gender difference in interest in biology for girls. In physics, there were differences in the level of interest in particular topics between boys and girls. Girls preferred the topics of light and astronomy, while boys were interested in the topics of technology and mechanics. Girls were more interested in human contexts than boys, in most topics. There was no difference in interest in chemistry and geology between girls and boys.

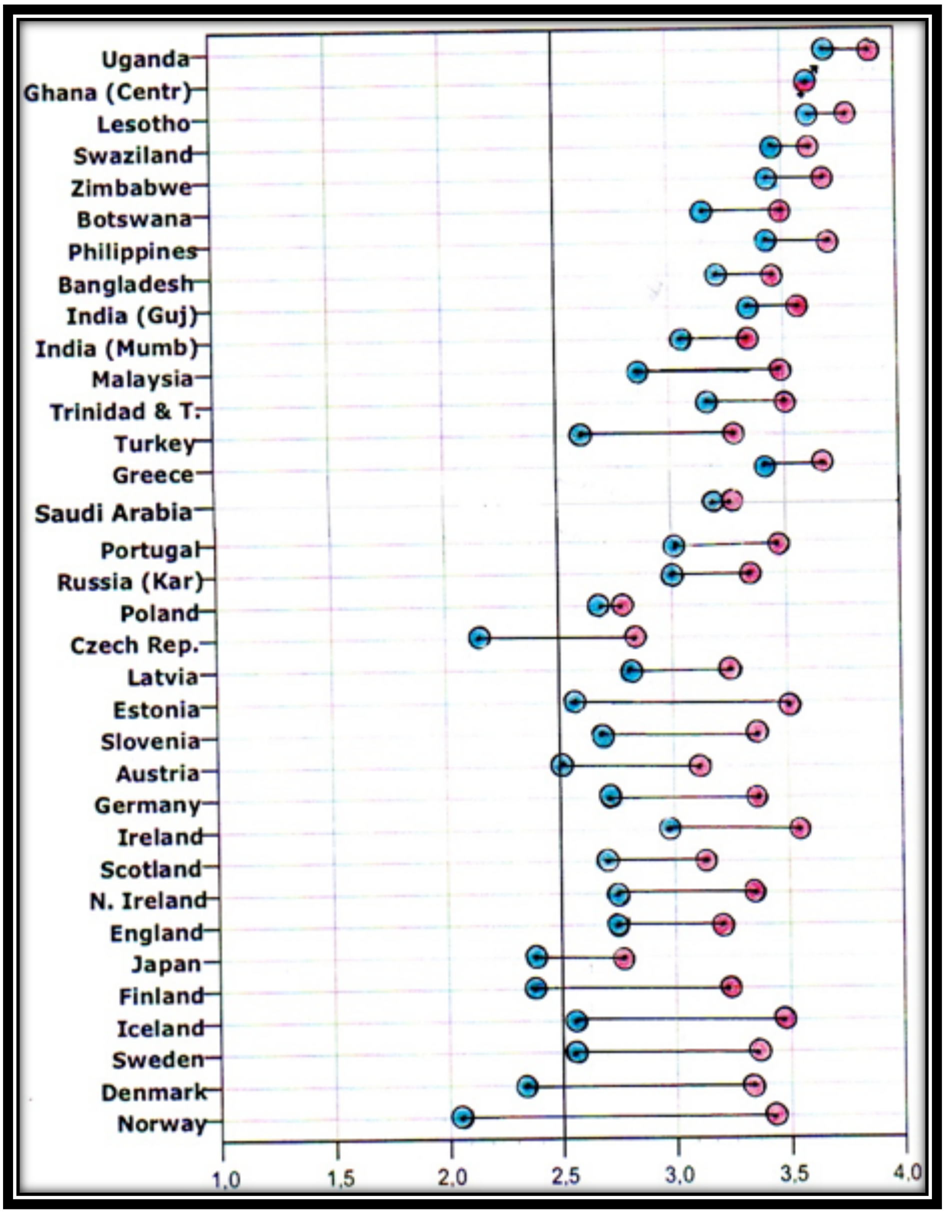
### 5.2.4. A comparison of Saudi Students' Interests in Scientific Topics with Students in Other Countries

Sections A, B and C on the ROSE questionnaire cover multiple aspects of science and technology, such as physics, chemistry and biology. In particular, the students responded to questions on how interested they were in several topics of science. Responses show a variety of mean results in different countries. For the purpose of comparison between Saudi students and students from other countries, the items 'What to eat to keep healthy and fit', 'How it feels to be weightless in space', 'How to exercise to keep the body fit and strong', 'How to perform first-aid and use basic medical equipment' and 'Why we dream while we are sleeping, and what the dreams may mean' were chosen from the ten strongest interests. Also, the items 'Atoms and molecules', 'How plants grow and reproduce', 'Benefits and possible hazards of modern methods of farming', 'The greenhouse effect and how it may be changed by humans' and 'Astrology and horoscopes, and whether the planets can influence human beings' were chosen from the ten least interesting. These are discussed below.

#### 5.2.4.1 Results

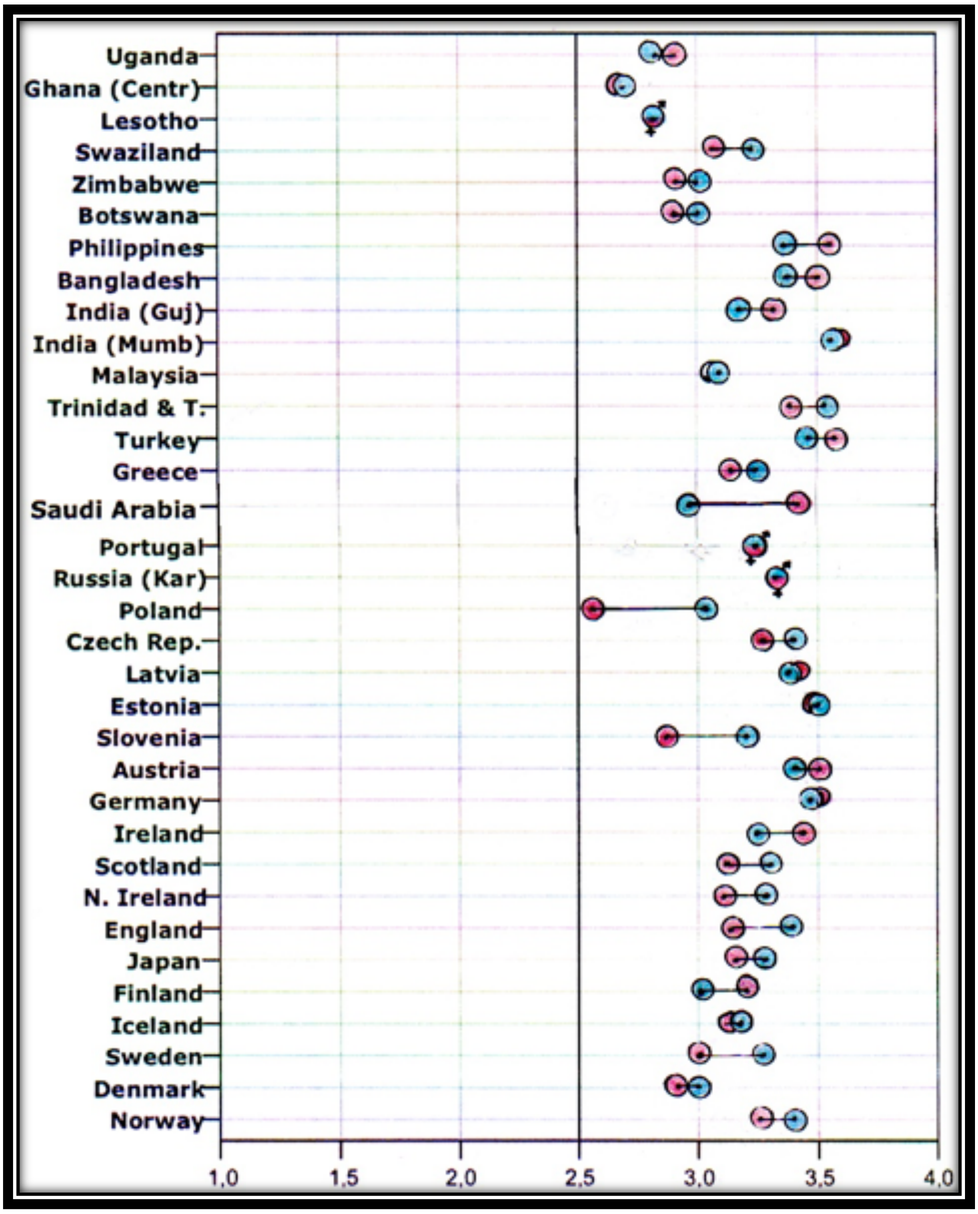
Notice (Red indicates the response of girls, blue the response of boys).

Figure 5-1 The mean of item A37: What to eat keep healthy and fit



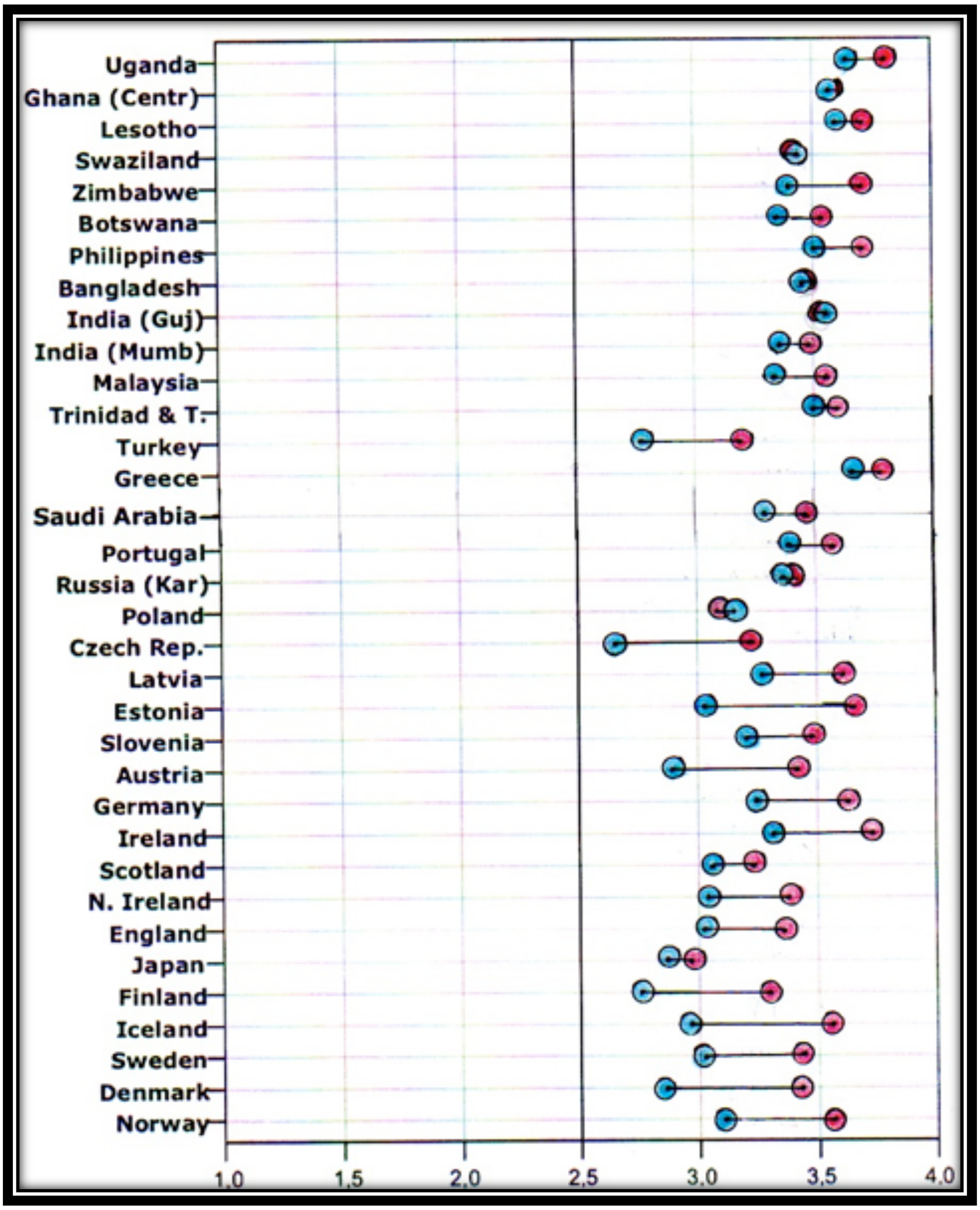

The data in Figure 5-1 show a diversity of interest among the students in different countries who participated in ROSE research. For example, A37 'What to eat to keep healthy and fit' was one of the items of greatest interest for both Saudi boys and girls, with mean values of 3.3 for girls and 3.21 for boys. This is consistent with the results of the ROSE project, which showed that boys and girls in developing countries were interested in this item. It is noteworthy that girls in developed countries had a much higher interest in learning about health than boys.

Figure 5-2 The mean of item A34: How it feels to be weightless in space




Regarding item A34, 'How it feels to be weightless in space', Figure 5-2 shows the similarities and differences between the results of the current study and the ROSE study. Saudi girls showed a higher interest than boys, with a mean value of 3.40, while for boys it was 2.96. Looking at the results for students in other countries, it can be concluded that both girls and boys have a desire to learn about 'How it feels to be weightless in space' in both developed and developing countries. However, compared with students in all other countries except Poland, the difference between boys and girls was greater in Saudi Arabia, and higher than that for the previous item, A37, while the results of the ROSE project in other countries show that the difference in this item was lower than for the previous item A37.

Figure 5-3 The mean of item A40: how to exercise to keep the body fit and strong




The responses to item A40, 'How to exercise to keep the body fit and strong' indicated that students in both developed and developing countries were interested in learning about physical education to maintain body fitness and strength. The gender difference is more pronounced in HDI countries except in Japan, for which no clear reason was given. Therefore, girls appear to be more interested in this component than boys in most countries. Also, the Saudi students, similar to students in other countries, were interested in learning about sport and fitness, but girls were likewise more interested than boys.

Figure 5-4 The mean of item E10: How to perform first-aid and use basic medical equipment

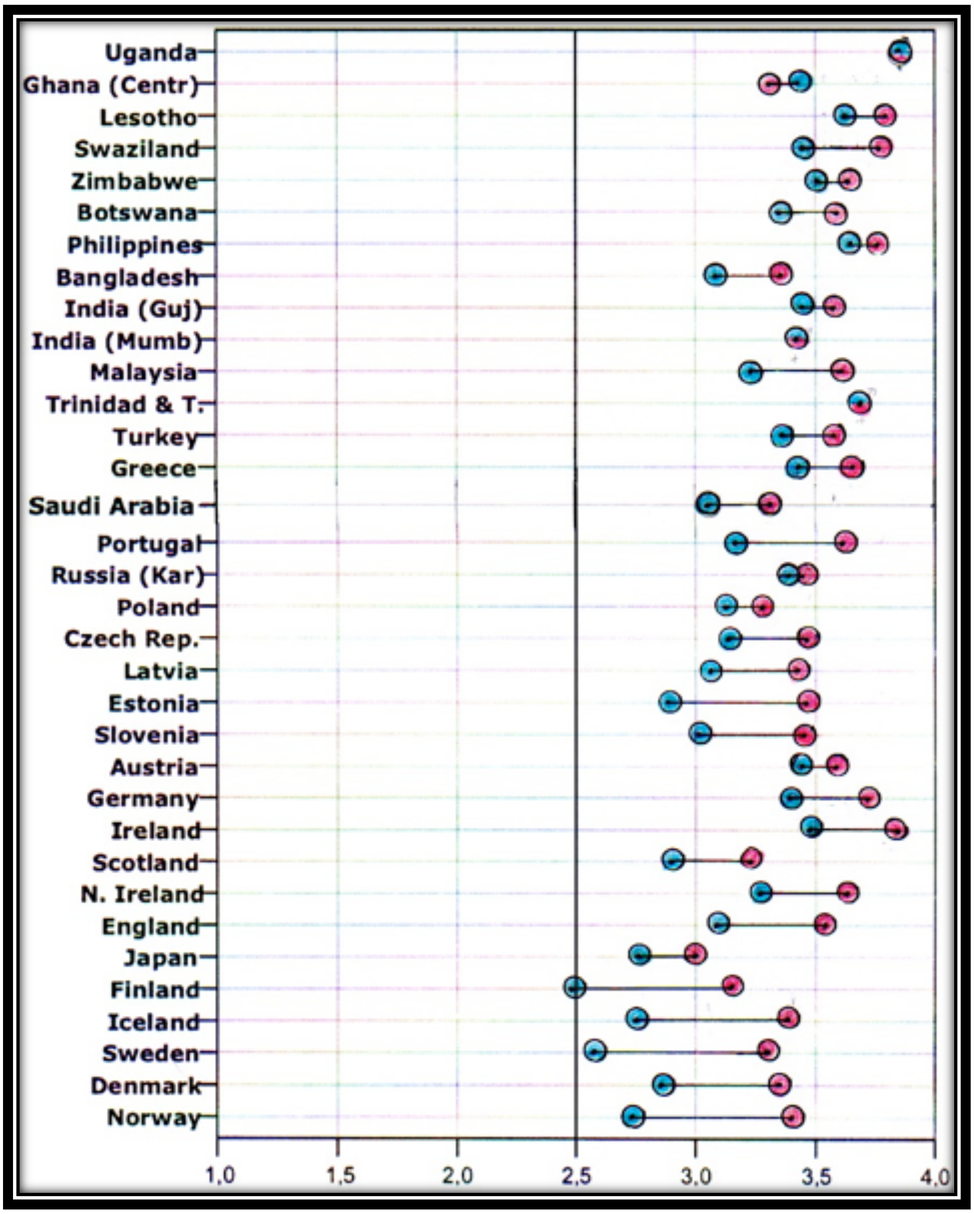
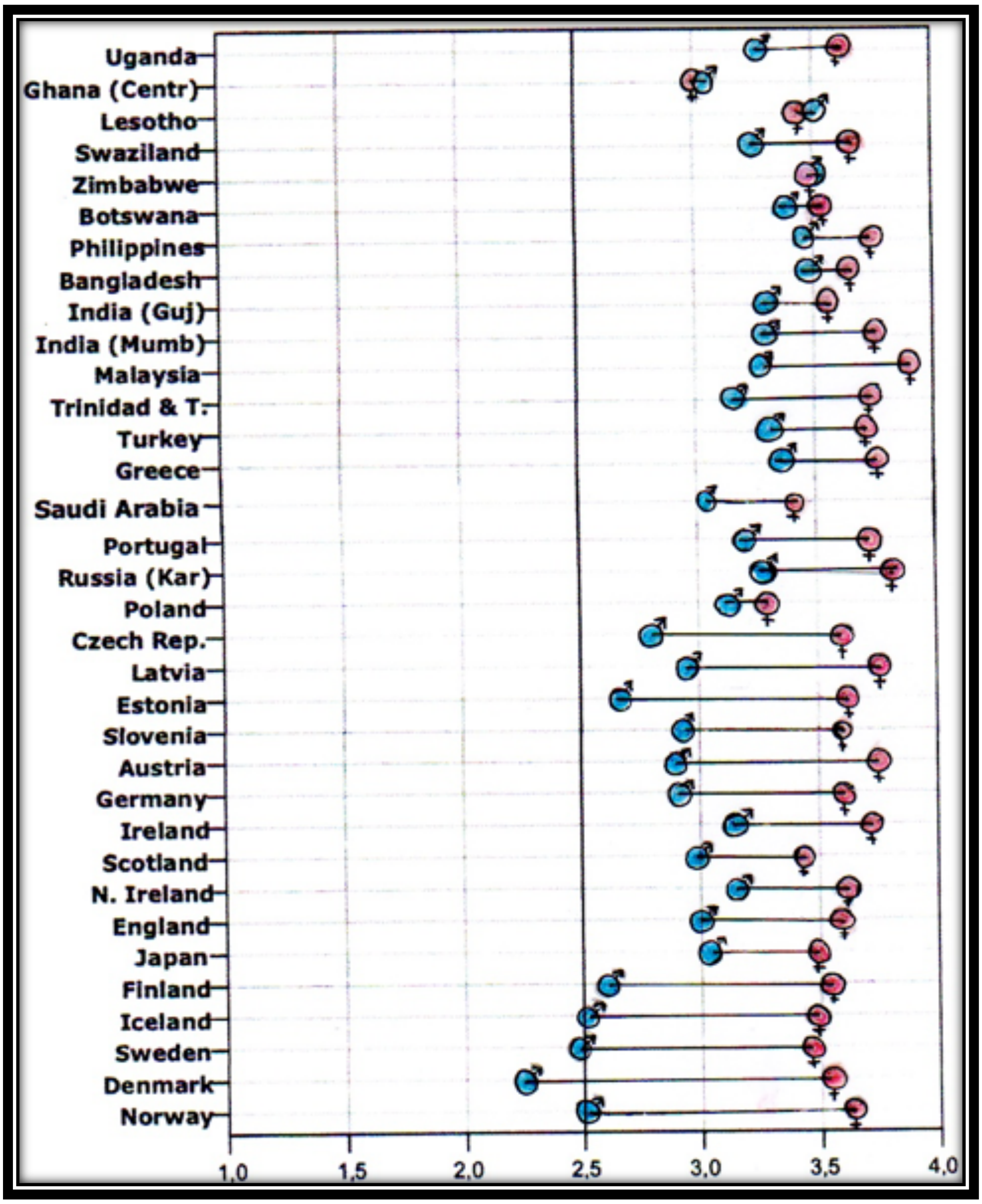



Figure 5-4 shows the similarities in the students' responses to item E10 'How to perform first-aid and use basic medical equipment' with their response to the previous item, A40. Additionally, the greater level of interest is clear among students in developing countries, while interest is lower in developed countries. Also, girls had more interest in this first-aid topic than boys in almost all countries, including Saudi Arabia. However, as is shown in Figures' 4, Polish boy students were more interested than girls, while in Uganda, there was no difference between boys and girls. Moreover, the figure shows that the gender differences in developed countries were clearer and more noticeable than in developing countries.

Figure 5-5 The mean of item C13**:** Why we dream while we are sleeping and what the dreams may mean




As shown in Figure 5-5, students who desired to learn about what dreams mean and why people dream when they sleep responded comparably to item C13, 'Why we dream while we are sleeping, and what the dreams may mean', with the exception of boys in Scandinavian countries, who expressed neutral opinions, while boys in Denmark were not interested in learning about that topic. Also, there were clear gender differences in developed countries and some of the developing countries. Figure5-5 shows that the interest of girls in that item was greater than that of boys in all countries (developing and developed), as the mean value was greater than 3.00.

Figure 5-6 The mean of item A17: Atoms and molecules

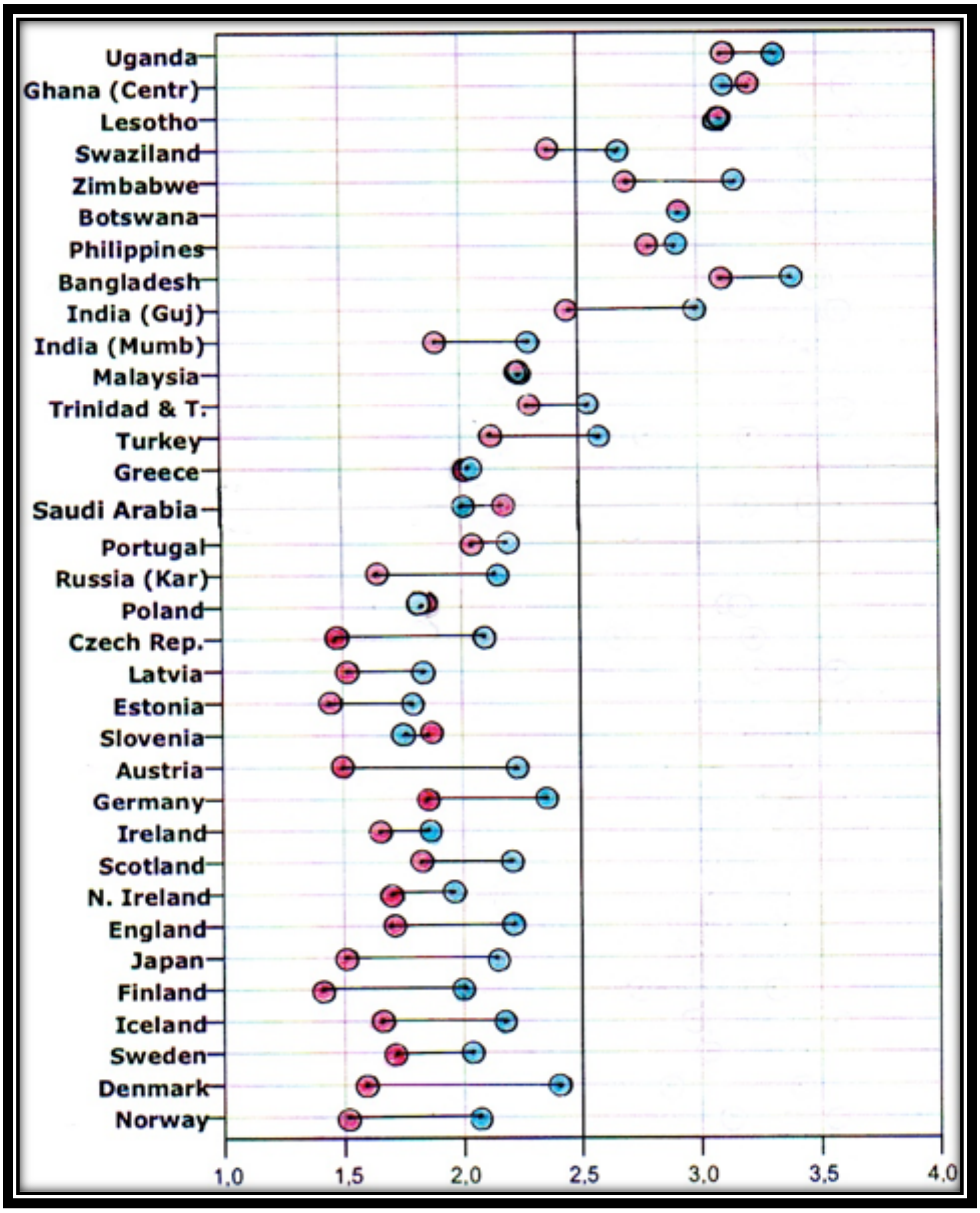
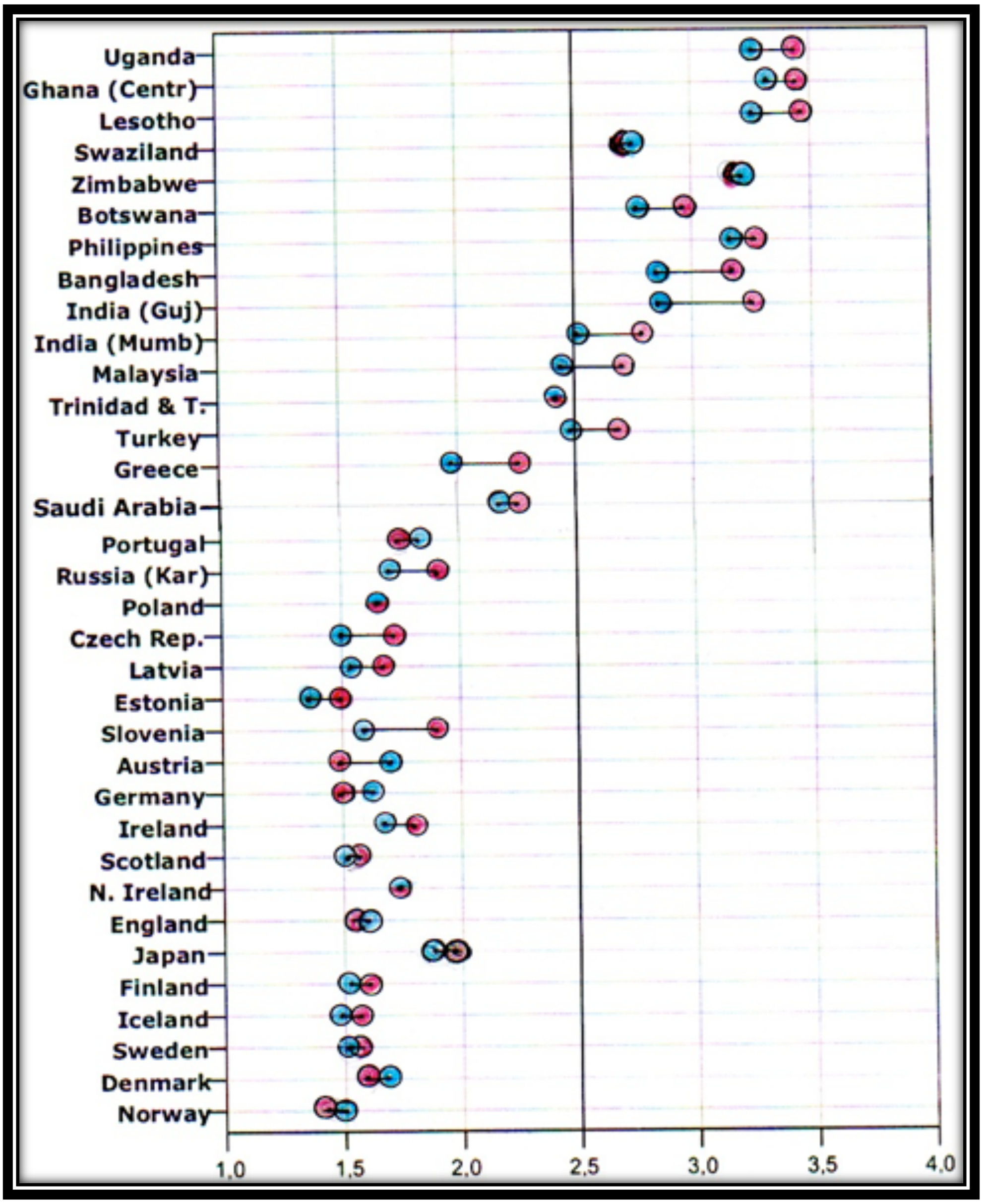


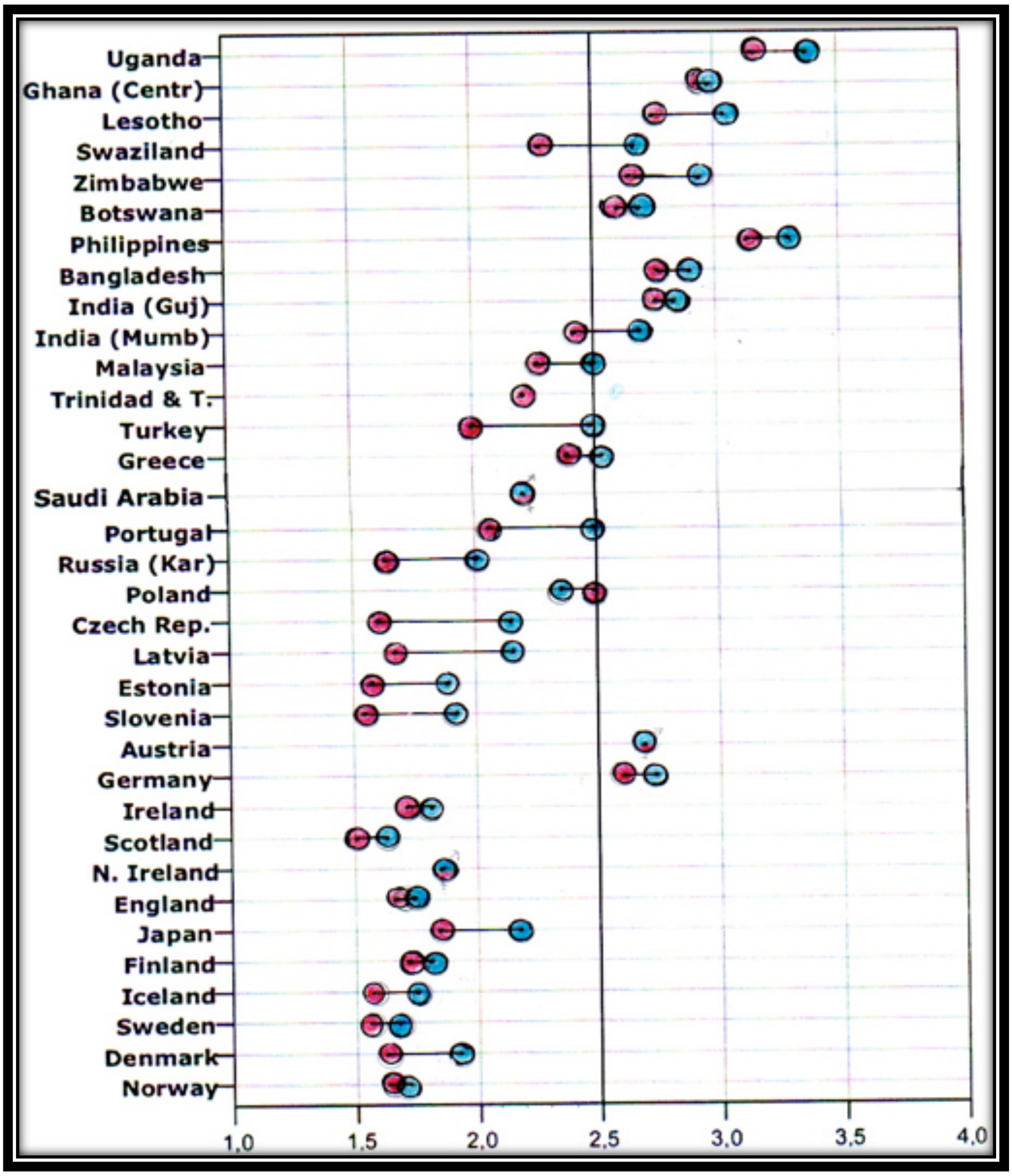

Figure 5-6 shows that Saudi students (both boys and girls) did not appear interested in studying topic A17, 'Atoms and molecules', as the mean value for boys was 2.05 and for girls it was 2.21. According to the results of the ROSE project, both boys and girls were interested in studying about atoms and molecules, in Malawi, Uganda, Ghana, Lesotho, Zimbabwe, Botswana, the Philippines and Bangladesh, all of which are developing countries. On the other hand, results from other developing countries, such as Swaziland and India showed that girls were not interested in atoms and molecules. In developed countries, both boys and girls showed less interest in learning about A17, as the mean value of this item was less than 2.5 for both girls and boys. It should also be noted that the mean value for boys was higher than the mean value for girls in most countries except Saudi Arabia, where the mean value for girls was higher than for boys.

Figure 5-7 The mean of item A15: How plants grow and reproduce



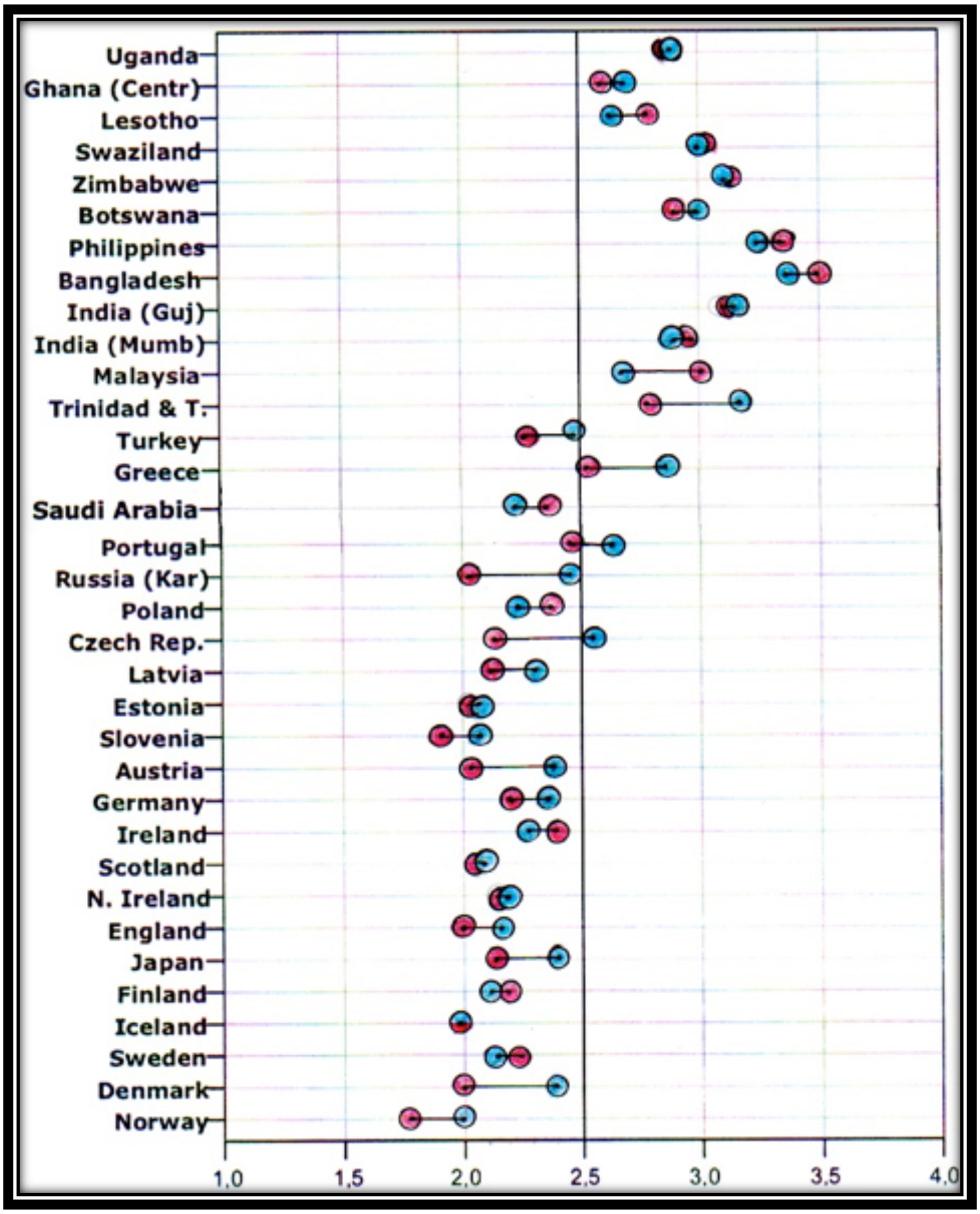

Although Saudi Arabia is one of the developing countries, the students' responses to item A15 'How plants grow and reproduce' were closer to those obtained from students in developed countries, rather than those in developing countries, where the mean value was less than 2.5, as shown in Figure 5-7. Students were not interested to learn about plants in developed countries or in some developing countries. On the other hand, students in some African and Asian developing countries showed an interest in improving their knowledge about plants, where the mean value of their response was greater than 2.5. However, the differences between boys and girls were very low in this item, including for Saudi students.

Figure 5-8 The mean of item E33: Benefits and possible hazards of modern methods of farming



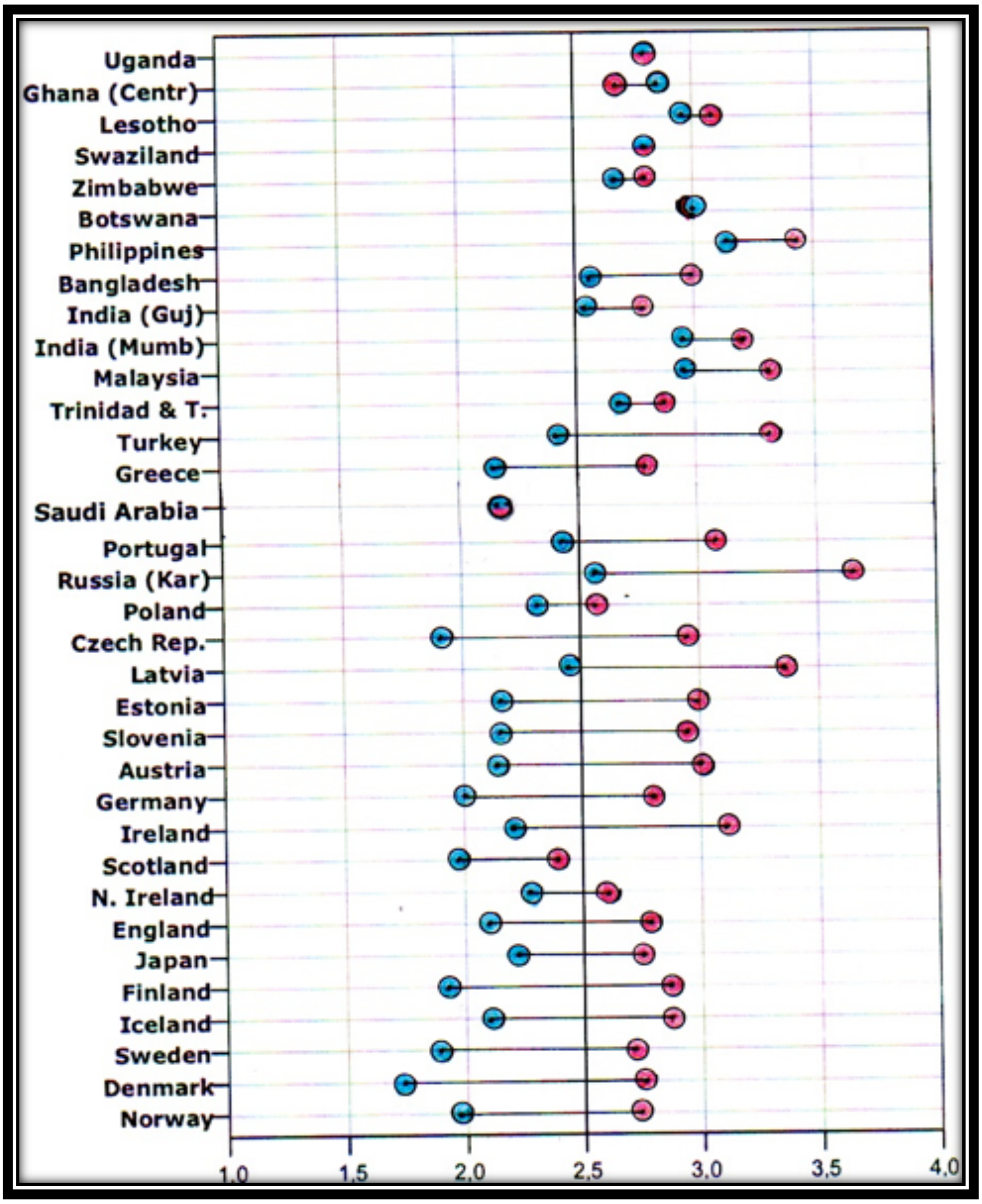

According to Figure 5-8, item E33, 'Benefits and possible hazards of modern methods of farming', attracted students in some developing countries, while most male and female students in developed countries were not attracted to that topic and expressed no desire to learn about it. Also, it is clear that the students in Austria and Germany had a slight interest in learning about the potential benefits and risks of modern methods of agriculture, to different degrees. Moreover, the gender differences were narrow in developed countries and some of the developing countries, but in some countries the mean scores indicated a difference between boys and girls in their attitude towards agriculture and its modern methods.

Figure 5-9 The mean of item E4: The greenhouse effect and how it may be changed by humans




On the subject of global warming, Saudi students, like other students in developed and some developing countries, were not interested to learn about it, as appears in their response to item E4, 'The greenhouse effect and how it may be changed by humans'. It is also noticeable from this item that there were no gender differences for this subject in almost all countries, including Saudi Arabia. However, the responses of students in developing countries in Africa and Asia, especially students from the Philippines and Bangladesh, show their interest in learning about global warming. Also, this item demonstrates the diversity among countries' situations, where girls in some countries had less interest, while in other countries, boys were less interested in learning about global warming.

Figure 5-10 The mean of item C9: Astrology and horoscopes and weather the planets can influence human beings




Item C9, 'Astrology and horoscopes, and whether the planets can influence human beings' shows that girls in developed countries were interested in learning about astrology, while boys were not. This item appears to clearly demonstrate diversity between students' attitudes toward this item in developed countries and some of the developing countries, where boys in African countries and some Asian countries expressed more interest in learning about astrology. However, for the same subject, the differentiation between boys and girls was less than in developed countries. In addition, neither boy nor girl students in Saudi and Scotland were interested in these topics.

Finally, the researcher can conclude that on the topics of most interest, Saudi students' attitudes were similar to those of students in developing and developed countries. However, for the items that had less interest, Saudi students' attitudes matched those of developed countries' students and conflicted with those of students in some developing countries such as those of Africa and Asia. However, in the case of item C9, 'Astrology and horoscopes, and whether the planets can influence human beings', girls in some countries had a greater interest in learning about it compared with their peers in Saudi Arabia, who were not interested in learning about astrology.

#### 5.2.4.2 Discussion

On the topics of most interest (A37, A34, A40, E10, C13), the data shows similarities between the Saudi students and their peers in developing and developed countries with slight variance, where the Saudi students had less interest in these topics than their peers in developing countries like India and Ghana. In contrast, the Saudi students expressed more interest in science than other students in developed countries, for example, Denmark and Norway, especially boys. In the items that the students were less interested in (A17, A15, E33, E4, C9), the Saudi students and their peers in developed countries such as Germany had situations that nearly matched, but those who were from developed countries such as England expressed less interest than the Saudi students. There was a difference in the interest in botany between the Saudi students and some others from developing countries, such as countries in Africa and Asia, who showed more interest in the topic than the Saudi students.

According to Sjøberg and Schreiner (2005), there is a strong inverse correlation between the overall score of interest in science and the state of development in a country. The higher the development status of a country, the lower the student interest and vice versa. Although the development index in Saudi Arabia is high, and it is considered a developing country, however, the interest in science of Saudi students is higher than that of their counterparts in developed countries. This confirms the findings of international research studies, which demonstrated that secondary school students in many developed countries do not exhibit high levels of interest in science and technology. This is not the case outside

Western Europe, where students tend to be far more interested in science (Sjøberg & Schreiner, 2005).

A more convincing explanation for this data is to propose that children in affluent countries with low unemployment rates see school as an obligation, and not as an opportunity and benefit. Many students believe school should be enjoyable and diverting. As a result, they are prone to state what they like, and what they do not like, and tend to be more discriminating in choosing what to learn. Students in (primarily) developing countries consider attending school at 15 an indulgence or an honour, and this means that, in theory, they are open to learning about virtually anything the school may teach, and pleased to have the opportunity (Sjøberg & Schreiner, 2010).

However, Vygotsky (1962) points out that the learning process is largely affected by social environments. Social learning theories can thus be used to explain how people learn in social settings. If socio-cultural factors (such as language, religion, economic status, gender, politics, ethnicity, values, habits and geographical locations) are taken into account, this can generate a richer understanding of students' beliefs, knowledge, skills and values.

From the data in this study, it is clear that the first five items of greatest interest to most students in countries are related to biology, for example, 'what to eat to keep healthy and fit'. Therefore, it can be said that the students' interest in these subjects (health) have a social relevance in all countries. For example, young people in more developed countries such as Norway "believe that the most important challenges facing our society are related to health and environmental issues" (Sjøberg & Schreiner, 2005, p. 15).

In Saudi, the Ministry of Health exerts great efforts in health awareness programmes to tackle the health challenges facing the country. Indeed, health topics are meaningful to students in Saudi and therefore they want to learn about them. In her study Uitto (2014) found that older high school students were more interested in human biology. Uitto's study also showed that student interest depended on the particular subject matter, with half of the student respondents showing mixed reactions to particular subjects, of which the most popular were human biology and medical problems.

Moreover, the effect of gender stereotypes appears in these items, but to varying degrees. In developing countries such as India and Botswana, gender differences are less than in developed countries such as Iceland and Sweden in items A37 and A40. Perhaps this is due to the cultural difference between countries. For example, in Saudi Arabia, Islam shapes all areas of Saudi culture and society, with Shariah law and the Qur'an. It forms the foundation upon which the Saudi monarchy rules (Al-Atawneh, 2009) unlike other Islamic countries such as Turkey and Malaysia. In Saudi society, the Qur'an provides a multifaceted and interwoven framework that provides citizens with a common moral code for everything from extended family structures and interpersonal relationships to tribal communities (Oyaid, 2009). Islam commands Muslims to preserve their bodies and cherish them as they will be asked about it on the Day of Judgement. Also, Islam's care for human health warns against harmful food and drinks.

The space item (A34) seems to be interesting for all students in developed and developing countries. It seems that popular science, such as museums, media and films etc help develop and stimulate interest in science and technology (Stocklmayer et al., 2010). For example, in the current study, girls expressed their interest in space due to the influence of social media.

However, the findings show that students from all developed countries and students from some developing countries, including Saudi Arabia, Malaysia and Turkey, are not interested in item (A17) 'atoms and molecules'. The cause for different views of science in students within a country is hard to identify. Research has suggested several explanations for why interest in scientific subjects is low. Sjøberg and Schreiner (2010) list a number of reasons, including old-fashioned curricula, a lack of qualified teachers, the negative stereotypes of scientists, an absence of role models in the field, religious explanations of scientific events and phenomena, and a mistrust of contemporary, wide-ranging scientific research. The educational environment influences students' interest in science. In Saudi schools, teaching does not allow students to go and explore things for themselves as a way of engagement. In chemistry, students are not expected to conduct practical experiments based on matters relating to their daily lives, like substances used in everyday life. However, the data shows that Saudi female students are more interested in chemistry than male students, and the segregated education system may be behind this finding, since gender stereotyping seems to happen more in mixed schools (Giovannoni, 2019).

Moreover, it is often the case that topics on botany and agriculture are less popular amongst students (Trumper, 2006; Uitto et al., 2006). There are three items (A15, E33 and E4) related to plants, in which Saudi students and students from developed countries showed little interest, whereas Turkish and Malaysian students were neutral, or only slightly interested. It seems that there are a few differences between these Muslim countries in some items, which may be due to cultural or geographical differences. When comparing Saudi students to Turkish and Malaysian students, Saudi Arabia is a desert region, with limited agriculture, which may explain students not being interested in plants, in contrast to the situation in Malaysia and Turkey. In addition, while Saudi Arabian farmers depend on foreign labour (UNESCO 2019), which reduces students' activities with the natural world, in Malaysia for example, the participation rate of women in agricultural sciences has reached 39% (UNESCO, 2019). It is noticeable, too, that interest in these items is much higher in some African countries. This may be because there is more dependence or agriculture and also because agriculture efficiency is more relevant and important, as a solution to problems of poverty and famine.

Reiess (2010) suggests that some students do not accept some items or scientific theories at all, such as the theory of evolution, because it contradicts their religious beliefs. An item that Saudi students, both boys and girls, were not interested in was item C9 (Astrology, horoscopes, and whether the planets can influence human beings). Religion was the reason behind their lack of interest in it. As previously mentioned, the Saudi society is religious, and the country was founded on religion. Since Islam prohibits astrology, the Saudi students did not have an interest in it, and their opinion on astrology was more strongly opposed than that of other students from Muslim countries, such as Turkey and Malaysia. In contrast to Saudi Arabia, Turkey and Malaysia are secular countries that rule by man-made law, not Islamic law, so their curricula are built on that basis. According to Reiess (2010), "There are, of course, countries (e.g., France, Turkey, USA) where due to a separation between religion and the state there are legal restrictions in force in respect of what can be taught" (p.11). Thus, the intensity of faith among Saudis may be higher than that of Malaysian and Turkish students. Hagay et al. (2013) studied students' interests in biology across religion, gender and country among high school students from Turkey, Israel, England and Portugal. He found that the intensity of faith and not a particular religion (Islam, Christianity, or Judaism) had a strong influence on the level of interest.

## 5.3. **Summary**

This chapter answered the first research question, which investigated the Saudi students' interests in aspects of science and technology. To achieve that, sections A, C, and E from the ROSE questionnaire were employed, besides focus group discussion, where both boys and girls showed a desire to learn science and technology, but girls showed more interest than boys. Though there were differences between boys and girls in their interest toward some scientific topics, they showed similarities in their interest toward others.

Culture, religion, and geographic location influenced the students' interests. Students were interested in topics with relevance to their community, such as diseases. Students gave several reasons for their interest in science, such as the desire to help others or the fact that science is tangible, allowing them to feel it, recognise it, or see it in everyday life, which makes it easy to understand. On the other hand, students had less interest in learning about scientific topics that were intangible or not of personal or community importance. There were other topics, such as ghosts and astrology, that the students considered superstitions and rejected, because Islam prohibits belief in them.

In addition, gender differences in interest were discovered, where the effect of stereotyping was found in some topics, such as girls' interest in biology and boys' interest in technology. Also, in this chapter, a comparison was made between the Saudi students' attitudes toward science and those of other students from different countries using the ROSE Project results. The opinions that appear in this chapter are important for education decision-makers in Saudi Arabia, as curriculum design could be informed by understanding of students' views toward scientific subjects.

The following chapter will analyse and discuss the Saudi students' responses in the interest of answering the second research question, which is about their out-of-school experiences.

# Chapter 6: Answering Research Question Two

**What is the students' experience of out of school science and technology?**

## 6.1. Introduction

This chapter will analyse and discuss the ROSE data collected from students in section H, 'My out-of-school experiences'. This section investigates students' activities and experiences, or experiments carried out outside of school, which may have influenced their interest in sciences and technology; this section can shed light on what might be significant approaches to use in teaching science and technology in schools.

Also, this chapter will examine gender differences in out-of-school experiences and make a comparison of Saudi students' experiences out of school as reported in section H of ROSE with students' out-of-school experiences in other countries.

## 6.2. My Out-of-School Experiences

Section H of the ROSE survey attempts to identify students' experiences outside of schools that may potentially be linked to the study of science. The section contains 61 activities in total, which is rather a large number, due to the developers' attempt to reflect the diverse activities found in different cultures and continents. The data gathered was divided into girls' and boys' responses and then, for each sex, the 10 most popular and the 10 least common activities outside of school were identified. Responses are measured on a four-point scale ranging from 'never' to 'often', with a mean value of 2.5, which is taken as the midpoint of the scale since there is no neutral response option. Mean scores ranged from 3.70 to 1.32 for girls and from 3.60 to 1.61 for boys.

### 6.2.1. Results

Table 6-1 The ten most common out of school experiences for girls

| N | Items | Frequency | | | | | | | | Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Never | | Low never | | Low often | | Often | | |
| | | Count | % | Count | % | Count | % | Count | % | |
| 1. | H44. used a mobile phone | 12 | 4.2 | 16 | 5.6 | 18 | 6.3 | 238 | 82.6 | 3.70 |
| 2. | H46. searched the internet for information | 8 | 2.8 | 20 | 6.9 | 25 | 8.7 | 231 | 80.2 | 3.69 |
| 3. | H31. used a camera | 5 | 1.7 | 22 | 7.6 | 55 | 19.1 | 204 | 70.8 | 3.60 |
| 4. | H53. baked bread, pastry, cake, etc. | 9 | 3.1 | 22 | 7.6 | 64 | 22.2 | 189 | 65.6 | 3.52 |
| 5. | H54. cooked a meal | 16 | 5.6 | 22 | 7.6 | 46 | 16.0 | 200 | 69.4 | 3.51 |
| 6. | H49. downloaded music from the internet | 15 | 5.2 | 44 | 15.3 | 53 | 18.4 | 171 | 59.4 | 3.34 |
| 7. | H40. connected an electric lead to a plug, etc. | 37 | 12.8 | 32 | 11.1 | 43 | 14.9 | 172 | 59.7 | 3.23 |
| 8. | H55. walked while balancing an object on my head | 22 | 7,6 | 30 | 10.4 | 95 | 33.0 | 136 | 47.2 | 3.22 |
| 9. | H45. sent or received an SMS (text message on mobile phone) | 21 | 7.3 | 63 | 21.9 | 53 | 18.4 | 146 | 50.7 | 3.14 |
| 10. | H51. used a word processor on the computer | 34 | 11.8 | 42 | 14.6 | 60 | 20.8 | 147 | 51.0 | 3.13 |

Table 6-1 reveals the ten most common experiences or activities for girls. Most of the girls' out-of- school experiences are related to modern, electronic technologies such as mobile phones H44 (mean 3.70) and H45 (mean 3.14), the Internet, in item H49 (mean 3.34) and item H46 (mean 3.69), computers, in item H51 (mean 3.13) and cameras in item H31 (mean 3.60). Other common activities involved cooking and baking.

Table 6-2 The ten most common out of school experiences for boys

| N | Items | Frequency | | | | | | | | Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Never | | Low never | | Low often | | Often | | |
| | | Count | % | Count | % | Count | % | Count | % | |
| 1. | H46. searched the internet for information | 8 | 2.5 | 21 | 6.5 | 55 | 17.1 | 219 | 68.0 | 3.60 |
| 2. | H44. used a mobile phone | 14 | 4.3 | 22 | 6.8 | 46 | 14.3 | 221 | 68.6 | 3.56 |
| 3. | H31. used a camera | 10 | 3.1 | 29 | 9.0 | 100 | 31.1 | 169 | 52.5 | 3.39 |
| 4. | H60. used tools like a saw, screwdriver or hammer | 17 | 5.3 | 44 | 13.7 | 92 | 28.6 | 157 | 48.8 | 3.25 |
| 5. | H40. connected an electric lead to a plug, etc. | 32 | 9.9 | 49 | 15.2 | 79 | 24.5 | 143 | 44.4 | 3.10 |
| 6. | H22. made a fire from charcoal or wood | 29 | 9.0 | 47 | 14.6 | 101 | 31.4 | 127 | 39.4 | 3.07 |
| 7. | H49. downloaded music from the internet | 33 | 10.2 | 58 | 18.0 | 76 | 23.6 | 135 | 41.9 | 3.04 |
| 8. | H47. played computer games | 34 | 10.6 | 59 | 18.3 | 74 | 23.0 | 133 | 41.3 | 3.02 |
| 9. | H54. cooked a meal | 35 | 10.9 | 52 | 16.1 | 95 | 29.5 | 123 | 38.2 | 3.00 |
| 10. | H45. sent or received an SMS (text message on mobile phone) | 25 | 7.8 | 73 | 22.7 | 86 | 26.7 | 118 | 36.6 | 2.98 |

Table 6-2 shows that, based on the responses to items H46, H44, H31, H49, H47 and H45, most science experiences for boys outside of school were related to modern electronic technologies such as the Internet, mobile phones and cameras. Item H46, 'searched the internet for information' had a mean value of 3.60, and item H44, 'used a mobile phone' had a mean value of 3.56. Boys' experiences were more related to technology than science. However, some students had other experiences. For example, many of them had cooked a meal, made a fire from charcoal or wood, used tools such as a saw, screwdriver or hammer and connected an electric lead to a plug.

Table 6-3 The ten least common out of school experiences for girls

| N | Items | Frequency | | | | | | | | Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Never | | Low never | | Low often | | Often | | |
| | | Count | % | Count | % | Count | % | Count | % | |
| 1. | H61. charged a car battery | 225 | 78.1 | 34 | 11.8 | 15 | 5.2 | 9 | 3.1 | 1.32 |
| 2. | H10. milked animals like cows, sheep or goats | 226 | 78.5 | 25 | 8.7 | 17 | 5.9 | 17 | 5.6 | 1.39 |
| 3. | H18. made compost of grass, leaves or garbage | 204 | 70.8 | 43 | 14.9 | 23 | 8.0 | 12 | 4.2 | 1.44 |
| 4. | H2. read my horoscope (telling future from the stars) | 206 | 71.5 | 33 | 11.2 | 37 | 12.8 | 8 | 2.8 | 1.46 |
| 5. | H19. made an instrument (like a flute or drum) from natural materials | 198 | 68.8 | 49 | 17.0 | 21 | 7.3 | 13 | 4.5 | 1.46 |
| 6. | H11. made dairy products like yoghurt, butter, cheese or ghee | 208 | 72.2 | 30 | 10.4 | 27 | 9.4 | 19 | 6.6 | 1.50 |
| 7. | H32. made a bow and arrow, slingshot, catapult or boomerang | 188 | 65.3 | 52 | 18.1 | 29 | 10.1 | 13 | 4.5 | 1.53 |
| 8. | H33. used an air gun or rifle | 188 | 65.3 | 55 | 19.1 | 21 | 7.3 | 20 | 6.9 | 1.55 |
| 9. | H30. used binoculars | 169 | 58.7 | 64 | 22.2 | 35 | 12.2 | 13 | 4.5 | 1.62 |
| 10 | H20. knitted, weaved, etc. | 167 | 58.0 | 68 | 23.6 | 33 | 11.5 | 15 | 5.2 | 1.63 |

Table 6-3 shows that the least common experience for girls was charging a car battery, with a mean value of 1.32, indicating that 78.1% of girls had never done it. The mean values of items H10, ‘Milking animals’ and H18, ‘Making compost of grass, leaves, or garbage’ scored 1.39 and 1.44 respectively. The mean score for item H2, ‘Read my horoscope – tell the future from the stars’ and H19, ‘Make an instrument, like a flute or drum, from natural materials’ was 1.46. The mean values for items H11 and H32 were 1.50 and 1.53, respectively. The option ‘never’ was used in these cases by 72.2% of respondents for item H11 and 65.3% for item H32. The low mean value of item H20, ‘Knitting or weaving’ was 1.63. The next table 6-4 shows the values for male students’ least common experiences outside of school.

Table 6-4 The ten least common out of school experiences for boys

| N | Items | Frequency | | | | | | | | Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Never | | Low never | | Low often | | Often | | |
| | | Count | % | Count | % | Count | % | Count | % | |
| 1. | H11. made dairy products like yoghurt, butter, cheese or ghee | 198 | 61.5 | 51 | 15.8 | 30 | 9.3 | 25 | 7.8 | 1.61 |
| 2. | H20. knitted, weaved, etc. | 191 | 59.3 | 59 | 18.3 | 30 | 9.3 | 24 | 7.5 | 1.63 |
| 3. | H2. read my horoscope (telling future from the stars) | 180 | 55.9 | 57 | 17.7 | 50 | 15.5 | 20 | 6.2 | 1.71 |
| 4. | H37. used a windmill, watermill, waterwheel, etc. | 159 | 49.4 | 66 | 20.5 | 52 | 16.1 | 22 | 6.8 | 1.79 |
| 5. | H18. made compost of grass, leaves or garbage | 165 | 51.2 | 58 | 18.0 | 50 | 15.5 | 30 | 9.3 | 1.82 |
| 6. | H16. participated in fishing | 152 | 47.2 | 72 | 22.4 | 53 | 16.5 | 30 | 9.3 | 1.87 |
| 7. | H19. made an instrument (like a flute or drum) from natural materials | 153 | 47.5 | 66 | 20.5 | 51 | 15.8 | 34 | 10.6 | 1.89 |
| 8. | H5. collected different stones or shells | 82 | 25.5 | 75 | 23.3 | 83 | 25.8 | 70 | 21.7 | 1.89 |
| 9. | H30. used binoculars | 130 | 40.4 | 102 | 31.7 | 54 | 16.8 | 22 | 6.8 | 1.90 |
| 10. | H32. made a bow and arrow, slingshot, catapult or boomerang | 137 | 42.5 | 81 | 25.2 | 58 | 18.0 | 29 | 9.0 | 1.93 |

Table 6-4 shows that the least common experience for boys outside of school was item H11, 'made dairy products like yoghurt, butter, cheese or ghee'. The mean value was 1.61, which was the lowest. Item H20, 'knitted, weaved' was second, with a mean value of 1.63. Clearly, a large number of students never read their horoscopes, as the mean value for this statement was 1.71. Moreover, students had little experience in fishing, using binoculars or making compost from grass, leaves or garbage. Furthermore, items H5 and H32 were not common experiences outside of school, as the mean values were 1.89 and 1.93, respectively.

### 6.2.2. Analysis and Discussion

Students have a wide variety of interests, attitudes and experiences that can be used in the process of learning science. Constructivist-based research evidence thus indicates that informal science experiences play a fundamental role in developing the crucial foundations that enable students to engage in deep conceptual understanding. Out-of-school experiences vary according to the educational and family environment, economic and social status, and cultural and ethnic origins (Korkmaz et al., 2017a). Therefore, it is necessary to define the students' out-of-school experiences related to science to develop a better understanding about the dynamics of science curricula and science classroom settings in future.

#### 6.2.2.1 Activities with mean value above 2.50

In the current study, the data in Tables 6-1 and 6-2 show the most common activities for boys and girls outside school. There is a noticeable similarity between the activities that the two sexes practise outside school. This result supports claims in previous studies that boys and girls in developing countries have similar out-of-school experiences (Sjøberg, 2000b). Of the 10 activities most frequently done outside school, seven the same for boys and girls, with only slight differences in the mean values and order of items. Technology-related activities are the most common among boys and girls. For example, 'used a mobile phone', has the highest mean value for girls (3.70) and is the second highest-ranked activity among the boys (3.56). Other common activities were 'searched the internet for information', 'used a camera', 'downloaded music from the internet', 'sent or received an SMS (text message on mobile phone)', 'used a word processor on the computer' and 'played computer games'. The economic and social situation of Saudi Arabia may explain this result. The Saudi economy has been ranked among the most powerful economies in the world (Honorable, 2020). Thus, an important factor that contributes to the increasing use of technology is the societal ability of the majority to own smart devices (Al-Sahli, 2016). The Saudis are very active in using social media. In a study conducted to find the relationship between internet use and social alienation among young Saudi people in Riyadh, Alsobehi and Almosa (2012) concluded that most of their participants spent between three and four hours on the internet every day. Sociologists identify three factors behind the Saudis' use of social media: freedom of expression, raising grievances by exposing corruption cases and being a source of entertainment which is otherwise scarce. Regarding the first two factors

Saudi society is very conservative, and it is difficult for individuals to express their opinions in official channels; therefore they resort to these networks to express themselves freely (Al-Sahli, 2016). Moreover, the government supports the technology quality (e.g., Vision 2030). Saudi Arabia is moving towards government digital communication to keep pace with development and to show mutual interest between government agencies and citizen beneficiaries, in addition to ensuring that information reaches the largest number, in the fastest time and in the highest quality (Al Mustadi, 2018). Regarding entertainment, in 2018, Saudi Arabia was ranked 19th among the world's largest gaming markets, and the first among Arab countries, with game revenues in Saudi Arabia amounting to approximately 761 million dollars (Al-Fhaid, 2018).

Thus, the data on the Saudi students' experience outside school shows that the students were especially involved in activities linked to communication and technology (H45, H44, H49, H46). The extensive use of such devices by students would also explain their experience in connecting an electric lead to a plug. This finding agrees with the result of Yeung and Li (2015), who found Greek and Chinese students also had high experience with these activities. Moreover, this result is consistent with that of Korkmaz et al. (2017a), who found that American students are more interested in technology-related activities outside school, such as the use of cameras, mobile phones, binoculars, and the internet for finding information. In contrast, the current study is inconsistent with the study of Anderson (2006) which found that technology-related activities were not common among Ghanaian students, especially rural students. Ghanaian students, especially in rural areas, may not be able to afford devices or have access to electricity and internet connection.

Some items related gender stereotypes. For example, item H55, 'walked while balancing an object on my head' was an activity that girls performed more than boys, consistent with previous studies for girls in other countries (Sjøberg, 2002c). This may reflect a gender stereotype, as this activity is supposed to enhance gracefulness and good deportment, which are qualities more expected of girls. Moreover, cooking is another duty stereotypically expected to be performed by women. Studies in Saudi have noted the role of school books in socialising girls and boys into expected gender roles. For example, Alsweel (2007) mentions that the Ministry of Education worked hard to ensure the traditional values since the beginning of girls' education. For example, the first-grade reader contained the statement 'My father goes to work; my mother stays at home and cooks'. Until now, under family and health education in Saudi schools, girls are taught skills that are not taught to boys, including cooking, table setting, cleaning, washing, child-rearing and other duties typically assigned to Saudi women as housewives. This would explain why items H54 ‘Cooked a meal’ and H53 ‘Baked bread, pastry, cake, etc’ are among the activities most practised by girls out of school.

However, restrictions on the movement of boys are much lower than those on the activities of girls. Therefore, boys have more opportunities to go outside their homes and experience nature and the outdoors (Hamdan, 2005). They also have more opportunities to, for example, camp or have picnics, which encourage them to practise certain activities, for example, cooked a meal on a ‘fire from charcoal or wood’ and ‘prepared food over a campfire, open fire or stove burner’. Furthermore, boys’ schools in Saudi Arabia have outside-school activities that girls do not experience, such as scouting activities and out-of-city trips (AlMunajjed, 2009). These activities give boys more chances to learn and practise activities that girls cannot.

> Social reproduction theorists argue that power relations and domination underlie formal education systems. Schools serve to support existing power relations and to socialize young people to play their class and gender roles in these relations. Feminist social reproduction theorists in turn argue that schools serve to preserve patriarchy and dominant gender relations that relegate women to a subordinate role in society (Adely, 2004, p. 354).

In this respect the education system in Saudi Arabia classifies tasks and jobs according to gender. Sewing, raising children and home management are taught to girls, whereas metal crafts and physical education are taught to boys. This explains high activity on ‘used tools like a saw, screwdriver or hammer’ for boys. In addition, the participants, particularly the boys (See Appendix 8), had many experiences regarding the use of electricity, batteries, lamps, engines, pulleys and jacks, which are related to physics subjects. Examples include the items ‘opened a device (radio, watch, computer, telephone, etc) to find out how it works’, ‘used a rope and pulley for lifting a heavy thing’, ‘mended a bicycle tube’, ‘charged a car battery’ and ‘changed or fixed electric bulbs or fuses’.

In the focus groups, several boys in the group (A-B-1) mentioned some of the experiences that they sometimes practised outside of school. For example, one of them mentioned taking apart a clock:

> "The clock, I take, it apart, I change its battery and I try to see how the hands turn."

Another had tried to use a solar panel:

> "I tried to convert the sun's energy into electricity to benefit from it." (A-B-1).

Another enjoyed fixing devices at home:

> "When I find broken stuff at home, I take a pleasure in fixing them, like fixing a light bulb." (A-B-1).

An examination of the results of this study reveals that boys' activities are oriented toward physics subjects. For example, hand tools, such as saws, screwdrivers and hammers, are devices or tools that are likely to be considered under the study of simple machines or arms in mechanics. Furthermore, activities that attempt to dismantle radios, surveillance devices, computers, telephones and similar devices to learn how they operate can be described as activities related to electronics and electricity.

This orientation towards physics (mechanics) subjects is greater for boys than girls. Sjøberg (2002c) found that in general, strong male dominance over all these activities is prevalent in all countries. A typical example is 'lifting heavy objects with ropes and pulleys', an activity likely to help in understanding simple mechanics. Evidence shows that in all countries, boys have much more experience in this area than girls. For activities such as using a car jack, male dominance is especially noticeable. In Saudi, until recently, women were not allowed to drive and relied on male relatives or hired drivers, so it is likely that they would not be expected or encouraged to show an interest in cars. Also, difficult or physically demanding activities are considered not suitable for women, as not corresponding to constructions of the feminine nature but deemed appropriate to the masculine nature. This probably explains Saudi boys' interest and girls' lack of interest.

Other out of school activities that the Saudi students performed, according to the research data, are those linked to health and diseases, such as the following items: 'cleaned and bandaged a wound', 'been to a hospital as a patient' and 'taken medicines to prevent or cure illness or infection'. There is a noticeable link between these activities and the interest in school science subjects (sections A, C and E) related to diseases, such as 'Epidemics and diseases causing large losses of life', 'How to perform first-aid and use basic medical equipment' and 'Cancer: what we know and how we can treat it'. The current study showed that biology is a favourite subject among Saudi secondary school students. In particular, human biology and health were more favoured by the girls and the boys. This means that students in this study were interested in learning about science topics related to community issues. Again, conforming the view that personal experiences of human biology and health and safety issues make these topics of particular interest to students PISA in 2006.

According to the results, boys and girls widely used measurement devices, for example, when cooking a recipe, or taking temperature in the event of illness. The ability to use and read thermometers and read and understand tables is critical in experimental science. However, the findings show that the girls had more experience in this area than boys (mean=2.87 for girls, mean=2.52 for boys). The reason may be that the girls' engaged in cooking and caring for sick family members because these activities are part of the role assigned to them by the culture. These results agree with those in other studies, such as Lavonen, Juuti, Uitto, Meisalo, and Byman (2005b) and Sjøberg (2002c). There are some activities performed by both boys and girls, but the results show varying mean values (See Appendix 8), such as those for 'watched nature programmes on TV or in a cinema', 'visited a zoo' and 'used a wheelbarrow'. Also, girls practised activities outside school, such as 'tried to find the star constellations in the sky', which is about space, which encouraged girls to learn about 'black holes, stars, planets and the universe'. The current result confirmed that out-of-school experiences contribute to development of interest in STEM (Braund & Reiss, 2006; Danielsson et al., 2013; Maltese & Tai, 2010; Stocklmayer et al., 2010).

This discussion of the results shows the activities that were most frequently done by the participating Saudi students. The next section analyses the activities that were the least frequently done, which had mean values are less than 2.5.

#### 6.2.2.2 Activities Have Mean Value Below 2.50

Tables 6-3 and 6-4 show the 10 least performed outside-school activities for female and male Saudi students respectively. The results reveal that many of the 10 least performed activities are similar for girls and boys. The students in the sample were only slightly involved in nature and outdoor activities. Although they both agreed on having little experience of the following items, 'made dairy products like yoghurt, butter, cheese or ghee', 'made compost of grass, leaves or garbage', 'made an instrument (like a flute or drum) from natural materials', 'used binoculars' and 'made a bow and arrow, slingshot, catapult or boomerang', the mean values differed. Boys' mean values were between 1.93 and 1.6 and girls' between 1.63 and 1.32. As indicated previously, the students' out -of school experience were focused on technology and communication, which may have prevented them from enjoying real-life experiences. This may be because, living in urban areas, they did not have access to such things. Making dairy products is more relevant to country farm life, and making compost is more relevant to people who cultivate land or, at least, have a garden. Moreover, Saudi Arabia relies on expatriate workers for most of these tasks (Al-Zamil, 2017). Perhaps this is one of the reasons that Saudi students have little experience of nature activities. In addition, there are some Saudi cultural and social factors that affect students' activities out of school. For example, manual work, industrial and vocational work are conferred less acceptance and low social value in Saudi society (Al-Zamil, 2017). As a result, the majority of students may have little activity in these items. These results agree with those of a study conducted in 2017 to investigate the biology and extracurricular experiences of high school students in Abu Dhabi, United Arab Emirates (Badri et al., 2017), which is an Islamic Gulf country, with a similar culture to Saudi Arabia.

Moreover, item H16 'participated in fishing' was among the 10 least experienced by the boys (mean=1.87) but not by the girls. However, it was among the girls' low ranked activities (See Appendix 8) (mean=1.64). The preceding analysis clearly shows that the Saudi students rarely participated in outside-school fishing activities. This may be explained by the fact that the participants lived in a desert area, far from the coast (located hundreds of miles away from the sea), which made their participation in fishing rare. Moreover, the use of smart communication devices, such as iPhones, Samsung Galaxy phones, and similar units, may have alienated the students from the use of compasses. It is now the habit of Saudi people when traveling to use mobile applications to show them the orientation to so they know the direction of the Qibla (The holy shrine in Mecca, which Muslims face when praying ) (Knnah, 2008).

The item 'read my horoscope (telling the future from the stars)' was among the 10 least experienced out of school activities for both boys and girls. With regard to this point, as noted previously. Islam rejects the belief that there is any force that can interfere with the ability of God to run the affairs of the universe (Budhwar, Mellahi, Elamin, & Omair, 2010). Therefore, students are taught that nature has laws controlled by the power of Allah that can help them study and explore the future, and they do not believe that the planets and constellations have an impact on their lives. Therefore, this is not among the activities that the students are interested in experiencing. This result is consistent with Muhammad's (2019) finding that Egyptian students did not read their horoscope.

A few of the boys and girls had experiences related to knitting and weaving (H20, 'knitted, weaved, etc'). However, this was among the 10 least practised activities for both the boys and girls, whose mean values were both 1.63. Sjøberg (2000b) stated that the use of needle and thread for sewing is an activity dominated by girls in all countries. By contrast, in this study, girls were not active in item H20 outside school, even though their school curriculum includes sewing. A possible explanation might be that students may have relied on domestic servants to sew, as most Saudi people rely on foreign housemaids to do the housework (Johnson, 2010). Another possibility is that in the modern consumer society, clothing and household textiles are bought rather than home-made and mended.

Item H61, 'charged a car battery' was also among the least practised activities for the girls; its mean value (1.32) was the lowest among the girls' activities. The ban on women's driving at the time this study was conducted, possibly contributed to making this item a less relevant activity for the girls. Moreover, the result is consistent with other studies' findings, that boys dominate 'electrical' activities, including charging car batteries (Badri et al., 2017; Sjøberg, 2000b). The present results also agree with those of Osborne and Collins (2001), who studied young British students and found that girls do not share the interest of boys in physics related to cars and trips.

Tunnicliffe and Reiss (2010) argued that home played a more important role than school in familiarising students with plant classification. This indicates that students who are interested in various forms of biology may simply be reflecting their personal overall interest in nature (Krapp, 2003), which they have acquired in a range of environments outside school; students who have not had these experiences are less likely to engage with different contexts of biology. Thus, this study's urban location explains students' lack of experience with animals and plants, e.g., 'cared for animals on a farm' and 'watched (not on TV) an animal being born', and 'planted seeds and watched them grow'. Furthermore, the participants were not interested in it, as revealed in the A, C and E section. In this regard, Uitto et al. (2006) indicated that farm animal husbandry experiences are associated with interests in applied biology, which involves local plants and animals, modern methods of agriculture and agriculture, and use of pesticides and industrial fertilizers. The participants in this study were not interested in such topics in biology and were rarely engaged in activities related to animals and plants outside the school, perhaps suggesting that the environment may have affected the science-related interests and activities of students in Saudi Arabia.

### 6.2.3. Gender Differences

In this section, the out-of-school experience differences between boys and girls are shown by presenting the results of the chi-squared test. The tables below show the differences between girls and boys by listing their p value, with p values less than 0.05 indicating a significant difference. Table 6-5 shows the statistical significance in favour of girls and Table 6-6 shows the statistical significance in favour of boys. Of the 61 activities, there are 15 with statistically significant differences in favour of girls and 21 items with statistically significant differences in favour of boys. Eight of these items are among the most common activities out of school (Table 6-5 and Table 6-6).

#### 6.2.3.1 Result

Table 6-5 Items statistically significant in favour of girls

| Girls' activities | Mean G[3] | Mean B[4] | p |
|---|---|---|---|
| H1. tried to find the star constellations in the sky | 2.70 | 2.24 | .000 |
| H5. collected different stones or shells | 2.39 | 1.89 | .000 |
| H25. cleaned and bandaged a wound | 3.12 | 2.82 | .001 |
| H31. used a camera | 3.61 | 3.39 | .000 |
| H34. used a water pump or siphon | 2.61 | 2.56 | .000 |
| H40. connected an electric lead to a plug, etc | 3.24 | 3.10 | .001 |
| H43. used a measuring ruler, tape or stick | 2.86 | 2.52 | .000 |
| H44. used a mobile phone | 3.70 | 3.56 | .002 |
| H45. sent or received an SMS (text message on mobile phone) | 3.14 | 2.98 | .011 |
| H46. searched the internet for information | 3.69 | 3.60 | .008 |
| H49. downloaded music from the internet | 3.35 | 3.04 | .001 |
| H50. sent or received e-mail | 3.01 | 2.76 | .001 |
| H51. used a word processor on the computer | 3.13 | 2.78 | .000 |
| H53. baked bread, pastry, cake, etc | 3.52 | 2.70 | .000 |
| H54. cooked a meal | 3.51 | 3.00 | .000 |
| H55. walked while balancing an object on my head | 3.23 | 2.79 | .000 |

3 The letter G refers to girls.

4 The letter B refers to boys.

Table 6-6 Items statically significant in favour of boys

| Boys' activities | Mean B | Mean G | p |
|---|---|---|---|
| H60. used tools like a saw, screwdriver or hammer | 3.25 | 2.67 | .000 |
| H59. mended a bicycle tube | 2.87 | 2.18 | .000 |
| H23. prepared food over a campfire, open fire or stove borne | 2.80 | 2.64 | .019 |
| H52. opened a device (radio, watch, computer, telephone, etc.) to find out how it works | 2.75 | 2.31 | .000 |
| H61. charged a car battery | 2.73 | 1.32 | .000 |
| H39. changed or fixed electric bulbs or fuses | 2.59 | 2.23 | .000 |
| H58. used a rope and pulley for lifting heavy thing | 2.54 | 1.86 | .000 |
| H3. read a map to find my way | 2.53 | 2.37 | .019 |
| Least common Boys' activities | Mean | Mean | p |
| H15. participated in hunting | 2.45 | 1.75 | .000 |
| H33. used an air gun or rifle | 2.38 | 1.55 | .000 |
| H7. cared for animals on a farm | 2.26 | 2.02 | .016 |
| H21. put up a tent or shelter | 2.26 | 1.74 | .000 |
| H57. used a crowbar (jemmy) | 2.26 | 1.64 | .000 |
| H6. watched (not on TV) an animal being born | 2.19 | 1.72 | .000 |
| H26. seen an X-ray of a part of my body | 2.05 | 1.93 | .042 |
| H10. milked animals like cows, sheep or goats | 1.99 | 1.39 | .000 |
| H32. made a bow and arrow, slingshot, catapult or boomerang | 1.93 | 1.51 | .000 |
| H30. used binoculars | 1.90 | 1.61 | .000 |
| H19. made an instrument (like a flute or drum) from natural materials | 1.89 | 1.46 | .000 |
| H18. made compost of grass, leaves or garbage | 1.82 | 1.45 | .000 |
| H2. read my horoscope (telling future from the stars) | 1.71 | 1.45 | .002 |

#### 6.2.3.2 Discussion

Specific childhood experiences tend to direct students towards particular disciplines in the field of science rather than science as a whole, and these preferences can be influenced by social change (Sjøberg, 2000b). Previous studies have found differences in experiences between boys and girls. Boys were more involved with the practical aspects of science from their contact with mechanical and electrical items such as electric toys, microscopes, batteries, fuses and pulleys. Girls were familiar with more domesticated activities such as knitting and sewing, bread-making and gardening (Jones et al., 2000).

The findings of this study were consistent with such results. The data in Table 6-5 and 6-6 illustrate the differences between boys' and girls' experiences outside school. While the boys' experiences outside school were mostly related to outdoor and physical activities, the girls' activities were mostly related to household tasks and activities related to space (but done from home) such as watching stars. Statistically significant differences in the mean scores in favour of girls were found for the following items: used a word processor on the computer; cooked a meal; baked bread, pastry or cake; sent or received e-mail: used a mobile phone; connected an electric lead to a plug; walked while balancing an object on my head and used a measuring ruler, tape or stick.

Statistically significant differences in favour of boys were found for the following items: read a map to find my way; used tools like a saw, screwdriver or hammer; participated in hunting; mended a bicycle tube; put up a tent or shelter; opened a device (radio, watch, computer, telephone, etc.) to find out how it works; prepared food over a campfire, open fire or stove; changed or fixed electric bulbs or fuses and charged a car battery.

The stereotypical gender differences may explain the results of the current study. Saudis' lives are regulated according to Islamic law, along with the cultural values of patriarchy and traditions of gender (Almutairi, 2007). Gendered values guide many aspects of life in Saudi Arabia, including people's relationships, education, and employment (Hein, Tan, Aljughaiman, & Grigorenko, 2014). For example, cultural constructions of gender influence the Saudi curriculum for boys and girls at the various educational stages. At the primary level, the core curriculum is the same for both genders, but in addition, boys study wood and metal crafts, while girls study home skills such as needlecraft, domestic science and child welfare (El-Sanabary, 1994). Thus, men and women are channelled to different studies and courses, consistent with what society perceives as their natural talents. Thus, female students in Saudi Arabia are prepared for their future roles as married women with children, while male students are prepared for careers in science, research, and so on (Al-Hamid, 2007). This can be interpreted as one of the reasons for differences between boys and girls in activities and experiences practised outside of school.

As noted previously, in Saudi culture, women's duties are inside the home, while men's are outside the home. Therefore, girls' experiences are in the home surroundings and related duties, such cooking and cleaning. On the other hand, the activities of boys are in maintenance, such as 'changed or fixed electric bulbs or fuses', and 'opened a device (radio, watch, computer, telephone, etc.) to find out how its works', and grocery shopping. These tasks are considered compatible with the male and female nature, as perceived by the Saudi society.

Moreover, the prohibition, until 2018, on Saudi women driving, is reflected in girls' experiences. Amoudi (2009) found that Saudi girls spent their spare time in activities at home or visiting relatives, due to family restrictions on girls' freedom. Therefore, girls in Saudi Arabia have limited options of activities compared to boys. Among the activities and entertainments that Saudi girls prefer are watching TV series and using social media (Taher, 2019). Given the restrictions on the movement of girls outside their homes, one of the first and most accessible information sources for them is the internet (Al Madani, 2019).

Despite the gender inequality in Saudi Arabia, the research showed that the results were similar to studies done in other countries, which revealed that boys' experience in out-of-school science often led to their engaging more in outdoor activities and having more experience in physical science. For example, Jones et al. (2000) examined the experience and viewpoint towards science of sixth-grade students in the USA. Boys were more involved with the practical aspects of science from their contact with mechanical and electrical items such as electric toys, microscopes, batteries, fuses and pulleys. Girls were familiar with more domesticated activities such as bread-making and cooking.

The present results agree with those of Juuti, Lavonen, Uitto, Byman, and Meisalo (2004) who suggested that, in studying physics, boys like to know how technical applications work, and girls like to know for what purpose the technical applications can be used. Despite the rich experience of both boys and girls with digital applications, there was a clear difference between them, in that girls had more experience in using digital applications. These results agree with of those of Badri et al. (2017) in Abu Dhabi, which has a similar culture. A possible explanation could be that in these patriarchal societies, the restrictions on girls' activities outside the house have led them to use technology more as a means of entertainment. Also, Saudi women use the internet for business purposes, because it is considered more suitable for the female nature, and it prevents them from working with men (LahaOnline, 2004). However, the present findings conflict with results of the Uitto et al. (2006), who found no clear gender differences in use of computers.

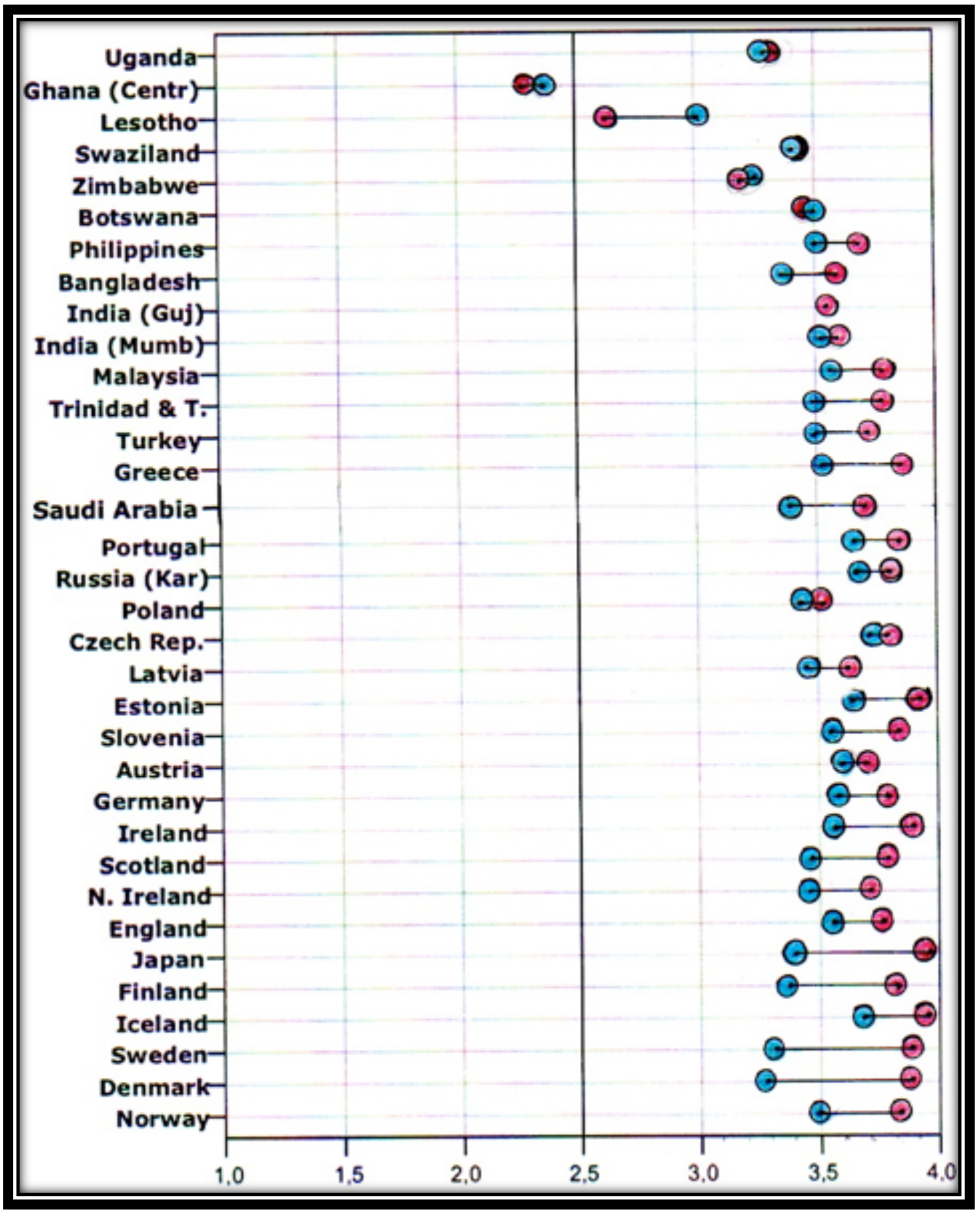
### 6.2.4. A comparison of Saudi Students' Out-of-School Activities with Students in Other Countries

This section will compare the experience of Saudi students outside school with those reported by their peers in other countries, focusing on five of the ten most common items and five of the ten least common items of students' experience. The most common activities are shown in Figures 6.1 to 6.5 and the least common in Figures 6.6 to 6.10. The findings are discussed and interpreted in section 6.2.4.2.

### 6.2.4.1 Results

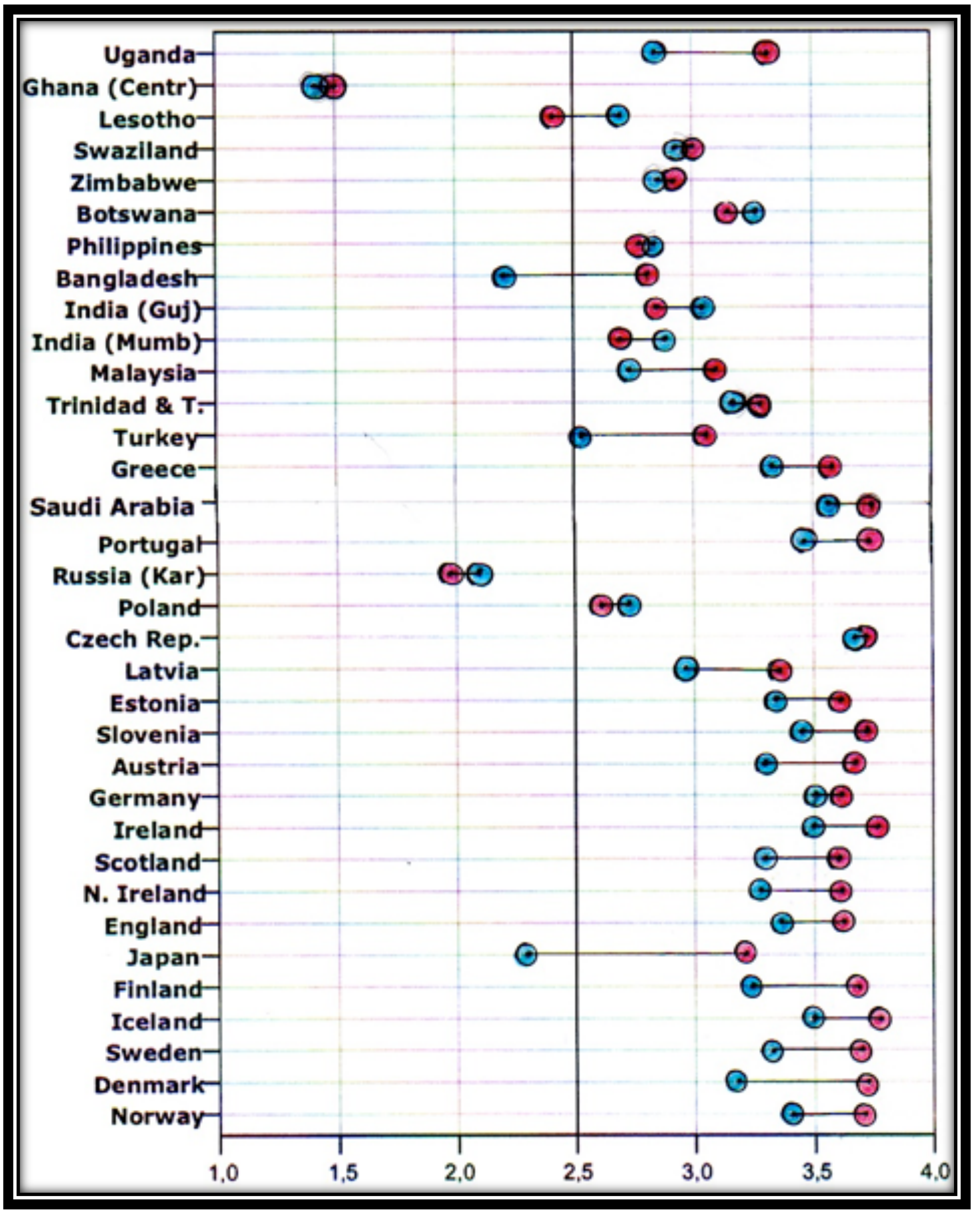
Notice (Red indicates the response of girls, blue the response of boys).

Figure 6-1 The mean of item H31: Used camera



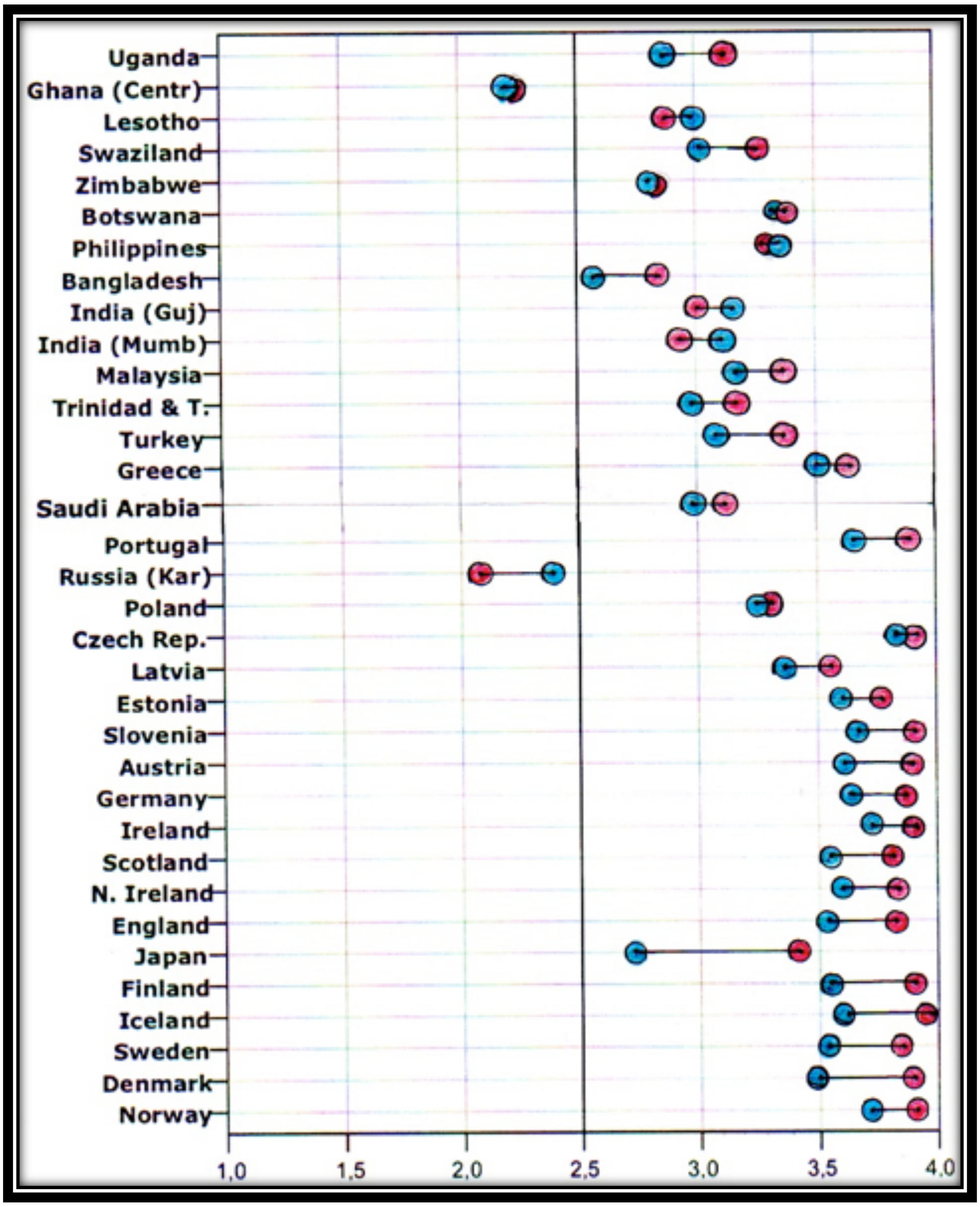

Although most of the students had used a camera as one of their outside school experiences, Ghanaian students had not, as shown in Figure 6- 1. Also, it is noteworthy that girls had used a camera more than boys in most countries, including Saudi Arabia. Also, the gender differences in developed countries and Saudi Arabia were small for girls.

Figure 6-2 The mean of item H44: Used a mobile phone



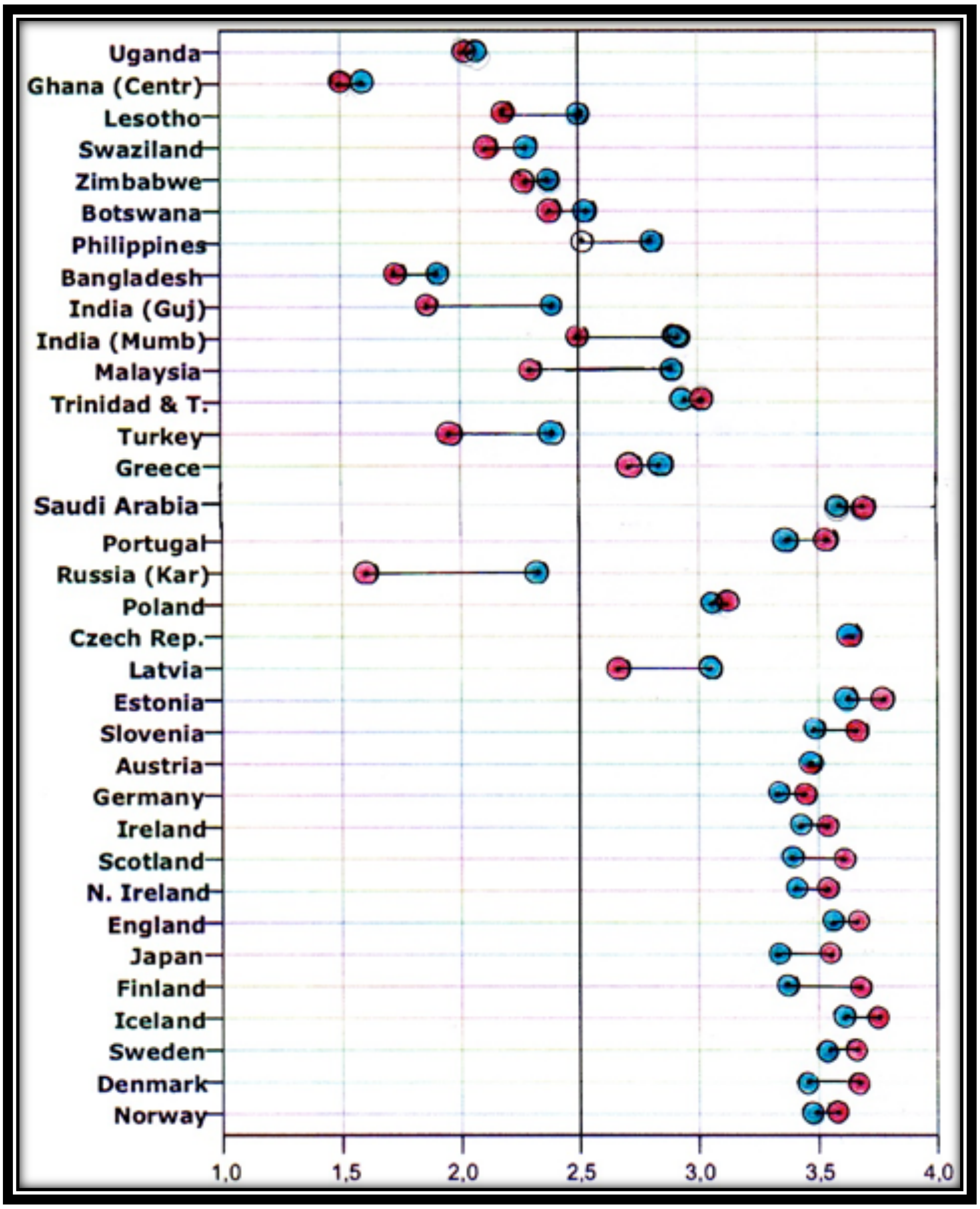

The data in Figure 6-2 clearly show mobile usage is high in both developed countries and Saudi Arabia, but when referring to the trend in developing countries, the usage of mobile phones is lower. Students from Russia and Ghana expressed particularly low use of mobile phones. It appears from the figures that male students from Japan and Bangladesh used mobile phones less than girls, with a mean value less than 2.50, whereas girls in Lesotho used mobile phones less than boys. However, it is worth noting that girls' use of mobile phones was higher than that of boys in most countries.

Figure 6-3 The mean of item H45: Sent or received an SMS



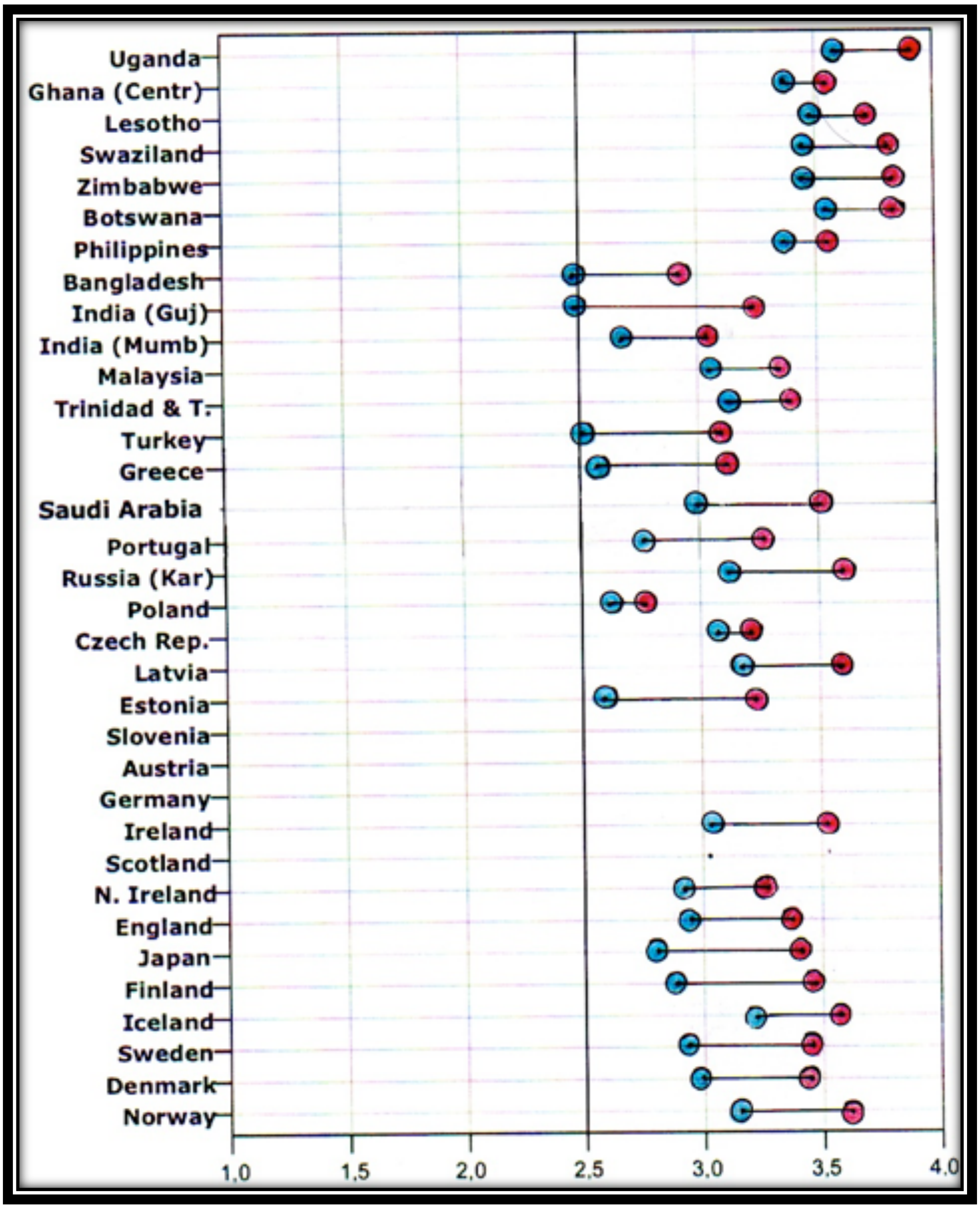

In Figure 6-3, item H45 'sent or received an SMS (text message on mobile phone)' shows a similar pattern to the previous item H44, 'used a mobile phone'. It shows that mobile phone users in developed countries sent or received an SMS more than those in developing countries. It also shows that girls, including Saudi students, did this more often than boys. Also, students in Russia and Ghana did not engage in text messaging as much as students of the other countries, with the mean values under 2.50.

Figure 6-4 The mean of item H46: Searched the internet for information



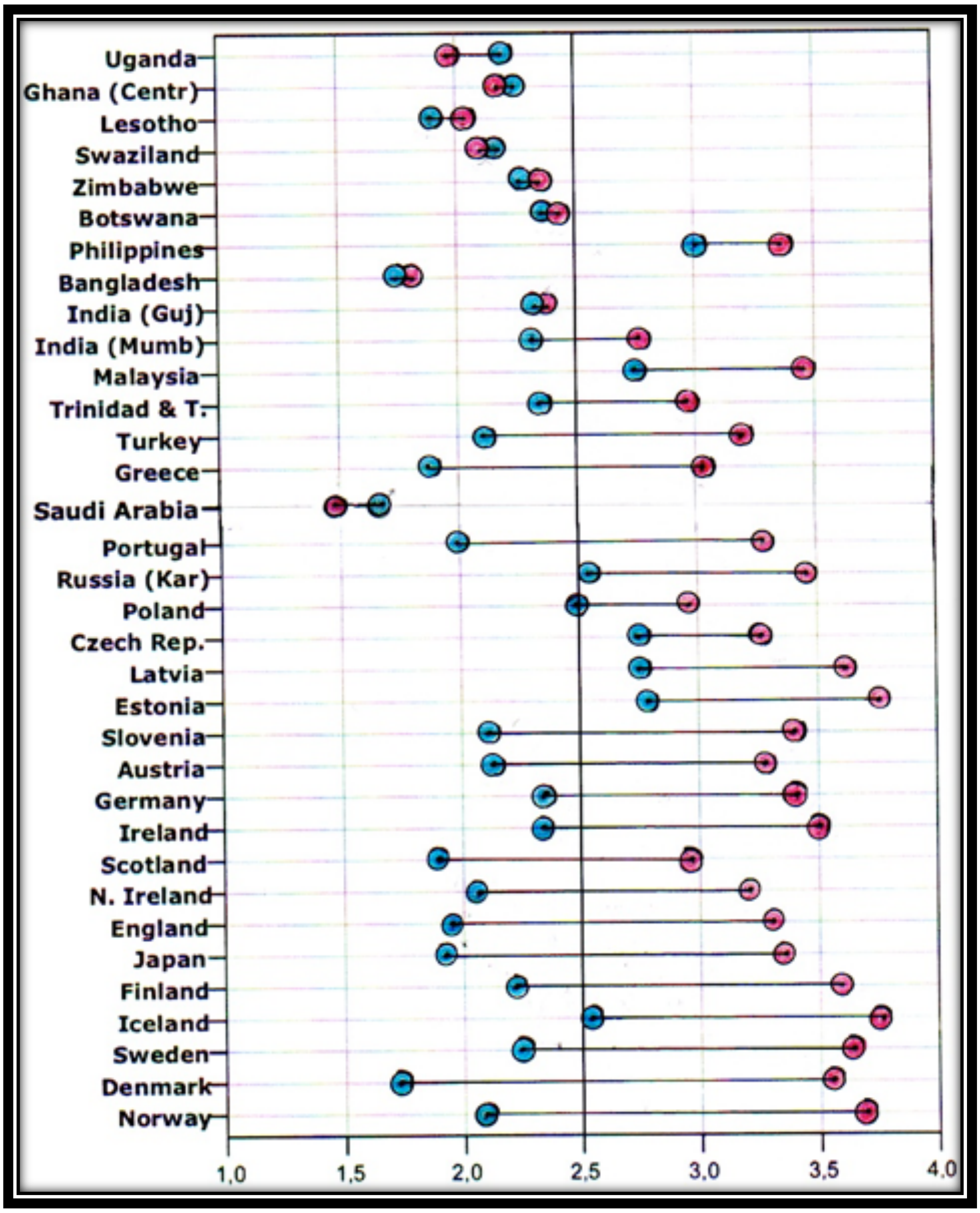

Data in Figure 6-4 show the answers of students to item H46, 'searched the Internet for information' revealing that the students in developed countries, as well as Saudi students, had frequent experiences of using the Internet to find information. In contrast, among developing countries' students, there was diversity in experience in searching the Internet, with some having much and others, none. It should also be mentioned that for some developed countries, as well as Saudi Arabia, these data showed no significant gender differences, although girls in developed countries had more experience than boys, but in developing countries such as in African and Asian countries, boys had more experience than girls.

Figure 6-5 The mean of item H54: Cooked a meal



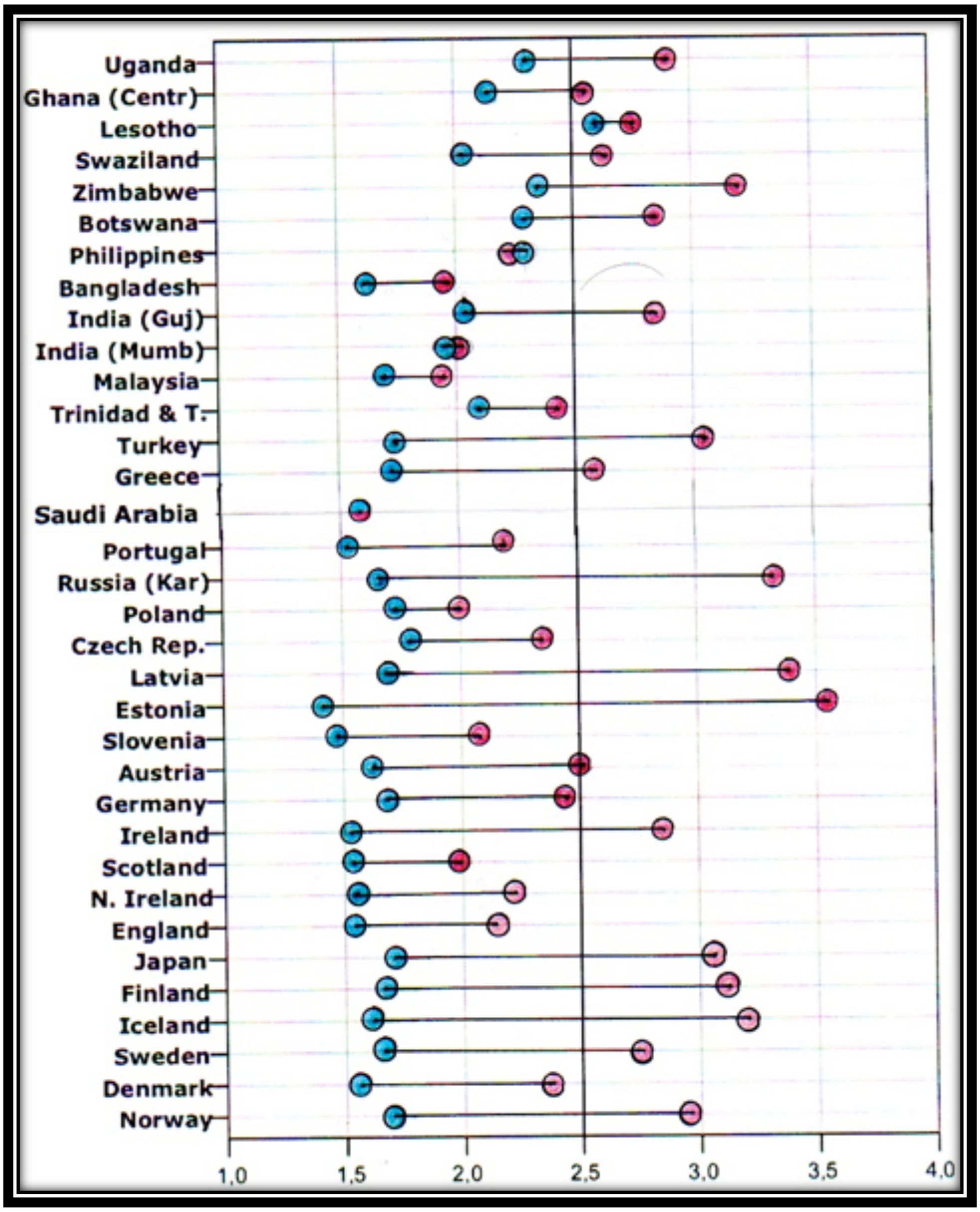

Many students, as shown by their responses to item H54,' cooked a meal' as Figure 6-5 shows, had frequently participated in cooking meals. However, students in developing countries, especially African countries, had greater experience than those in other countries. Also, this item clarifies the involvement of girls in cooking, as they had more experience than boys in all participating countries, which suggests that in their nations' cultures, cooking is a job for women, so the gender differences would clearly be in favour of girls.

Figure 6-6 The mean of item H2: Read my horoscope



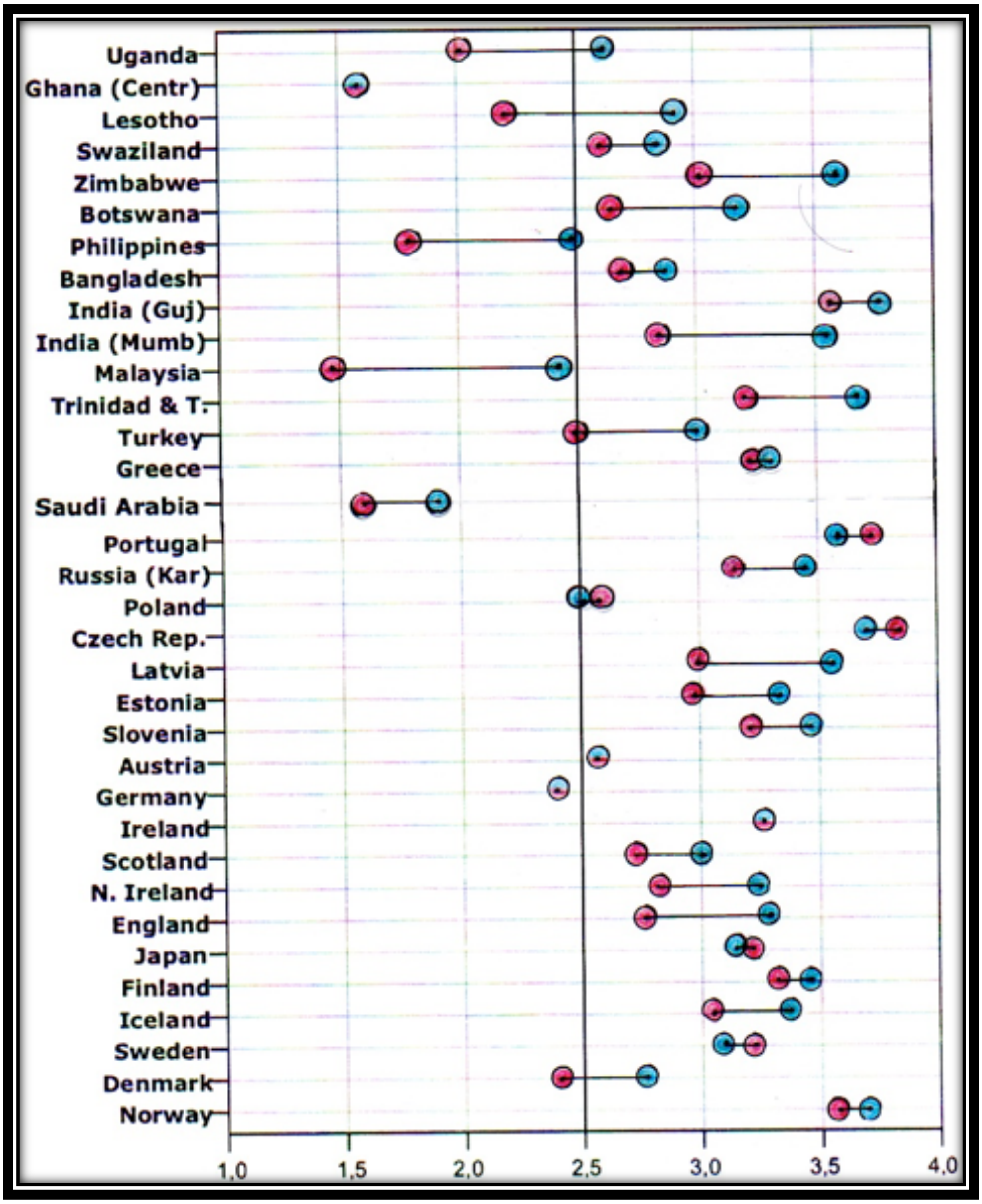

The results of students' responses to item H2, 'read my horoscope (telling the future from the stars)' show the disparity in gender experience in developed countries and some developing countries. In most countries, girls had greater experience outside school in reading their horoscope than boys, for whom in some countries, that item had a mean value less than 2.5. However, according to the figure, there was no gender difference in developing countries in Africa, Bangladesh or the Philippines. Saudi students, irrespective of gender, has less experience of this activity than those in all other participating countries.

Figure 6-7 The mean of item H20: Knitted, weaved, etc




In general, and as shown in Figure 6-7, the dominance of girls in knitting and weaving activities is very strong in almost all countries. This means that girls had greater experience than boys in H20 in most countries. However, Figure 6-7 shows that the Saudi students had very little experience in this activity, and there was no difference between girls and boys, as the mean value for both boys and girls was 1.63.

Figure 6-8 The mean of item H30: Used binoculars




The students' experience of item H30, 'used binoculars' in participating countries differed widely. Some reported frequent experience with using binoculars and others had low experience. Some students had very little experience, such as Saudi, Filipino and Ghanaian students. It is clear that boys had more experience in using binoculars than girls in most countries. Also, the gender differences in some developing countries such as Malaysia, and India as well as Saudi Arabia, were clearer than in developed countries.

Figure 6-9 The mean of item H18: Made compost of grass, leaves or garbage

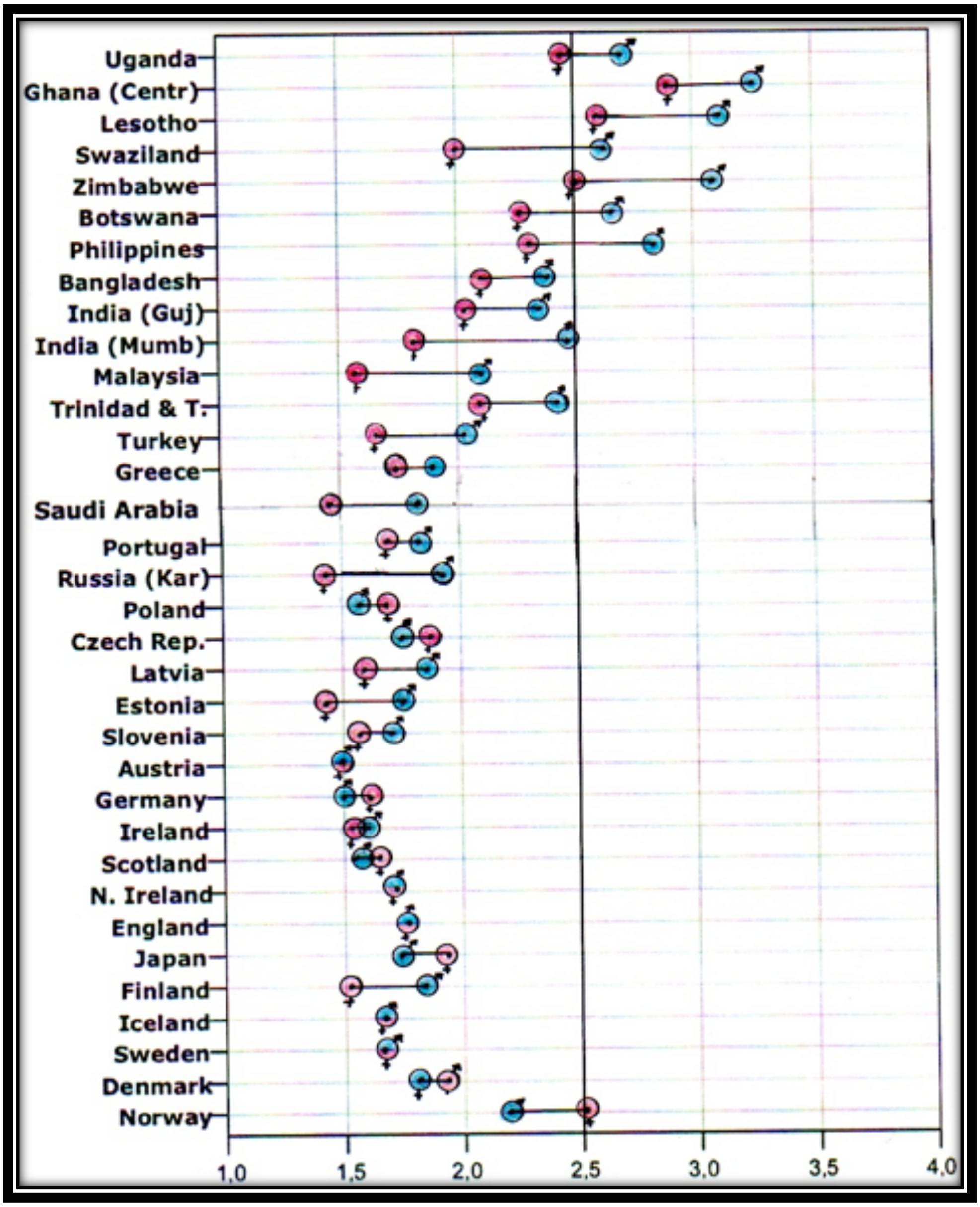
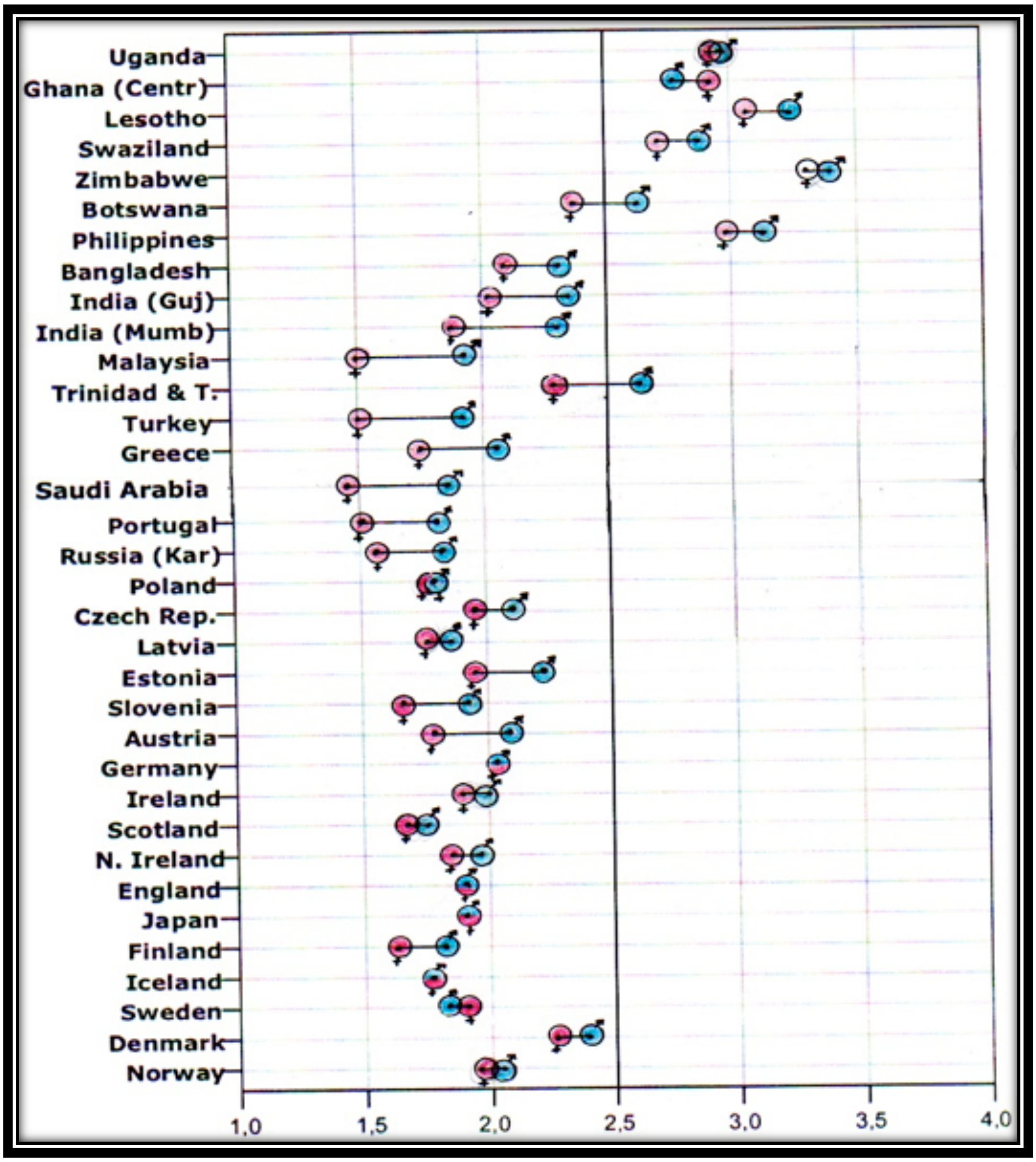


Figure 6-10 The mean of item H19: Made an instrument (like a flute or drum) from natural materials




Items H18, 'made compost of grass, leaves or garbage' and H19, 'made an instrument (like a flute or drum) from natural materials' will be discussed together because of the similarity in students' responses to these items. The relationship between the development of a society and the weakness of experience in these two items is noticeable, as indicated by the fact that in less developed societies, students reported more experience of these activities. However, the gender differences were less in developed countries, while in developing countries there were differences for both items, as shown in Figures 6-9 and 6-10. For item H18, the gender differences are less than those for H19. Also, the experience of Saudi students in items H18 and H19 was very low, and the gender differences were small, but boys had more experience than girls for both items.

#### 6.2.4.2 Discussion

Many educationalists argue that students' understanding of science could be improved if teachers link what is being taught in the classroom with the students' personal, practical experiences and their environment (Darling-Hammond, Flook, Cook-Harvey, Barron, & Osher, 2020). Thus, teachers could benefit from learning about the out of school experiences of their students and apply their insights in their practice (Anderson, 2006).

It is clear that in this study, Saudi students recorded more experience outside school in the area of technology, which was matched by the experience of students in developed countries such as and some of the developing countries such as Trinidad & Tobago. In other words, they used technology in their daily life more than their peers in developing countries. According to (Sjøberg, 2002c). there is a clear and significant difference between students in rich countries and students in poorer countries, in terms of their technological activities. These results were expected, due to technology being too expensive for most children in poorer countries to possess. According to Sjøberg's study, Saudi Arabia is a wealthy country, so it is common for students to be engaged in technology and practise related activities outside school, which matches the current study's result. 'Out of School Experiences', a study by Korkmaz et al. (2017a), found that, when compared to Turkish students, American students were more likely to be interested in physics and biology activities, and to become engrossed in technology experiences in their out of school free time. The students' experiences out of school differed depending on their socio-economic status, family, cultural, and ethnic origins (Korkmaz et al., 2017). In this context, it can be said that the students in developed countries have more technology in their environment outside school compared to those in the developing countries, especially poor countries. Moreover, girls use technological devices such as mobile phones more frequently than boys in most countries. Girls seem to use computers and the Internet more specifically for communication and social networking (Ofcom, 2015). A possible explanation might be that social media is the source of news and communication with friends and family;

another reason is to help with studying and find information (Badri et al., 2017). It is also an advertising platform for small and medium business owners (Badri et al., 2017; LahaOnline, 2004). In the Arab countries such as Saudi where there are restrictions imposed on women, especially at work or leaving the house, they particularly rely on social networking for their own business or communicating with friends.

Also, according to ROSE and the current research results, cooking a meal seems to be an activity dominated by girls in all countries, and the gender difference seems to be almost the same in all countries. In addition, there is not a strong divide between students in developed and developing countries. Gender-stereotypic images are apparent in this type of experience in all countries. When it comes to cooking and working with tools, there are indications that, as development levels increased, so did the differences between the sexes. This suggests that girls and boys in developed societies continue to choose tasks according to gender stereotypes. Girls and boys in developed countries are in theory free to choose to perform any task, and are guaranteed gender equity by law; nevertheless, they continue to follow established patterns of gender stereotyping in their choices (Sjøberg & Schreiner, 2019). Perhaps gender stereotypes in the media have an influence on girls' and boys' activities. "Research in the area of media, psychology and communication studies has suggested that television programs and movies can contribute to children's gender-role learning in terms of their perceptions of gender-typical occupations" (Wille et al., 2018, p. 4). As a result, 'Cuisine and Handicraft' activities remain mainly the preserve of females, while 'Manual Work' tends to attract the participation of boys (Christidou, 2006). In Muslim societies such as Saudi Arabia, Malaysia and Turkey, the role of the man is to engage in the outside world and be productive, protecting and financially supporting the family, while the woman has a complementary role within the home, where she is responsible for bringing up the children and being a wife (Kim, Rou, & Kim, 2019).

The infrequent experience of Saudi students outside school in activities such as 'read my horoscope (telling the future from the stars)' matched the experience of some students in developing countries (especially Africa) and boys' experience, more than girls', in developed countries. As mentioned before, Islam prohibits astrology and Saudi students rarely practise it out of school. This is an example of how cultures play a key role in shaping how students view science and science-associated subjects. For example, in Botswana in Africa, traditional beliefs in omens, witchcraft, taboos etc, result in students having a negative perception of science (Kesamang & Taiwo, 2002) since it conflicts with their long-established socio-cultural belief systems. This explains the African students' attitude toward horoscopes. In this respect, the role of religion and culture can be observed in the results of the ROSE project and the current research.

When comparing the 'read my horoscope (telling the future from the stars)' activities of Saudi students with other Muslim students such as Turkish and Malaysian students, there is a difference between Saudi, Turkish and Malaysian students. It seems that the reason for the difference could be the religious preaching in Saudi schools, which is not found in Turkish and Malaysian schools. The preaching discourse is one of the most important discourses affecting cultural formation in Saudi Arabia, as it is ingrained in the Saudi school curriculum. Its purpose is to build aspiration towards Heaven, warn against Hellfire, or increase faith in God. Many preachers do not accept scientific facts until they have researched the Islamic heritage in order to search for a link between the claimed fact and an Islamic source, such as a Quranic verse, hadith or aphorism (Alsyf, 2011).

Despite the difference in the activities of girls between countries, girls' dominance in knitting and weaving activities is very strong in almost all countries. It is interesting in this study, however, that Saudi students (especially girls) did not have experience in sewing. This result was not expected, because schools in Saudi teach girls, not boys, sewing, which is considered a girl's activity. A possible explanation may be that, due to the country's economic prosperity, there are housemaids in many Saudi households, who perform household responsibilities and chores, so students rely on housemaids to complete their daily tasks. Income could also affect the practice of such activities as weaving or knitting. On the one hand, lower income may render making and mending clothing and textiles a necessity; on the other, it may make the materials for these activities unaffordable. Also, these are now in many societies quite 'old-fashioned' activities, which are less practised now, generally. A possible reason could be the decline in the use of natural fibres in favour of synthetics and 'fast fashion'. Also, in some societies, such activities are more associated with old people. Therefore, these reasons may contribute to the reluctance of young people to engage in these activities.

There are differences in the out-of-school experiences of boys and girls. Jenkins (2006) noted that girls undertake activities with links to the natural world, such as planting, or crafts such as weaving or knitting. Boys tend to be assigned mechanical tasks, although girls are allowed to use simple hand tools (Jenkins, 2006). Students' activity outside school differs depending on the family, cultural, socio economic status, and ethnic origins, which confirms the gendered socialisation theory that gender roles are learned through social institutions, such as family, government, economy, education and religion (Hoso, 2009). In this context, it can be said that there are similar experiences in knitting and weaving in almost all cultures. Although the girls in this study reported they had domestic-oriented experiences (cleaned and bandaged a wound, making bread) they also reported having not done much hand work (knitting, weaving, sewing). This may reflect the impact of the family, or their economic situation, on the participating girls, which resulted in them not knitting.

As indicated previously, the Saudi students' out of school activities also reflected their ban environmental; for example, the lack of access to activities like making compost of grass and leaves or making an instrument from natural materials. The Saudi students' situation agrees with that of students from developed countries, and some developing countries, but differs from that of students from Africa. To understand the disparity in situation among students in developing and developed countries, Sjøberg and Schreiner (2019) mention that in developing countries, outdoor activities are more necessary chores that have to be done, unlike in developed countries, where they are done more for pleasure. The urban environment may explain why the Saudi students had little experience of using binoculars, compared to students from most other counties. In Saudi Arabia, people often use binoculars when hunting, which would be more relevant in rural areas. Overall the finding's support Sjøberg and Schreiner (2019) claim that a range of factors, including gender, nationality, culture and the environment ( urban or rural) impact on out of school experiences, and hence in the relationship students have with science and science education.

## 6.3. **Summary**

In this chapter, the second research question was answered through analysing and discussing the data collected from participants. This chapter investigated students' science-related activities and experiences outside school. The results showed that Saudi students' outside school experiences were similar for both boys and girls. They both had experience of cooking and technology, which were among the ten most frequent activities, but had little experience of activities related to nature. Religious factors affected some Saudi students' activities out of school. Moreover, Saudi culture impacted on students' activities, as there were some gender differences in a number of experiences that appear to be related to gender stereotypes, including boys having more experience than girls in activities such as repairing light bulbs or valves. Despite the rich experience of both boys and girls with digital applications, there was a clear difference between them, in that girls were more experienced in that area, perhaps because they had fewer other activities open to them. Also, in this chapter, the research results were compared with results from other countries. The activities of Saudi students are similar to those of some students from developing countries such as Turkey and Malaysia, and students from developed countries such as England and Norway in some items such as 'used camera', 'sent or received an SMS'. On the other hand, the experiences of Saudi students contrasted with some developing countries such as Zimbabwe and India, and some developed countries such as Finland and Sweden, in some items such as 'used binoculars'.

Saudi students' interests and experiences should be taken into consideration when deciding on the curriculum and creating schoolbooks. If there is no attempt to create a connection between science teaching and learning and the students' values and interests, this could lead to a negative view of science, both in the short and long term. Ultimately this negative reaction could carry over from school days and result in the rejection of science in adulthood.

The following chapter will analyse and discuss the Saudi students' responses, in the interest of answering the third research question about their opinion of science.

# Chapter 7: Answering the Research Question Three

**What are the Saudi students' responses to science and technology?**

## 7.1. Introduction

In this chapter, the opinions of young Saudi students on the importance of the value of science in their daily lives, as well as the broader value of science education. This involves analysing and discussing both quantitative and qualitative data. The ROSE questionnaire was used to collect quantitative data; specifically, Section G of the questionnaire, where students responded on a four-point Likert scale (Disagree, Low Disagree, Low Agree, Agree) to a series of statements about 'My opinions about science and technology'.

Quantitative data were collected via focus group interviews using a diamond-ranking technique that encouraged young students to provide their opinions in response to the question, **'**Why is it important to study science at school?' Thirty-one students participated. Boys and girls participated in separate groups; there were 14 boys and 17 girls in total, and each group contained at least four participants. These groups were coded depending on school name, group gender and group order.

In the diamond ranking activity, students were asked to rank nine statements reflecting reasons for the importance of teaching and studying science and technology subjects. The statements were:

To introduce young people to the excitement of science.

To provide a unique contribution to a balanced education, reflecting the fact that science is a major cultural achievement.

To introduce young people to the important facts and theories of science.

To help prepare young people for life in an advanced technological society.

To develop practical skills.

To help with understanding and decision-making in everyday situations.

To help young people make some sense of topical science-related issues reported in the media.

To help young people become aware of the jobs scientists do.

To help meet the country's need for well-qualified scientists.

Students were asked to rank these statements, which were printed on cards, in a diamond shape, with the most important statement at the top, followed by the next two most important, then the next three most important, and so on, until the single least important idea was placed at the bottom of the diamond.

In this chapter, participants' responses to section G of the ROSE instrument are presented, then their perceptions are analysed and discussed by linking them with the students' comments on the diamond-ranking statements in order to support the ROSE results or to understand their answers in the ROSE questionnaire. Gender differences of opinion are also investigated, and participants' opinions on science and technology are compared with the views of their peers in other countries.

## 7.2. My Opinions about Science and Technology

Students reportedly believed that science and technology will provide greater opportunities for future generations and that they make human lives healthier, easier and more comfortable (Najafi, Ebrahimitabass, Dehghani, & Rezaei, 2012). Science education serves as a gateway that allows people to understand phenomena, which eventually helps in improving scientific literacy, thereby leading to future generations attaining the means to have better lives (Korkmaz et al., 2017a). Therefore, several studies have investigated science education and its role in society.

In this section, Saudi students' perception of the role and function of science and technology in society are investigated, based on the 16 statements in section G of the ROSE questionnaire.

### 7.2.1. Results

The Saudi female students' answers to section G of the ROSE questionnaire and the mean values of the 16 items about science and technology are given in the following table.

Table 7-1 Girls' responses about science and technology

| N | Items | Frequency | | | | | | | | Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Disagree | | Low disagree | | Low agree | | Agree | | |
| | | Count | % | Count | % | Count | % | Count | % | |
| 1. | G2. Science and technology will find cures to diseases such as HIV/AIDS, cancer, etc. | 1 | 0.3 | 20 | 6.9 | 113 | 39.2 | 151 | 52.4 | 3.46 |
| 2. | G1. Science and technology are important for society | 3 | 1.0 | 26 | 9.0 | 123 | 42.7 | 133 | 46.2 | 3.36 |
| 3. | G11. A country needs science and technology to become develop | 4 | 1.4 | 36 | 12.5 | 116 | 40.3 | 125 | 43.4 | 3.30 |
| 4. | G3. Thanks to science and technology, there will be greater opportunities for future generations | 8 | 2.8 | 28 | 9.7 | 127 | 44.1 | 119 | 41.3 | 3.28 |
| 5. | G12. Science and technology benefit mainly the developed countries | 11 | 3.8 | 38 | 13.2 | 100 | 34.7 | 132 | 45.8 | 3.26 |
| 6. | G5. New technologies will make work more interesting | 8 | 2.8 | 40 | 13.9 | 117 | 40.6 | 118 | 41.0 | 3.23 |
| 7. | G4. Science and technology make our lives healthier, easier and more comfortable | 8 | 2.8 | 40 | 13.9 | 117 | 40.6 | 118 | 41.0 | 3.22 |
| 8. | G16. Scientific theories develop and change all the time | 10 | 3.5 | 37 | 12.8 | 120 | 41.7 | 116 | 40.3 | 3.21 |
| 9. | G6. The benefits of science are greater than the harmful effects it could have | 14 | 4.9 | 55 | 19.1 | 131 | 45.5 | 79 | 27.4 | 2.99 |
| 10. | G13. Scientists follow the scientific method that always leads them to correct answers | 13 | 4.5 | 75 | 26.0 | 120 | 41.7 | 73 | 25.3 | 2.90 |
| 11. | G7. Science and technology will help to eradicate poverty and famine in the world | 34 | 11.8 | 100 | 34.7 | 94 | 32.6 | 53 | 18.4 | 2.61 |
| 12. | G8. Science and technology can solve nearly all problems | 46 | 16.0 | 110 | 38.2 | 101 | 35.1 | 25 | 8.7 | 2.36 |
| 13. | G15. Scientists are neutral and objective | 27 | 9.4 | 140 | 48.6 | 85 | 29.5 | 22 | 7.6 | 2.37 |
| 14. | G9. Science and technology are helping the poor | 53 | 18.4 | 118 | 41.0 | 74 | 25.7 | 35 | 12.2 | 2.32 |
| 15. | G10. Science and technology are the cause of the environmental problems | 45 | 15.6 | 142 | 49.3 | 70 | 24.3 | 24 | 8.3 | 2.25 |
| 16. | G14. We should always trust what scientists have to say | 67 | 23.3 | 152 | 52.8 | 47 | 16.3 | 18 | 6.3 | 2.06 |

Table 7-1 shows the optimistic views of girls about studying science and technology and also their interest in finding cures for diseases such as HIV/AIDS and cancer (item G2), with a mean value of 3.45. The students believed that science is important (item G1), giving this item a mean value of 3.35. They agreed that developments in science and technology are creating more opportunities for the coming generations (item G3) with a mean value of 3.37. It was also agreed that science can make life better, simpler and healthier (item G4) and future developments will make work more interesting (item G5) with a mean of 3.23. However, they were not convinced that the benefits of science are greater than its harmful effects (item G6), which scored a mean value of 2.99. Science was not perceived as the cause of all environmental problems by most of the girls (item G10), and some agreed that science may be helpful for the poor (item G9) and that solutions to most problems will be found using science (item G8), giving mean scores of 2.33 and 2.37, respectively. There was much disagreement on the objectivity of scientific methods and the extent to which scientists can be trusted in the responses to items G14 and G15, which had means of 2.06 and 2.37 respectively. However, there was agreement on the idea that scientific theories change over time (item G16).

Table 7-2 Boys' responses about science and technology

| N | Items | Frequency | | | | | | | | Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Disagree | | Low disagree | | Low agree | | Agree | | |
| | | Count | % | Count | % | Count | % | Count | % | |
| 1. | G1. Science and technology are important for society | 7 | 2.2 | 33 | 10.2 | 102 | 31.7 | 173 | 53.7 | 3.40 |
| 2. | G2. Science and technology will find cures to diseases such as HIV/AIDS, cancer, etc. | 12 | 3.7 | 31 | 9.6 | 126 | 39.1 | 143 | 44.4 | 3.28 |
| 3. | G11. A country needs science and technology to become develop | 20 | 6.2 | 40 | 12.4 | 100 | 31.1 | 152 | 47.2 | 3.23 |
| 4. | G12. Science and technology benefit mainly the developed countries | 14 | 4.3 | 48 | 14.9 | 104 | 32.3 | 141 | 43.8 | 3.21 |
| 5. | G3. Thanks to science and technology, there will be greater opportunities for future generations | 14 | 4.3 | 47 | 14.6 | 113 | 35.1 | 139 | 43.2 | 3.20 |
| 6. | G5. New technologies will make work more interesting | 9 | 2.8 | 56 | 17.4 | 118 | 36.6 | 128 | 39.8 | 3.17 |
| 7. | G4. Science and technology make our lives healthier, easier and more comfortable | 16 | 5.0 | 55 | 17.1 | 110 | 34.2 | 132 | 41.0 | 3.14 |
| 8. | G16. Scientific theories develop and change all the time | 20 | 6.2 | 58 | 18.0 | 134 | 41.6 | 96 | 29.8 | 2.99 |
| 9. | G13. Scientists follow the scientific method that always leads them to correct answers | 16 | 5.0 | 82 | 25.5 | 132 | 41.0 | 77 | 23.9 | 2.88 |
| 10. | G6. The benefits of science are greater than the harmful effects it could have | 25 | 7.8 | 74 | 23.0 | 131 | 40.7 | 81 | 25.2 | 2.86 |
| 11. | G7. Science and technology will help to eradicate poverty and famine in the world | 36 | 11.2 | 97 | 30.1 | 102 | 31.7 | 77 | 23.9 | 2.71 |
| 12. | G10. Science and technology are the cause of the environmental problems | 40 | 12.4 | 127 | 39.4 | 94 | 29.2 | 48 | 14.9 | 2.49 |
| 13. | G9. Science and technology are helping the poor | 61 | 18.9 | 109 | 33.9 | 85 | 26.4 | 55 | 17.1 | 2.43 |
| 14. | G8. Science and technology can solve nearly all problems | 58 | 18.0 | 119 | 37.0 | 83 | 25.8 | 52 | 16.1 | 2.41 |
| 15. | G15. Scientists are neutral and objective | 46 | 14.3 | 134 | 41.6 | 95 | 29.5 | 31 | 9.6 | 2.36 |
| 16. | G14. We should always trust what scientists have to say | 68 | 21.1 | 129 | 40.1 | 75 | 23.3 | 40 | 12.4 | 2.28 |

Table 7-2 depicts male students' mean scores for their opinions regarding science and technology. Generally, the responses to the issues concerning science and technology in society appeared to indicate a widespread respect for science and technology issues. The response scores had high values (greater than 2.5) for 11 of the items in a 4-point Likert-type scale. Item G1 (Science and technology are important for society) had the highest mean value at 3.40. Also, students agreed with item G2 (Science and technology will find cures to diseases such as HIV/AIDS, cancer, etc.), as its mean value was 3.28. Conversely, some items had mean values less than 2.5. These were G9, G8, G15 and G14.

## 7.2.2. Analysis and Discussion

The statistical analysis of student responses demonstrated clearly that most responses were close for both genders in both order of priority and mean values. Tables 7-1 and 7-2 both display a number of positive indicators concerning young Saudi students' opinions toward science and technology. Moreover, the results appeared to show that Saudi students were conscious of the importance of science and technology. In that regard, Groups A-G-1 and D-G indicated that science

"Helps life to understand difficult things" (A-G-1).

and that

"Scientific subjects help with medicine and manufacturing." (D-G).

The analysis and discussion in this section will be divided into three parts. The first presents items with a mean value over 2.99, the second contains items with mean value below 2.99 and over 2.50, and the third items with a mean value below 2.50. The items in each part are organised in the order of the ROSE questionnaire. Moreover, the item statements will be considered as titles. For example, item G1 will be analysed and discussed alone, with links to the related diamond ranking statements and respondents' quotations from their focus group discussions.

### 7.2.2.1 Items with mean value over 2.99

In this section, the most agreed upon items amongst participants will be discussed. In these items most students chose 'agree' and 'low agree'. The items which will be discussed are G1, G2, G3, G4, G5, G11, G12 and G16, which have means of over 2.99.

1. **G 1 'Science and technology are important for society'**

Tables 7-1 and 7-2 show that more than 80% of the students responded to Item G1 with either 'Agree' or 'Low agree'. The mean values revealed that science and technology were regarded as important by both male and female Saudi students. Statement G1 was ranked in first place for boys and second place for girls, with mean values of 3.35 and 3.40 for girls and boys respectively, showing no statistically significant difference. The reason for the students' great interest in science and technology was their belief in the importance of science and technology in helping people to address the issues and problems they face in everyday living. A number of participants also explained why their belief in the importance of science and technology to society in their discussions about the diamond ranking statement,

1.1. 'To help prepare young people for life in an advanced technological society'.

The participants identified the statement as important and as one of the main reasons for teaching science in schools. Six groups of participants placed the statement second in priority in their ranking of statements, for various reasons, including the following:

*1.1.1. Future of technology*

Technology has become an essential part of everyday life. Consequently, students expected many new technologies eventually to be incorporated into daily life in the future, creating a need for improved understanding of science and technology through continuous learning. Thus, Groups F-G-1, F-B-1 and D-G-1 ranked the statement, '*To help prepare young people for life in an advanced technological society*' as the second most important. Examples of comments made by the various groups of students included:

> "We are heading towards a technological society, so we need to prepare young people to adapt them to it." (F-B-1).

> "Young people are more important because they create the future." (D-G-1).

*1.1.2. Self-help*

Science and Technology are important for society, from participants' perspectives, because they enable individual self-help. Technology makes life easier, enabling people to perform various services themselves without the help of others. Group E-G-2 reflected this view in the statement:

> "So that you will be able to work on anything without anyone's help, so that I will know everything and would be informed about a lot of things and I would have a lot of information."

Saudi Arabia is a rich country (Grant, 2019), so most people possess technological items such as cars, washing machines, computers and mobile phones (Communications and Information Technology Commission, 2008). Thus, Group F-B-1 suggested that the prevalence of technology made it a crucial issue in education: According to one student.

> "I feel like it is important because everything we use is technology."

From their statements, it was clear that the participants had positive attitudes toward science and technology. It is likely that the interest in science is related to the perceived relevance to everyday life. It can be said that the more the topic is related to the students' lives, the more they believe in its importance. So, students in this study believed science and technology play a role in society and they also perceived that science and technology have helped society, making life easier. Moreover, they believed that a country that is unable to thrive will not be able to sustain life and may have to rely on other countries for basic requirements. As their expressions referred to the significance of science and technology to societies; these results were in agreement with previous studies that used the ROSE questionnaire (Amri, 2012; Najafi et al., 2012; Sjøberg & Schreiner, 2010).

2. **G2. 'Science and technology will find cures to diseases such as HIV/AIDS, cancer, etc.'**

Participants were optimistic that science and technology will improve the treatment of serious diseases such as HIV / AIDS and cancer. The two tables show optimism according to the mean value of the item regarding the importance of scientific and technological progress in the treatment of diseases, which was 3.45 for female students and 3.28 for males. Although both mean values are high, there are statistically significant differences in favour of girls. These scores reflect students' belief that, because of many new discoveries and research in medical science, scientists may be able to discover the best methods of treatment for diseases that were once thought of as incurable.

In the discussion after they performed the diamond- ranking activity, students provided several reasons to explain why they believed that science was crucial in the progress achieved by mankind. An important aspect of science and technology that participants repeatedly mentioned in these discussions was that science and technology made human lives healthier because of the development in medicine supported by scientific research and advances in technology. Despite the high number of cancer patients in Saudi Arabia, students believed that science is able to find cures for this disease. It is likely that advanced medicine that students view in real life would enhance their belief in the role of science and technology in finding cures for diseases. One of the reasons given for ranking the statement at a high level is because science has a major role in treating diseases. This rationale also featured in explanations regarding the next statement.

1.1. To help meet the country's need for well-qualified scientists

Nine of the 31 group members ranked this statement as their top reason for supporting the importance of science and technology subjects. As disease can be a critical issue for countries, it was suggested that the only way to avoid it is by encouraging scientific development. For example, Groups A-G-1 and A-B-1 believed that;

> "There is a need to develop the country first, to be able to develop young people and help with curing diseases" (A-G-1).

2.1. To develop practical skills.

This statement was ranked third in importance, and four groups placed the statement at the top. They justified their choice for various reasons. Among these reasons, they mentioned that treating diseases required developing scientific skills.

Groups H-B-1 and G-G-2 agreed with Group B-B-1 in explaining the importance of science in education, stating that countries can treat diseases by developing their scientific skills. Comments made by students included the following:

> "Like, if you have skills you have to improve them more to benefit other people." (H-B-1).

> "The most important I think is the illnesses and things like that that we can't cure, the progression of scientific skills; for example, like, the cancer disease could be cured by science." (G-G-2).

1.2. To help with understanding and decision-making in everyday situations.

Although some of the groups ranked this statement as the most important reason for teaching science and technology in schools, there were two groups who ranked the statement at the second level. They compared science to other subjects and found it to be more linked to the real world. Participants mentioned the role of science in improving their knowledge about many diseases and also its contribution in discovering the appropriate medicine to treat diseases. Their statements included the following:

> "Scientific subjects brought to us things from real life. for example, how a light works and how chronic diseases affect humans" (G-G-1).

> "The natural science, for example, medicine brings out things that we benefit from more" (C-G-1 and C-G-2).

In this study, students expressed the belief that science and technology have profoundly altered human lifestyles and activities in both the home and work environments. Science has also influenced health, as scientific advancements are central to both the diagnosis and treatment of many conditions that threaten life. Indeed, the knowledge acquired by science about the function and mechanisms that operate in diverse living organisms, means that diseases that were once considered a death sentence are now preventable or treatable. These findings support Bennett's (2008) study in the UK, in which two-thirds of the ninth-year students surveyed agreed that science has had a positive impact on society, mainly because of the medical progress science has made. Medical advances have a high profile in the media so students may be more aware of them than of some other benefits of science.

Saudi students' responses and expressions revealed that they were similar to their peers from other countries who participated in similar studies and who also believed that science and technology had a significant role in the discovery and development of treatments for diseases such as HIV / AIDS, cancer, and other diseases (Najafi et al., 2012; Sjøberg & Schreiner, 2010). In their responses to the ROSE questionnaire, students in England displayed positive attitudes toward science and technology. There was also a clear agreement and optimism about the contribution of science and technology in promoting innovation and development in the treatment of incurable diseases such as HIV / AIDS and cancer (Jenkins 2006). Students in Iran also believed that science and technology would invent appropriate treatments and cures for diseases (Najafi et al., 2012), as did students in Ghana (Anderson, 2006).

3. **G3. 'Thanks to science and technology, there will be greater opportunities for future generations'**

In regard to Item G3, Tables 7-1 and 7-2 show that both boys and girls agreed that item, Thanks to science and technology, there will be greater opportunities for future generations'; the mean values for both boys and girls were close, with the value for girls being 3.27 and for boys, 3.20. Also, in their discussion in the diamond-ranking activity, participants asserted the importance of studying science because it increased knowledge, which would reflect a better future for society. As one said, science 'increases knowledge and [creates] a better future'. Likewise, participants mentioned that science and technology would benefit them in the future: 'I will benefit from science in the future'. Saudi students believed that science and technology would provide a better future, by creating more opportunities for a better and easier life for future generations. This result was consistent with other studies such as Amri (2012). Moreover, it supports Sjøberg's (2019) suggestion, that there is a close relationship between the images people hold of the future and their attitudes towards the role of science and technology in society. Those who are optimistic about the future also tend to be positive about the role of science and technology in society and about scientific and technological developments.

4. **G4. 'Science and technology make our lives healthier, easier and more comfortable'**

Both male and female students also agreed that science and technology made human life healthier and more comfortable, as both science and technology added tremendous means of comfort and reduced the effort and time needed for a number of tasks in everyday life. This opinion is clearly reflected in the mean values, which were 3.22, for girls and 3.14 for boys, as displayed in Tables 7-1 and 7-2, indicating students' agreement with Item G4.

In their discussions in the diamond-ranking activity, participants mentioned that one of the reasons for the importance of science and technology was that it made life more comfortable and healthier. For example, one of the participants said, '*How did we get to mobile phones? From studying science and technology*' This development, in turn, makes access to information easier, communication with others and work or running a business more comfortable. This concern was also reflected in the discussion of the item, 'To help with understanding and decision-making in everyday situations.'

1.3. To help with understanding and decision-making in everyday situations.

Four groups selected this statement as the most important reason for teaching science. Group E-G-1 supported this statement because they believed science made people's lives better. Group D-G-1 added that studying science provided people with the ability to take care of themselves and the development in disease diagnosis and medicinal development has been made easier and faster through science and technology, which improves quality of life. This has resulted in a better quality of life, as people would be able to understand themselves and the world around them. According to students:

> "So that I would live in a better life" (E-G-1).
>
> "If a person doesn't study [science], he won't be able to do those things like take care of himself." (D-G-1).

Studying and understanding life leads to the development of theories, which can be tested by scientists. If they are taught these theories, which have been justified and tested, people can use them in their lives, as a student in Group A-B-2 mentioned:

> "I study so that I can apply the things that I learn to reality."

Furthermore, science not only helps people understand their current life, as previously mentioned, but it can also be used to understand the future, as someone from group G-B-2 believed:

> "I will benefit from it in my lifestyle and I will benefit from science in the future."

While some groups made a link between science and more effective life choices in the future, others believed that studying science provided the ability to comprehend phenomena around them, thus helping them to understand problems and fix them, and know things which would make their lives healthier, easier and more comfortable. Therefore, some groups made the following statements:

> "Physics will help with electrical problems." (G-B-2).
>
> "Now for example, the different types of plants, like in biology, if you go somewhere you know what type the plant is, or the human body parts, you would know that, that's like that." (A-B-2).
>
> "If the substance is dangerous, we would know." (D-G-1).

Science impacts human life by making it more comfortable, as it adds inspiring means to rest and reduces the effort and time needed to perform the various tasks in humans' daily lives; inventions and innovations in all areas of life (especially in hospitals) have proven very useful to humans, such as the invention of the computer and x-rays, as a member of Group G-B-1 mentioned:

> "Technology is useful for things like hospitals and computers help us to know what illnesses we have, and x-rays show us our diseases. X-rays are considered physics."

Science contributes to distance approximation and shortening of time, as people can travel from place to place very quickly using modern means of transport. As one student said:

> "How do you make aeroplanes? You need to acquire the learning and knowledge." (A-B-1).

The impact of bringing science and technology together cannot be underestimated. Everyday life has been improved by the modern devices and tools that are now available. Students believed that studying science gave people wide access to knowledge and enhanced their experience (especially in the medical field). Moreover, life has become simpler in Saudi Arabia due to the availability of modern technologies in all aspects of life, for example transportation, electrical appliances at home, searching for information online. This resulted in Saudi students believing in the importance of science and technology. Without modern equipment, whether it is in medicine, infrastructure, aviation, electricity, information technology, etc, the ease of life available today would not have been possible.

Science and technology may serve as a motivation for people to face their challenges and contributes to providing them with methods and skills to analyse problems, which in turn would lead them to explore the appropriate solutions, which would make life easier and healthier. The attitudes of Saudi students toward studying science confirm those reported in similar studies, which discovered that the majority of students believed that science and technology played significant roles in making peoples' lives healthier and more comfortable (Anderson, 2006; Jenkins & Pell, 2006; Najafi et al., 2012).

5. **G5. 'New technologies will make work more interesting'**

There was also agreement among students on Item G5, as the mean value for both male and female Saudi students was over 3.00; the mean value for girls was 3.22 and that for boys was 3.17. Results revealed that 41.5% of girls chose 'Agree', while 42.2% chose 'Low agree', which means more than 80% of girls agreed that new technology would make work more interesting (see Table 7-1). For the boys, 39.8% chose 'Agree' and 36.6% chose 'Low agree,' which meant that 76% of boys supported that item (see Table 7-2). It is interesting that they had this positive view, as technology actually replaces human labour in some areas, with the emergence of greatly improved computing power, artificial intelligence and robotics, a much larger scope of occupations is at risk (Millington, 2017). However, technology also gives scope for entrepreneurship and working from home, especially for women, giving them new career opportunities in contexts where they traditionally face job related obstacles, such as Saudi Arabia. In the Saudi context, women use the internet for business purposes because it is considered more suitable for the female nature, and it prevents them from working with men (LahaOnline, 2004). Such factors may help to explain why the Saudi students believed that employing technology in the workplace would make work more interesting.

6. **G11. 'A country needs science and technology to become develop'**

In regard to the importance of science and technology to the country, the attitude of Saudi students in both the qualitative and quantitative analyses were clear. As can be seen in both Tables 7-1 and 7-2, the mean values were high, which indicates that students strongly agreed that countries need science to evolve. The mean values for both girls and boys were close, with the mean value for girls being 3.29 and for boys, 3.23. In addition, both boys and girls placed it in the third level after Items G1 and G2. In their conversation during the diamond-ranking activity, both male and female students also agreed that countries need science to develop and improve. One of the statements that students were asked to rank in the diamond-ranking activity was "To help meet the country's need for well-qualified scientists."

1.4. <u>To help meet the country's need for well-qualified scientists.</u>

Nine of the 31 group members ranked this statement as their top reason for supporting the importance of science and technology subjects. The groups held diverse opinions. An analysis of the groups' conversations uncovered several reasons for them ranking this statement as the most significant, and these reasons mostly involved the idea of self-reliance and keeping pace with developed countries.

*6.1.1. Self-reliance*

The participants believed that countries should rely on themselves and not foreign countries, which would ensure continuity in building and improving their knowledge through their own research and theories. In this respect, Groups C-B-1 and C-G 2 believed that a country's citizens would possess greater ability to know and understand their own country's needs than foreigners; thus, they would be able to meet these needs, which would reflect positively on their country. According to them:

> "It is the most important, because we should not rely on someone else, since Saudi scientists will help the country more than foreigners" (C-B-1).

> "We would fulfil these requirements and we would not have to rely on foreigners to carry them out" (C-G 2).

In addition to the importance of improving the citizens' scientific skills and knowledge, Group G-B-1 added that developing countries always start by building their knowledge through paying attention to scientific pursuits. According to them:

> "If you want to build a country, you need to improve the scientists and if you want to develop the country the scientists need to be developed. We study to develop our country."

Qualified scientists increase the country's ability to discover knowledge and to stand alongside developed countries, avoiding the need to wait for others to provide them that knowledge. A member of Group E-B-2 believed the following:

> "Because if you have proper qualified scientists you will open everything, you will have a suitable department for the right scientific level, so you would develop their knowledge in a faster way to keep up with other countries."

*6.1.2. Keep pace with developed countries*

Remaining competitive with other countries emerged as an additional reason why this statement was ranked at the top by students. Participants stated that competition encouraged countries to pay attention to scientific pursuits in order to keep pace with developed countries. In that regard, Groups H-G-1 and H-B-2 mentioned:

> "To keep up with the developed countries in industry" (H-G-1).
>
> "Keep pace with development" (H-B-2).

The above results indicate that Saudi students realized the importance of science and technology to their society. Since 2016, Saudi aspires to join of the ranks of developed countries through Vision 2030, desiring to take steps in the quest for the advancement of the homeland, and to address the global challenges it faces, including challenges related to inequality, environmental degradation, and achieving prosperity, peace and justice (Saudi Press Agency, 2020). Saudi Arabia pays great attention to infrastructure and digital support for promising industries, regional and international connectivity, and support for innovation, research and technology. It supports research, technology and innovation, prepares national plans and strategies in this field, and develops mechanisms to convert practical and technical research into industrial products (Mohammed, 2018). Therefore, students believed that science and technology played critical roles in a country's development. They considered science and technology as one of the main pillars of knowledge on which civilizations are built, and that they provide countries with the means to keep up with modernisation. Participants realize that, if nations do not implement science and technology, then the chances of their becoming developed becomes minimal and thus they could even be rated as under- developed. One of the functions of the state is providing livelihoods and welfare and achieving a decent standard of living for its citizens (Attia, 2020); this can be achieved by placing the necessary importance and emphasis on science in the society (Ragheb, 2020). Therefore, due to the importance of science and technology to the development of countries, developed countries promote science and scientists. It should be noted that the results of the study are in agreement with the results of the study by Sjøberg and Schreiner (2010) which suggested that students who participated in the ROSE questionnaire in all other countries agreed with statement G11.

7. **G12. 'Science and technology benefit mainly the developed countries'**

The Saudi students also believed that science and technology could have a positive impact on developed countries. The mean value for that item was 3.26 for girls and 3.21 for boys. Saudi students were aware that Saudi Arabia is not a manufacturing or industrialised country but buys technology from developed countries. This means Saudi Arabia cannot practise science and therefore does not benefit from science like developed countries. Saudi curricula also contain several foreign scientific names from developed countries, which created the impression that science and technology contributed to the rise of developed countries. Consequently, the perception of Saudi students was that scientific research primarily occurs in developed countries for the primary purpose of benefitting those same developed countries. Thus, the research operates in a feedforward manner, furthering the development of developed nations. Therefore, Saudi students agreed with the statement that developed countries benefit more from science and technology than developing countries, which was also in accordance with the results of previous studies that have already been mentioned, such as Anderson (2006).

8. **G16, 'Scientific theories evolve and change all the time'**

For Item G16, Saudi students agreed; the mean value for girls was 3.21, which was higher than the mean value of boys (2.99) (See Tables 7-1 and 7-2). They also believed that the theories should be studied, since studying science helps young people understand their lives, and the phenomena around them. Therefore, it is important to continue learning and knowing about scientific developments, so young people will gain other advantages, such as enhancing their confidence and protecting them from potential dangers. Therefore, science plays a major role in protection against exploitation. As a member of group, A-B-2 said:

> "Because making young adults aware of these facts and theories is important. This is because maybe if they were not made aware, anyone would be able to lie to them."

In the following quotation, the student complains about studying wrong theories, which might be the reason students become aware that theories are developing and changing.

> "They teach us about false theories; like why do we need to learn that, it's false? Just give us the right theories and that's it." (G-G-1).

Saudi students study scientific theories in school, which may have prompted the realization of the frequent change in scientific theories. According to Reiss (2014) a key concept of science is that science is not fixed and there are often multiple theories used to describe a phenomenon and long-established theories are discarded when a better theory emerges. For example, Albert Einstein overturned the prevailing understanding of early twentieth century physics when he presented his Theory of Photoelectric Effect, Theory of Brownian Motion and Special Theory of Relativity. The influence of his Theory of Relativity is profound, as it formed the basis for all later physics, as well as changing philosophy and people's understanding of space and time. Directly and indirectly, Einstein's theory influenced many fields of science and their subsequent development.

#### 7.2.2.2 Items with mean value less than 2.99 and above 2.50

The following three items also met with agreement, but with less agreement than the previous items, since the mean values were less than 2.99 and higher than 2.50: G6, G13 and G7. None of the focus group participants gave comments related to items G 6 and G13, but there were comments that matched the G7 item.

1. **G6. 'The benefits of science are greater than the harmful effects it could have'**

This can possibly be explained as ignorance of some of the deleterious effects of technological applications upon society. For example, factories and transportation, despite the enormous benefits that they offer to humans, can have significant negative impacts on the environment, and various environmental issues and problems are among the biggest challenges facing the world, particularly depletion of the ozone layer and global warming. However, the participating students seem to believe that the benefits of science in areas such as health, education, transportation, and communication, outweigh the harmful effects.

2. **G13. 'Scientists follow the scientific method that always leads them to correct answers'**

Based on the responses to G13, it would appear that this was the prevailing view among the students. However, it is unknown why they replied as they did. One possibility is that students regard textbooks as a reliable authority, and many of these textbooks claim there is only one scientific method (Matthe, 2007). Perhaps the progress of science and technology that students had observed in treating diseases, making people's lives easier and inventing new technologies contributed to making them agree with or support Items G6 and G13. Despite the agreement with these items, the agreement was weaker than the previous items, and this indicates that more students disagreed or there was some hesitation or uncertainty.

3. **G7. 'Science and technology will help to eradicate poverty and famine in the world'**

Saudi students believed that science and technology would help poor people and reduce problems such as famine in the world by providing low-cost solutions to the problems of the poor, such as providing water filters to purify drinking water in swamps and rivers, which would contribute to saving lives in poor countries. This point of view was expressed when students discussed the following statement:

1.5. <u>To help meet the country's need for well-qualified scientists.</u>

During the diamond-ranking activity the students gave their comments on the statement, as in this example from group G-B-1;

> "Saving people: From science, I can help people like Africans; they have dirty water; through science, I can learn how I can save them by learning how to create things such as water filters."

Science is a system of study to yield information or facts that are analysed and understood to become knowledge. Application of this scientific knowledge is the domain known as technology. Thus, students in this study believed that from science, they could develop the technological instruments necessary to help people in poorer countries.

#### 7.2.2.3 Items with mean value less than 2.50

This section covers items that have mean values less than 2.50, which indicated the participants disagreed with these items, as shown below.

1. **G8. 'Science and technology can solve nearly all problems'**

Despite the positive attitudes that students held towards science and technology, several items under section G of the ROSE questionnaire yielded mean values below 2.5, from both boys and girls, thereby indicating disagreement. For example, item G8, which states that 'Science and technology can solve almost all problems', received the mean value of 2.37 for girls and 2.41 for boys, thereby indicating that these Saudi students did not believe that science and technology have the ability to solve all problems. The wars and famines that are observed in the media may have contributed to students' belief that science and technology cannot solve all problems. In addition, when it comes to the capacity of science and technology to solve environmental problems, in particular, a number of studies find that young people do not believe much in the power of science and technology (Sjøberg & Schreiner, 2019). "Science and technology are perceived as cold and inhuman, the cause of the pain on Earth, the root of mega-wars, the cause of environmental problems and the ruthless exploitation of natural resources, etc" (Sjøberg & Schreiner, 2019, p. 120).

2. **G9. 'Science and technology are helping the poor'**

A small number of students supported the statement that science and technology can help to eradicate poverty and famine in the world, with 37.9% of girls and 43% of boys agreeing with it. However, although a number of students mentioned the importance of science in helping the poor, the majority thought the opposite, as shown by the mean values of item G9: 2.33 for girls and 2.43 for boys. The contradiction in items G7 and G9 can be explained by the suggestion that in G7, students may think that rich countries with technological advancements can contribute to some industries that help poor countries, such as making water filters. In item G9, students may believe that science and technology have not eliminated poverty. Rather, many people are still poor, whether in rich or poor countries.

3. **G10. 'Science and technology are the cause of environmental problems'**

Students did not believe that science and technology caused environmental problems as mentioned in item G10, where the mean value for the item was 2.26 for girls and 2.49 for boys. A possible explanation may be an absence of social awareness and environmental legislation in Arab countries. Instead, extravagant consumption and excessive luxury, without thinking of the negative consequences, and material exploitation without any environmental or humanitarian controls, are common in those countries, especially oil-producing countries such as Saudi Arabia (Moustafa, 2018). Consequently, Saudi students did not agree that science and technology are the cause of environmental problems. However, they agreed that science and technology are incapable of solving most problems, especially poverty.

In regard to this, and referring to items G8, G9 and G10, the results of this study agreed with Jenkins (2006): he found that a small number of students 47.1% of the girls and 37.3% of the boys agreed that science and technology can help to eradicate poverty and famine in the world. In this study, the percentage of students who agreed with item G8 was 43% .8 of the girls and 41.9% of boys as mentioned in G8. Also, according to his study, a relatively small number of girls (22.4%) and of boys (35.3%) thought that science and technology have the ability to solve all problems (as item G9 suggested), while the number of Saudi students who agreed with item G9 was 37.9% of girls and 43.5% of boys. Moreover, in Jenkins' study, the majority of responses to item G10 did not agree that science and technology were the cause of environmental problems.

4. **G14 'We should always trust what scientists have to say'**

The data in Tables 7-1 and 7-2 indicate that both boys and girls disagreed with item, which was ranked in last place in section G for both girls and boys, with mean values of 2.06 for girls and 2.28 for boys. There were several reasons leading students to express distrust of scientists, but it is interesting to mention that during their discussion of the diamond ranking activity, they were concerned about the experiments or theories they had been studying and expressed doubt whether these were still valid. Also, other theories had proven to be incorrect, which may have negatively affected the students' trust of scientists.

> "Why do we study the debates between scientists? Each one tries to prove the other wrong and try to prove themselves right." (E-G-1).

Students' ideas about science, the personalities of scientists and the purpose and meaning of their activities may have different sources. They may emerge from the media and out-of-school influence, or they may arise from their encounter with school science and the science teachers (Sjøberg, 2002c). In this study, Saudi students may have come to believe that scientists are not infallible and that they should not always be trusted based on school science, as they mentioned. Another reason is the possible role of religion; students may believe or be told certain scientific theories are "false" because they contradict religion. An example is the theory of evolution. According to Nielsen (2016),

> The teaching of evolution is totally banned at the pre-college level in Saudi Arabia. The only time it is mentioned is in the Grade 12 level biology textbook, where it is presented as an erroneous and blasphemous theory which contradicts the teachings of Islam (BouJaoude, 2018, p. 302).

In this item, the result found is compatible with Rashed's (2019), result in Egypt, where students said they did not trust everything scientists said. Although in Egypt, the theory of evolution is part of the curriculum and teachers are required to teach their students about it, however they make sure to profess that it is false as it conflicts with religion (Zohny, 2012). Therefore, religion may influence students' attitude toward the trustworthiness of scientific thought.

5. **G15, 'Scientists are neutral and objective'**

It is clear that the majority of girls and boys did not believe this, as the mean value for the item was 2.26 for girls and 2.36 for boys. On this point, not only did the Saudi students not agree but also, sociologists seldom believe in the objectivity and neutrality of scientists, as mentioned by Matthe (2007), although a core property of science is, purportedly, the notion of objectivity. The aim is to eliminate, or minimise as far as possible, the influence of partiality arising from personal and community bias and interests, value judgments and perspectives. All of these and other factors can influence the claims, methods and results of science. Scientists themselves are also required to be as objective as possible. The quality of objectivity is important to facilitating scientific inquiry and evaluating findings; it underpins any trust that science has in society (Reiss & Sprenger, 2014). Referring to the current research participants' opinions expressed during the diamond ranking, they complained about the volume of theories studied and the debate about these theories among scientists. Perhaps Saudi students came to the conclusion that there is some lack of objectivity from learning scientific theories in school. The results agree with a number of studies such as Jenkins and Pell (2006) and Rashed (2019).

In the above sections, the results of the ROSE questionnaire and students' discussion during the diamond ranking activities have been merged. Accordingly, quotations from the students' discussions were offered in support of the results of the ROSE questionnaire. However, there were numerous opinions expressed by the students during the diamond ranking that did not match the ROSE sections, which are worthy of analysis and discussion. Therefore, these opinions are quoted and discussed below.

### 7.2.3. Ranking of Statements in Diamond Ranking Activity

This section will present and discuss the participants' opinions and views reflected in the diamond-ranking statements that did not match the ROSE items.

1. **To help young people make some sense of topical science-related issues reported in the media.**

Nowadays media of all kinds, such as radio, television, newspapers and others, enable information to reach people almost everywhere. They provide news reports, documentary programmes and films that have the ability to form people's impressions on a particular subject. People use all forms of media to fulfil their needs for news and information that they require or might otherwise miss. Four groups ranked this statement as the most important; however, they provided few justifications. However, the participants considered that studying science and technology broadens young people's perceptions, enabling them to understand phenomena, which can reflect positively on themselves and their relatives:

"If we learn something and I see it on TV, I have to tell my parents about this phenomenon and explain it to them." (J-G-2).

The Media can be considered as one of the best tools or resources that can be used in education, as it provides various educational programmes. In addition, it helps to facilitate access to, and understanding of, information, because it has the ability to present practical activities with more accurate and clear details, in order to build a clear conception of ideas and information among its consumers:

"It increases knowledge and destroys ignorance." (E-G-1).

"First of all, young people need to know about the cosmic phenomena, for example how mountains are formed, and they would understand everything." (B-G-1) and (B-G-2).

Some students referred to gaining access to scientific information by watching science-related programmes on television, about such subjects as black holes:

"I watch programmes about black holes and learn about them and enjoy watching them. I hope we learn about them in school." (E-G-1).

Science contributes to protecting humans from events such as natural disasters, many of which science gives people the ability to predict. Also, technological equipment exists that can be used for this purpose in a timely manner. Technology can provide the necessary information about these disasters, and also give warning before disasters happen, and then people can be warned through the media to take the appropriate precautions, which can then reduce the damage:

"For example, if there is a hurricane or something, you have knowledge on how the hurricane was formed. Also, rain, how clouds are formed; you would have experience of this knowledge of natural phenomena." (A-B-3).

The participants believed that studying science and technology in schools gave young people chances to have a deeper understanding of the phenomena around them, enabling them to know how technology works. Thus, they ranked the statement in the top level, which means they had a positive attitude toward science. The current study confirms the result of Baker and Learry's (1995) study, which found that students' positive attitudes towards science were not due solely to school science, but clearly due to the extracurricular scientific practices of learners outside the classroom, such as home science activity, reading scientific articles and watching scientific programmes on television.

2. **To introduce young people to the important facts and theories of science.**

Three groups of participants ranked this statement at the top, and the participants provided justifications for the statement. Science can contribute to inspiring goals and ambitions that can be achieved through the will. For example, groups I-G-2 and A-G-1 thought that the science facts they had studied helped them improve their knowledge of life:

> "We study physics, chemistry and biology so that we will understand what's in nature; for example, in biology we study about plants, so we will know what scientific facts are in nature." (I-G-2).

> "When some phenomenon comes around in life, I would know it from physics." (A-G-1).

Pritchard (2014) states knowledge is acquired through study, which results in novel behaviours. This is reflected in this study, as many of the participants expressed the view that studying science is beneficial to acquiring knowledge. Thus, people will be able to understand the natural phenomena in the universe, so they will have knowledge on how to deal with them. Also, most students in in this research believed that science and technology can help improve the country's development and will provide greater opportunities in future. They mentioned that they needed to study science (biology) if they wanted to be a doctor and to study physics if they would work with machines in hospitals.

From the data, it was concluded that Saudi students who participated in the current research held positive attitudes towards science and technology. They believed that teaching science in school is beneficial to society, the country and future generations. These findings are consistent with Hogarth and Bennett's (2008) study, in which two-thirds of the ninth-year students surveyed agreed that science has had a positive impact on society, mainly because of the medical progress science has made. Students thought acquisition of scientific knowledge will expand each person's character by improving their consciousness of the real world and provide a real and understanding of what is happening around them. They also believed that science contributes to medical fields, by finding treatments for diseases that are now incurable. These responses reveal attitudes towards science and technology, which are likely to play a role in the students' motivation and willingness to engage in school science. At the same time, as in this study, there is strong evidence indicating that students' attitudes towards science outside school are more positive than the attitudes towards science within school (Bennett & Hogarth, 2008).

A number of students believe that science has an important role to play in society, although they do not have a desire to study scientific subjects personally (Bennett et al., 2013b). Furthermore, similar to this study, reviewing numerous published studies indicates that students' attitudes, interests and perceptions of science and technology are determined by multiple factors other than school; for example, television programmes are very influential (Korkmaz, et al., 2017). Responses in this study support the view that students' motivation and readiness to participate in science lessons in school could be influenced by their general attitudes towards science and technology (Anderson, 2006).

### 7.2.4. Gender Differences

Gender is one of the factors that plays a role in the attitude towards science (Akcay et al., 2010) and this study explored gender differences in opinions towards science, in order to identify differences between boys and girls in their views about the importance of science education for them personally and for society in general, as reflected in section G of ROSE. Chi-square tests were used to compare means for each item, and to compare the means of all the items. The gender differences in attitudes towards science and technology that were found through the testing appear in Table 7-3. If the p value is less than 0.05, it is considered a statistically significant difference; if the p value is greater than 0.05, it indicates that there is no difference.

Table 7-3 The gender differences between girls (G) and boys (B)

| N | Items | Gender | | Chi-Square | p |
|---|---|---|---|---|---|
| | | Mean B | Mean G | | |
| 1. | G1. Science and technology are important for society | 3.40 | 3.36 | 7.256 | .064 |
| 2. | G2. Science and technology will find cures to diseases such as HIV/AIDS, cancer, etc. | 3.28 | 3.46 | 11.581 | .009 |
| 3. | G3. Thanks to science and technology, there will be greater opportunities for future generations | 3.20 | 3.28 | 7.546 | .056 |
| 4. | G4. Science and technology make our lives healthier, easier and more comfortable | 3.14 | 3.22 | 4.219 | .239 |
| 5. | G5. New technologies will make work more interesting | 3.17 | 3.23 | 2.384 | .497 |
| 6. | G6. The benefits of science are greater than the harmful effects it could have | 2.86 | 2.99 | 5.154 | .161 |
| 7. | G7. Science and technology will help to eradicate poverty and famine in the world | 2.71 | 2.61 | 3.058 | .383 |
| 8. | G8. Science and technology can solve nearly all problems | 2.41 | 2.36 | 13.171 | .004 |
| 9. | G9. Science and technology are helping the poor | 2.43 | 2.32 | 4.734 | .192 |
| 10. | G10. Science and technology are the cause of the environmental problems | 2.49 | 2.25 | 13.478 | .004 |
| 11. | G11. A country needs science and technology to become develop | 3.23 | 3.30 | 14.424 | .002 |
| 12. | G12. Science and technology benefit mainly the developed countries | 3.21 | 3.26 | 1.175 | .759 |
| 13. | G13. Scientists follow the scientific method that always leads them to correct answers | 2.88 | 2.90 | .342 | .952 |
| 14. | G14. We should always trust what scientists have to say | 2.28 | 2.06 | 15.817 | .001 |
| 15. | G15. Scientists are neutral and objective | 2.36 | 2.37 | 5.750 | .124 |
| 16. | G16. Scientific theories develop and change all the time | 2.99 | 3.21 | 10.716 | .013 |

In general, the results of the chi-square test carried out for section G items as a whole were similar to those of Reddy's (2017) study in South Africa, which found no significant differences between girls' and boys' opinions towards science and technology. In the current study, there were no statistically significant differences, as the mean value for all items was 2.88 for girls and 2.87 for boys, with a p value of 0.674, which is greater than 0.05.

On the other hand, the results were different when chi-square tests were conducted separately for each item, as some items appeared to indicate differences in girls' and boys' attitudes towards particular aspects of science and technology. Table 7-3 shows that in six out of the sixteen items there are statistically significant differences, as the p value is less than 0.05. The differences are in three items with mean values higher than 2.5, and three items where the mean values are less than 2.5. Three items have statistically significant differences in favour of girls, and the other three items show statistically significant differences in favour of boys. One item that appears to have a significant difference in favour of girls is G2, 'Science and technology will find treatments for diseases such as HIV / AIDS, cancer', where the mean values for that item were 3.46 for girls and 3.28 for boys, with a p value of 0.009, which is less than .05. It should also be noted that a number of boys chose this item second, after item G1, but girls showed the strongest faith in science and technology as the best path to discover treatments for diseases. The current result is also consistent with the evidence reported in the previous chapter, which showed that girls were more interested than boys in the human body and its health. The second item that shows gender differences in this particular study is G11, 'The country needs to develop science and technology', which has statistical significance in favour of girls because the p value is 0.002, which is less than 0.05, and the mean value for item G11 is 3.30 for girls and 3.23 for boys. Furthermore, G16, 'Scientific theories evolve and change all the time' is the third item showing differences of statistical significance between girls' and boys' opinions towards science and technology; the p value is 0.013, which is less than 0.05, and the mean value for the item is 3.21 for girls and 2.99 for boys.

On the other hand, a number of items reveal differences of statistical significance for boys, but the mean value of these items is less than 2.5. One of these items is G8, 'Science and technology can solve almost all problems', where the p value is 0.004, which is less than 0.05. Item G10 'Science and Technology is the cause of environmental problems' is another of these significant items, as the p value is 0.004. Similarly, item G14, 'We must always trust what scientists say' appears to have a statistically significant difference for boys, as the mean value of this item is 2.06 for girls and 2.28 for boys, and the p value is .001.

Interestingly, the results of this study agree with another study by Jenkins and Pell (2006), who found that English students, both girls and boys, had positive opinions about science and technology. On the other hand, however, there is inconsistency with the study by Jenkins and Pell (2006) in terms of gender differences for some of the items within section G of the ROSE questionnaire, as they found gender differences with statistical significance in 11 items; also girls were generally less optimistic than boys in their responses to section G of the ROSE questionnaire. In the current study, in general, both girls and boys had almost the same opinions on science and technology and there are only six items that had gender differences with statistical significance. Students in developing countries such as Saudi Arabia are more positive about science and technology than students in developed countries, such as England. Also, gender differences in developing countries are less than those in developed countries (Sjøberg & Schreiner, 2010).

Overall, although Saudi girls appear to have more positive attitudes towards science and technology than boys in general, the results also indicate that Saudi students, girls and boys alike, hold positive opinions towards science and technology, and that there is no statistically significant difference between them overall.

After investigating the gender differences in views and attitudes towards science and technology in section G, in the coming section, the researcher will compare the views of Saudi students with those of students of other countries who participated in the ROSE project.

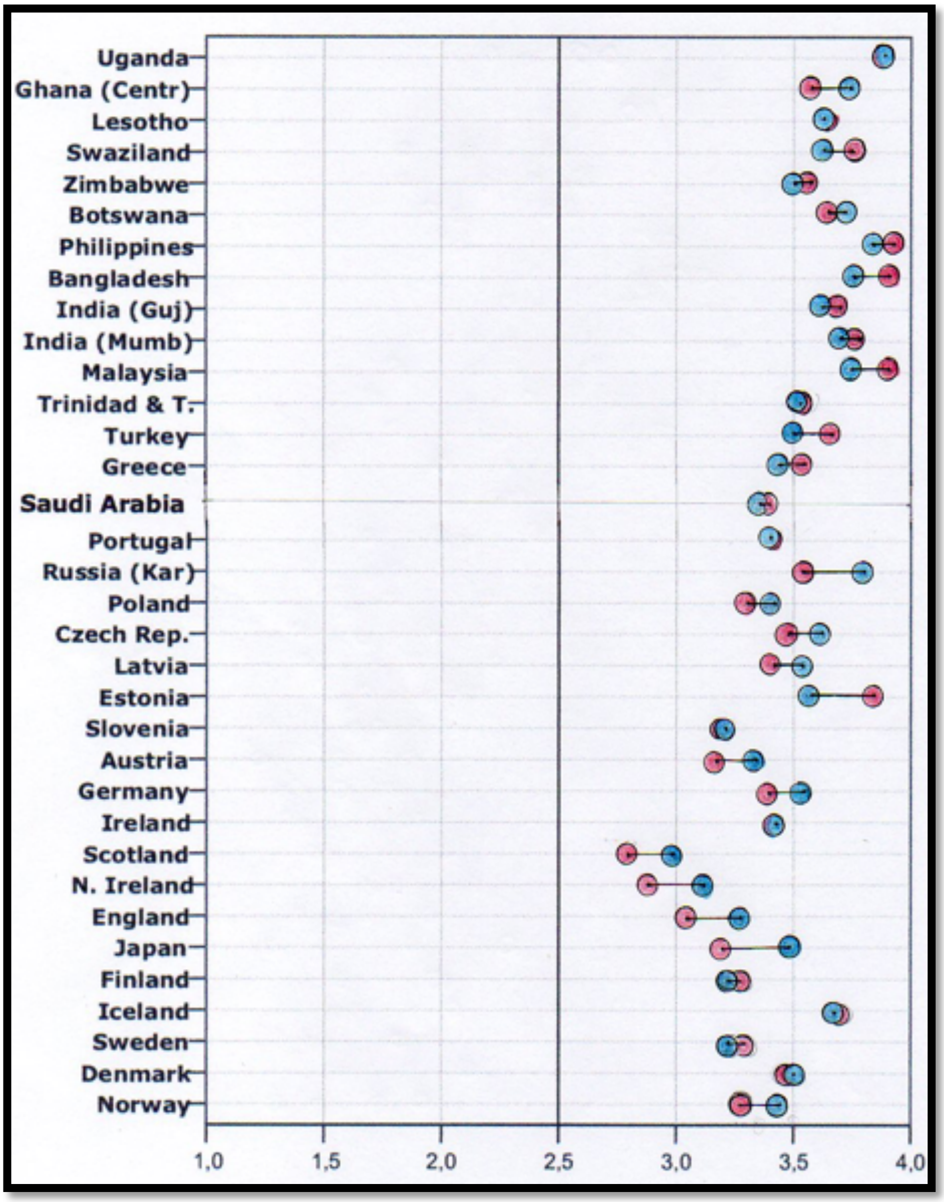
### 7.2.5. A comparison of Saudi Students' Opinions about Sciense and Technology with Students in Other Countries

The previous section showed gender differences based on Saudi students' responses to section G of the ROSE questionnaire. The current section compares Saudi students' opinions towards science and technology with those of their peers in other countries who participated in the ROSE project. The following graphs will show the mean values of both girls and boys aged 14-16 years from several countries that participated in the ROSE project, adding to them those of the Saudi students who participated in the current study.

### 7.2.5.1 Results

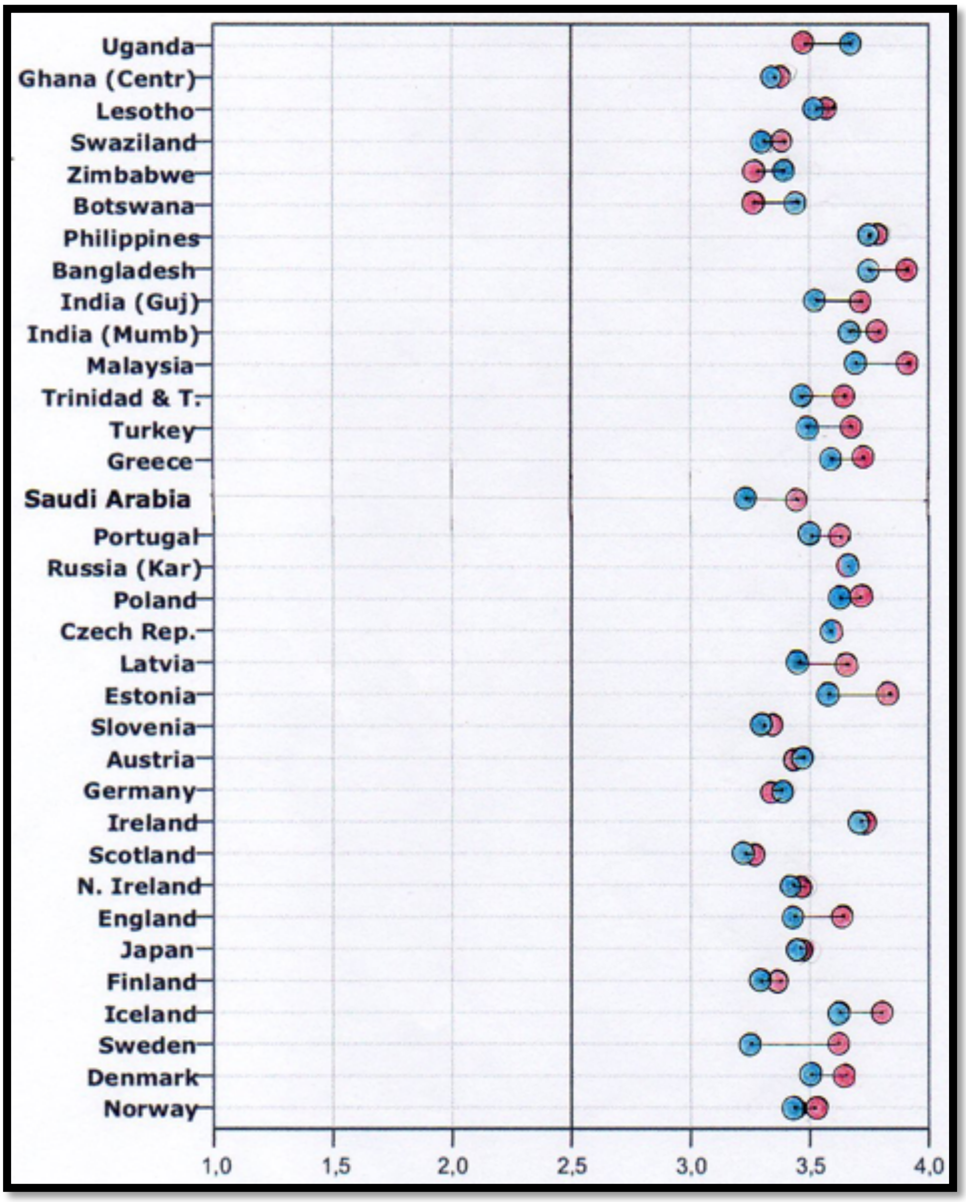
Notice (Red indicates the response of girls, blue the response of boys).

Figure 7-1 The mean of item G1: Science and technology are important for society



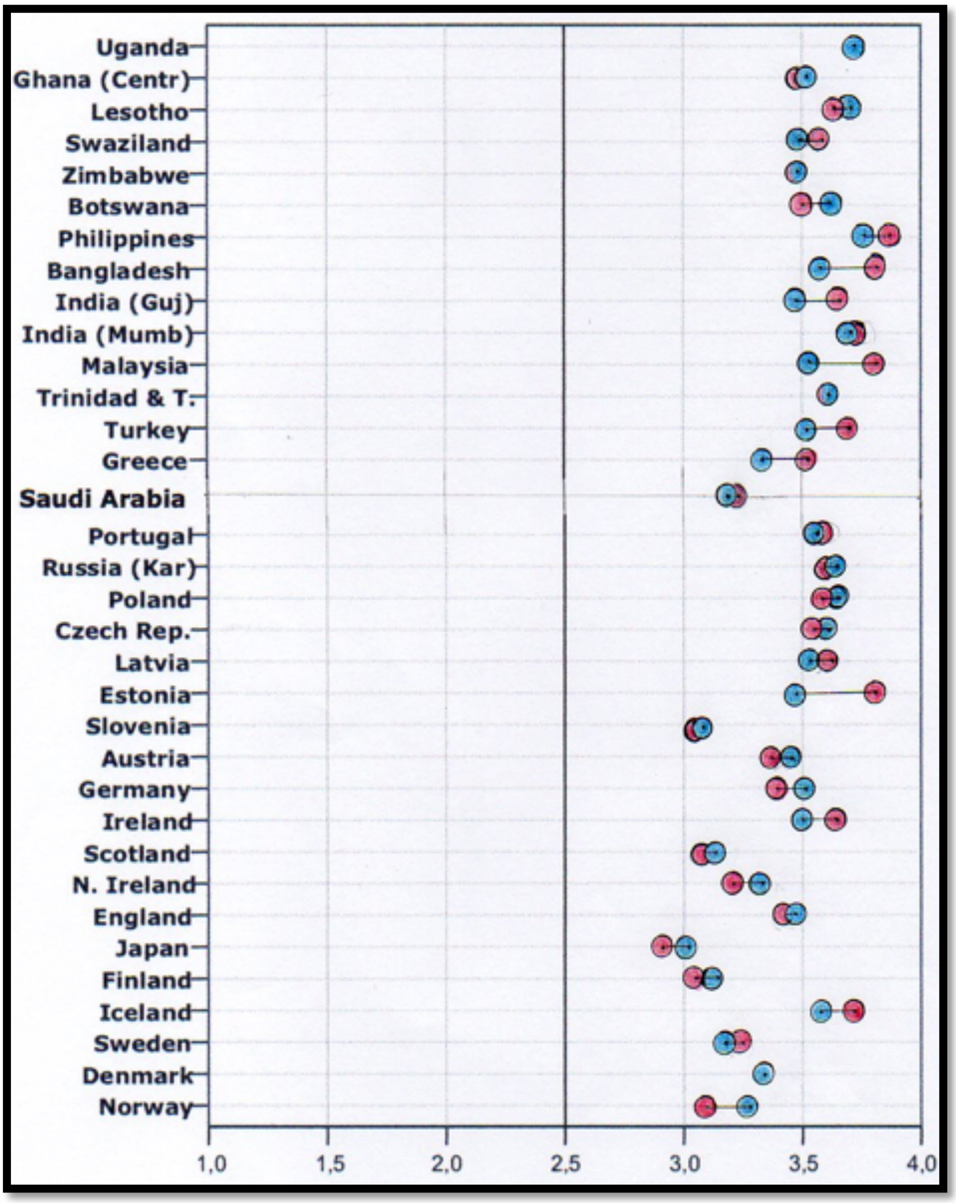

The students responded to item G1 'Science and technology are important for society', as shown in Figure 7-1. The mean values indicate that the girls and boys in all countries agreed on the importance of science and technology in their society. Additionally, the narrow gender differences, even between the Saudi students, are clear. In general, students in developing countries held positive attitudes towards science and technology, while in some developed countries, such as Scotland, the students were more hesitant. The gender differences in this item are fairly small for most countries.

Figure 7-2 The mean of item G2: Science and technology will find cures to diseases such as HIV/AIDS, cancer, etc



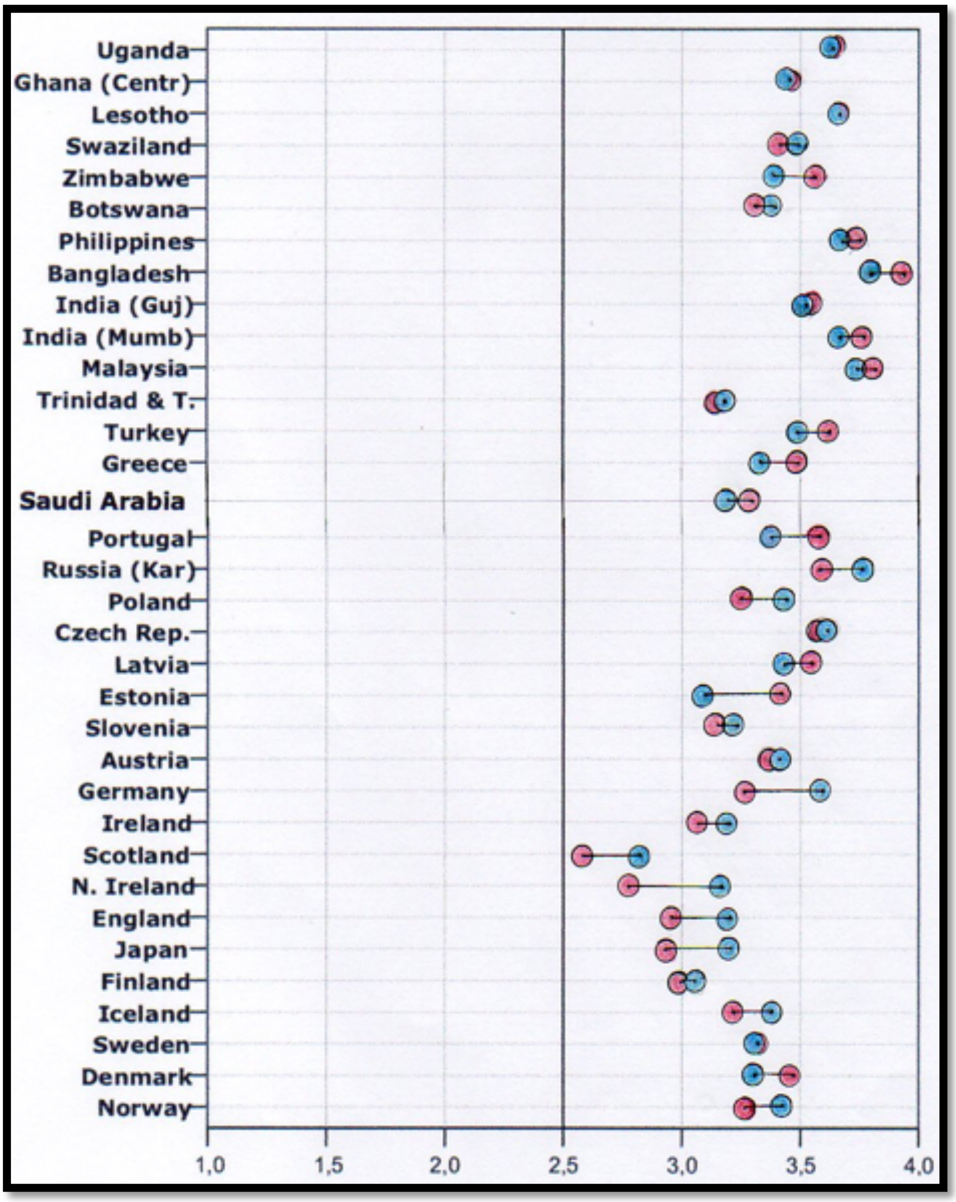

In most countries, students agreed with item G2 'Science and technology will find cures to diseases such as HIV/AIDS, cancer, etc.', as appears in Figure 7-2, with the mean value greater than 3.00 in most countries. This item also demonstrates that the gender differences were narrow in most countries, but there are statistically significant differences between gender in Saudi Arabia and countries such as England and Sweden.

Figure 7-3 The mean of item G3: Thanks to science and technology, there will be greater opportunities for future generations



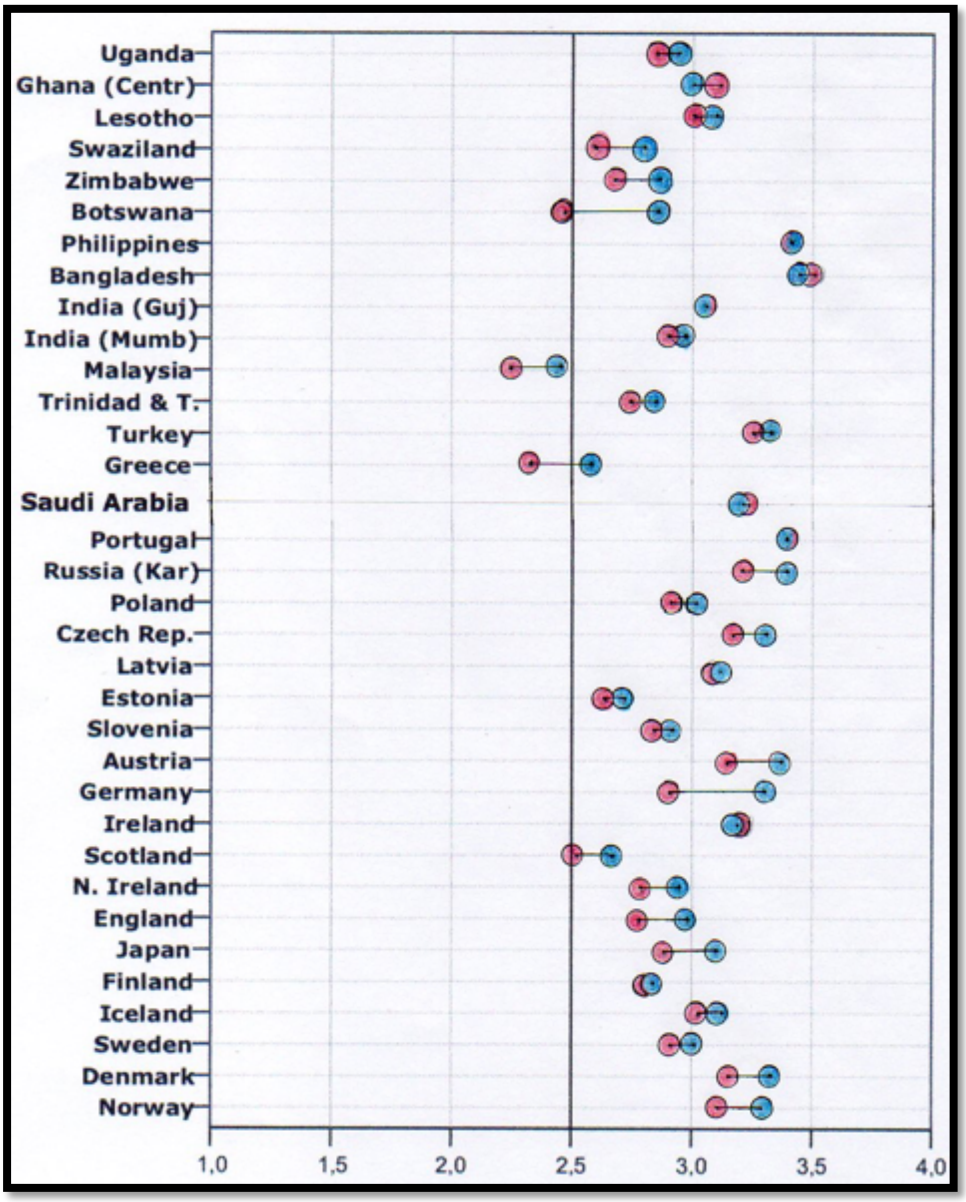

The students' responses to item G3, 'Thanks to science and technology, there will be greater opportunities for future generations,', described in Figure 7-3, show that the students in all countries gave positive responses, as the mean values are greater than 3.00, with the exception of Japanese girls, who have a mean value less than 3.00. There were also smaller differences in developed countries and certain developing countries such as Zimbabwe and India (Mumb), but the Saudi students had less positive views than others in some developed and developing countries.

Figure 7-4 The mean of item G11: A country needs science and technology to become developed



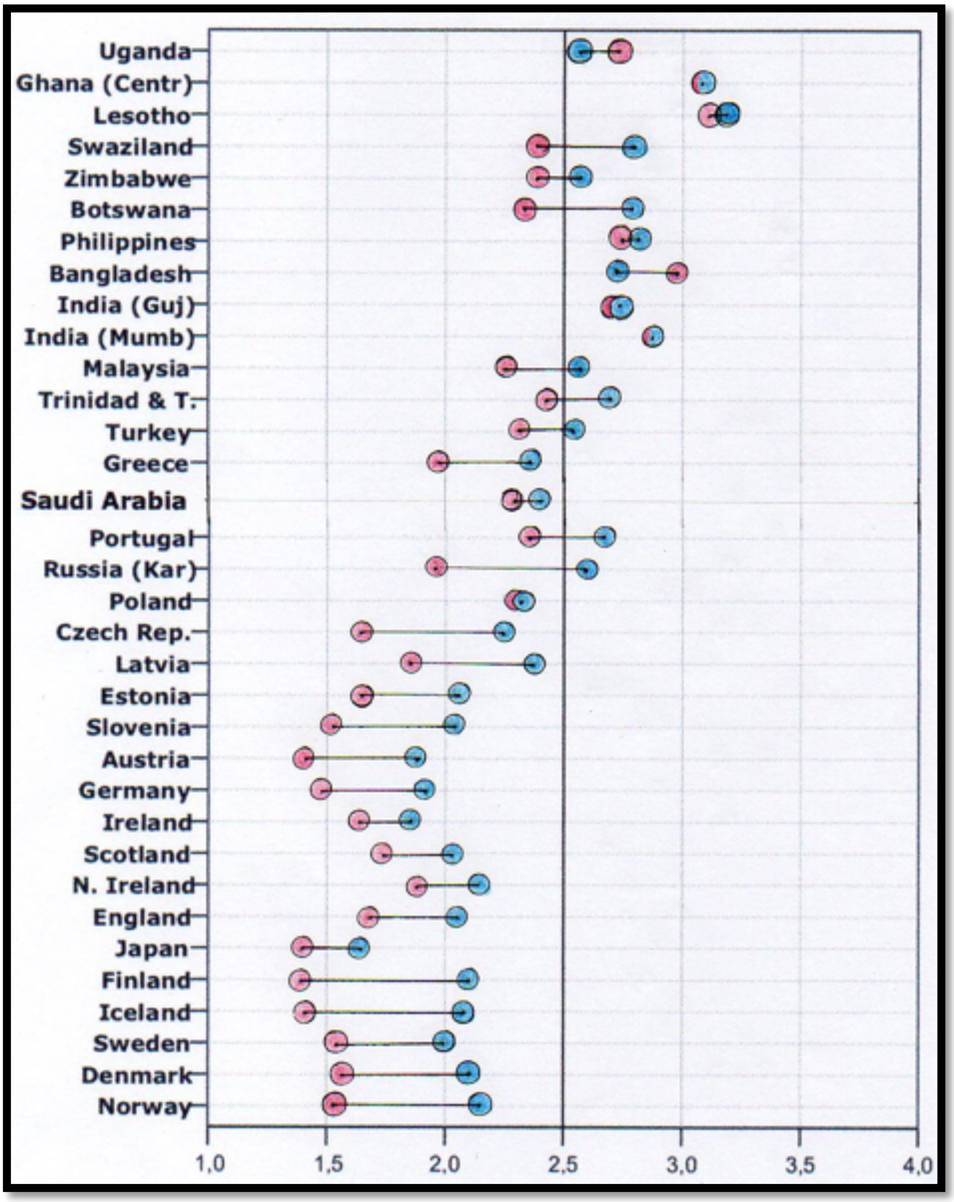

The data in Figure 7-4 indicate that students in all countries had positive opinions towards item G11, 'A country needs science and technology to become developed.' The mean values were greater than 3.00 in most countries, except in Scotland, where values for both boys and girls were less than 3.00, and in Northern Ireland, England and Finland, where the girls' responses were less than 3.00. Gender differences vary as well; in Saudi Arabia and a few developing countries and developed countries such as Northern Ireland, the differences were statistically significant, whereas in other countries, gender differences were absent, for example Sweden, Turkey and Lesotho.

Figure 7-5 The mean of item G12: Science and technology benefit mainly the developed countries




Although the students had positive opinions towards science and technology, as appeared in the previous item, the responses to item G12, 'Science and technology benefit mainly the developed countries' indicated that the students were less positive, as revealed by the variation in their responses (Figure 7-5). The Saudi students agreed with other students in developed countries such as Denmark and Norway, and in developing countries such as Turkey and Bangladesh. However, there were students in other countries such as Malaysia and the girls in Botswana, Greece, and Scotland, who did not agree with the item. Another clear feature is the narrow gender differences in some countries, contrasting with the more prevalent differences in others. Overall, the girls in most countries had less favourable opinions than the boys.

Figure 7-6 The mean of item G8: Science and technology can solve nearly all problems




The results from the students' responses to item G8, 'Science and technology can solve nearly all problems' show that the students in developed countries show less agreement than students in developing countries that science and technology can solve nearly all problems (Figure 7-6). However, the students in a number of developing countries in Asia and Africa had positive beliefs about this item. As for gender differences, the data show clear and statistically significant differences in developed countries and certain developing countries, for example Norway, Greece and Botswana, though girls had less positive attitudes than boys in most countries, including Saudi Arabia.

Figure 7-7 The mean of item G9: Science and technology are helping the poor

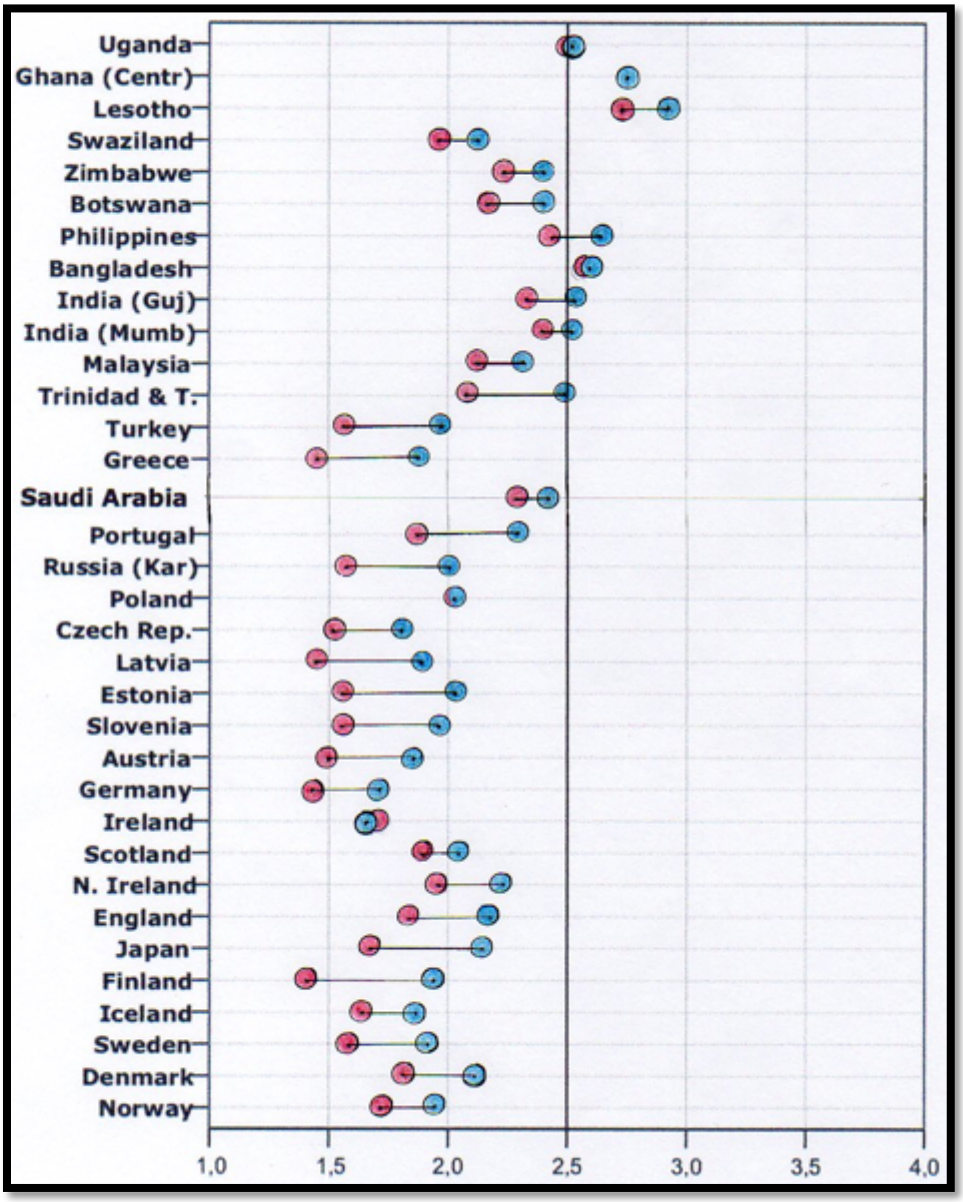
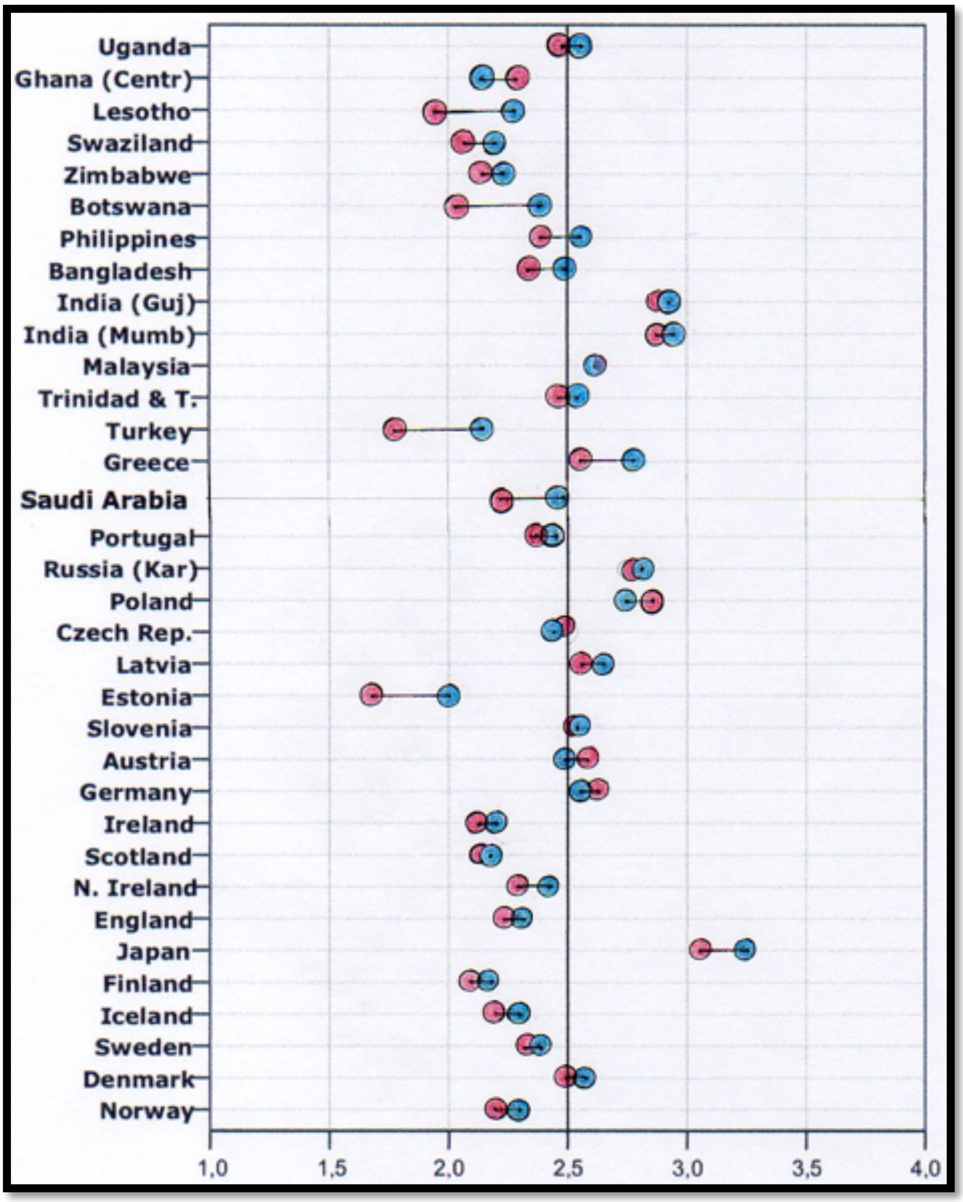


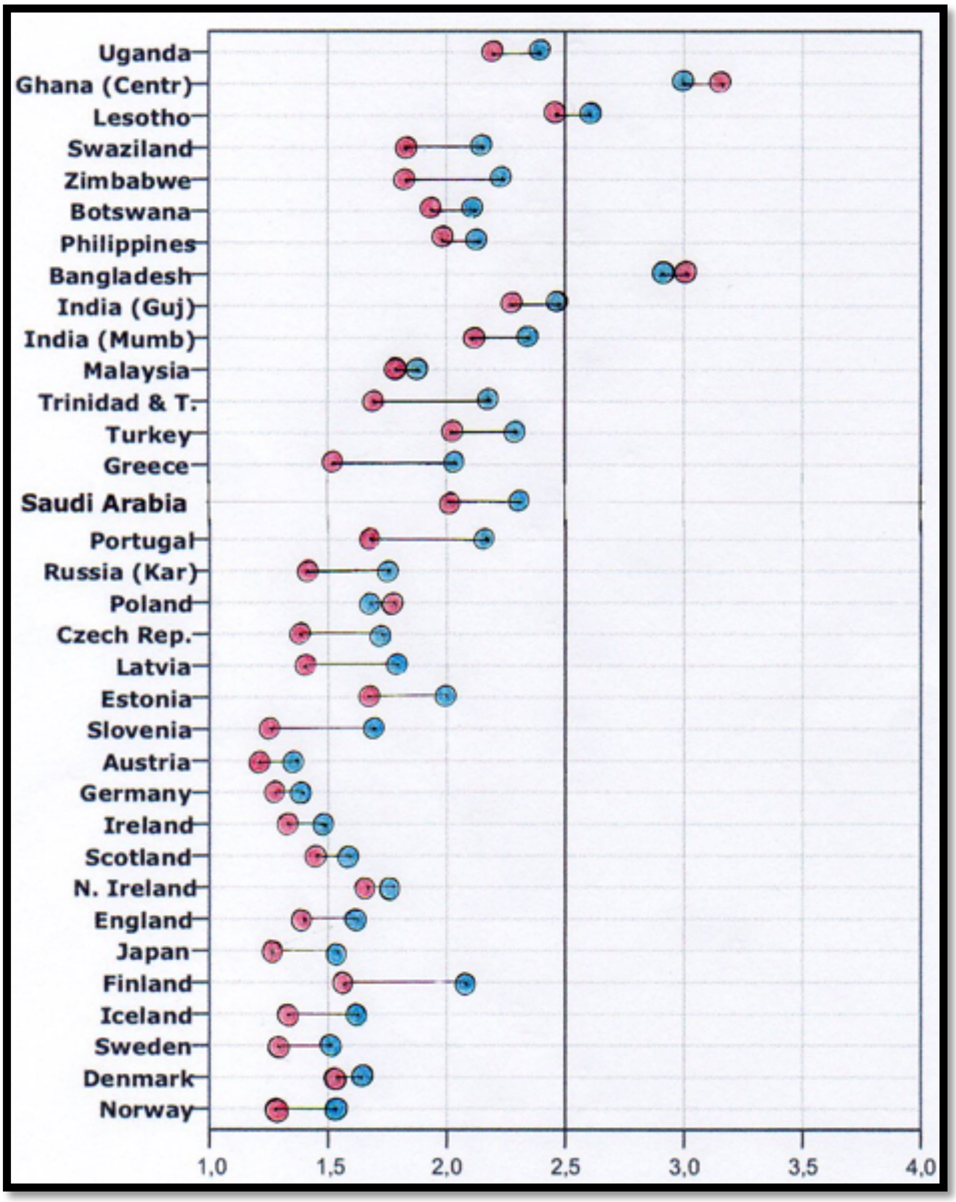

Figure 7-7 shows that the student responses to item G9, 'Science and technology are helping the poor' were similar to the item G8 responses, with mean values indicating that students from developed countries and most developing countries disagreed that science and technology help the poor. While there were clear gender differences in most of the countries, Saudi Arabia, a few developing countries and the developed country, Iceland, revealed no differences between girls and boys.

Figure 7-8 The mean of item G10: Science and technology are the cause of the environmental problems



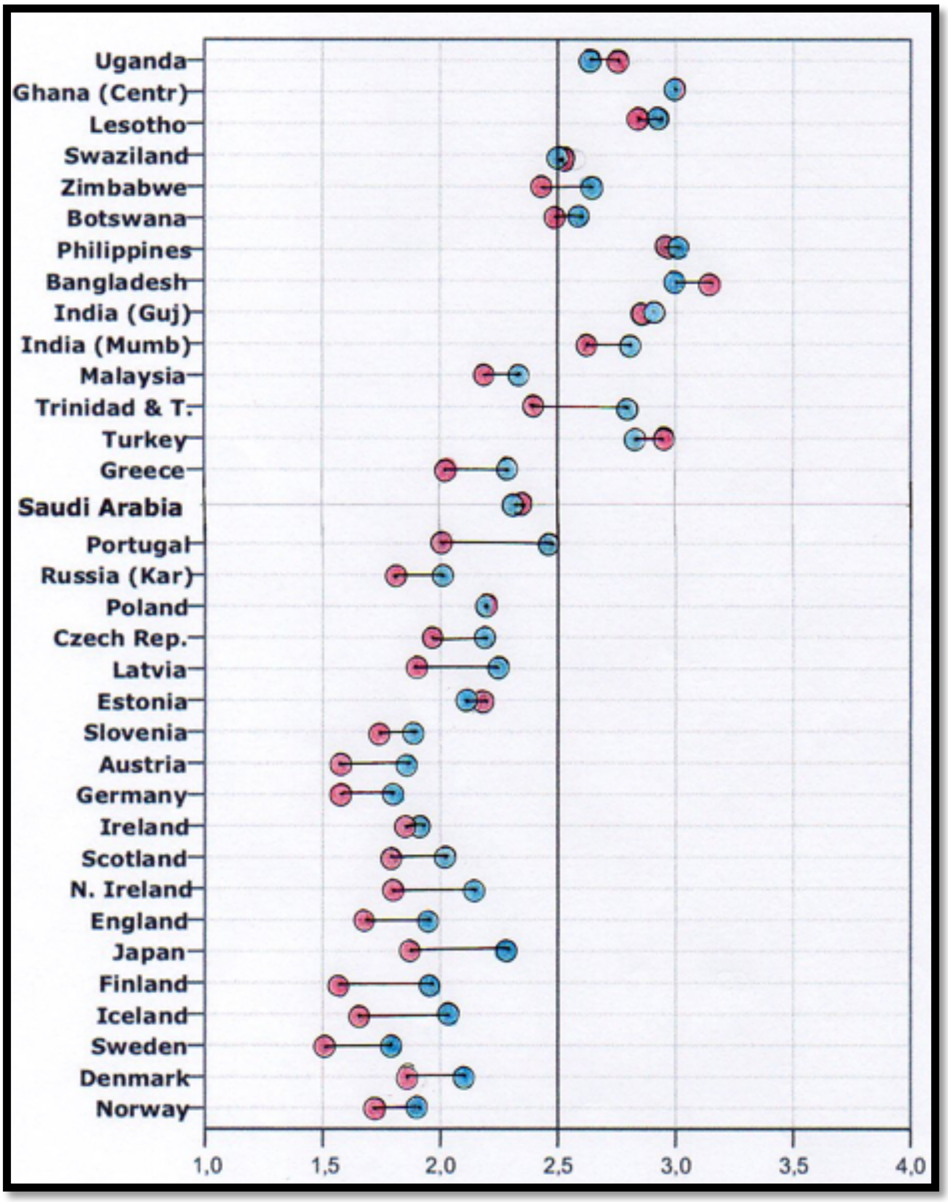

Regarding item G10, ‘Science and technology are the cause of the environmental problems’, the students’ responses differed, being distributed across Agree, Neutral and Disagree. For example, in Saudi Arabia, girls did not agree that science and technology are the cause of environmental problems, while boys had a neutral opinion. However, the overall ratio of gender differences was low in most countries, except Saudi Arabia and a few other countries such as Botswana and Turkey that showed statistically significant differences in this item. The girls’ average value is lower than that of the boys in most countries as well.

Figure 7-9 The mean of item G14: We should always trust what scientists have to say




It is clear that students in almost all the countries that participated in the ROSE project disagreed with item G14, ‘We should always trust what scientists have to say’ (Figure 7-9). Only the students of Bangladesh and Ghana and the boys of Lesotho agreed with the item. Figure 7-9 also indicates the more negative attitude of students from developed countries and their greater doubts compared to the students from developing countries. As for gender differences, there were statistically significant differences in Saudi Arabia and some developed countries such as Finland and developing countries such as Trinidad and Tobago, as well as a lack of gender differences in other developing and developed countries, for example, Malaysia and Denmark respectively.

Figure 7-10 The mean of item G15: Scientists are neutral and objective




The results of item G15, ‘Scientists are neutral and objective’, presented in Figure 7-10, indicate the difference between developed countries and a number of developing countries in Africa and Asia. Although the Saudi students and their peers in developed countries did not believe that scientists are neutral and objective, students in some developing countries, especially poor countries, had a different opinion, and agreed with item G15. Gender differences are more noticeable in developed countries (in favour of boys) but are absent in Saudi Arabia and certain developing countries.

#### 7.2.5.2 Discussion

Developing and developed countries differ economically and socially. There are a multitude of factors that contribute to these differences, including geographic features, cultural, economic and social elements, history, international relationships and political situations (Korkmaz, Thomas, Tatar, & Altunay, 2017b). These differences are reflected in students' attitudes, so the attitudes and perceptions towards science held by students vary, depending on the country from which the student hails. As in this study, compared to students from developed countries, the attitudes of students from developing countries are more positive (Sarwar et al., 2011). Smith et al. (2019) proposed that in developing countries, this could be the result of the comparatively recent availability of science and technology education, as well as the influence of social desirability effects.

There is strong evidence that students' attitudes towards science outside school are more positive than the attitudes towards school science (Bennett et al., 2013b) . The results of the current study show the Saudi students had a positive attitude toward science and technology, consistent with the view of Bennett et al. (2013b) that a number of students believe that science has an important role to play in society, although they do not have a desire to study scientific subjects personally. From the data in this section, it is clear that the Saudi students' responses to the first five items (G1, G2, G3, G11 and G12) agreed with those of their peers in developed and developing countries, in that the Saudi students expressed positive opinions towards science and technology. The Saudi students also agreed with their peers in developed countries and several developing countries in the last five items (G8, G9, G10, G14 and G15), in expressing negative attitudes towards these items.

Science and technology have contributed to solving different problems, for example treating diseases. The tangible medical progress in the current era may contribute to the optimism of students about science and technology in all developing and developed countries. In addition, technology offers many of the mechanisms that contribute to raising work efficiency and productivity, as well as speeding and facilitating the work process. Therefore, this progress in technology may have contributed to students' positive attitudes towards science and technology, which will provide opportunities for future generations. So, technology may carry hopes for the future, such as many economic development projects, and the emergence of developments in many areas providing opportunities for future generations. However, developing countries are largely dependent on scientific and technical knowledge that was produced in developed countries (Alwahadina, 2020). Also, productive enterprises prefer foreign technology because its use involves less risk than new local productive technologies, if any. On the other hand, the local productive system presumes that researchers and local technicians are unable to produce useful knowledge which can replace foreign science and technology (Alwahadina, 2020), which could explain some students' opinion on developed countries in items G12 and G11.

When responses to section G given by Saudi students are compared to responses from students in other countries that share the same religion, such as Turkey and Malaysia, it is shown they had similar attitudes such as items G2, G3 and G11. Despite the role of culture in attitudes toward science, it was noticed there is agreement between countries in these items. However, in item G15, Turkish students gave more positive responses compared to Saudi and Malaysian students. Perhaps students from Turkey have higher confidence in scientific achievements. They perceive science to be absolutely true and able to resolve the majority of life's problems (Griethuijsen et al., 2015). The possible explanation may be that the focus of science education in Turkey is on students being able to "understand how scientific knowledge is generated, increase inquiry and problem solving skills and to understand the interaction among science, technology, and society and its effect on the work of scientists" (Akcay, 2011, p. 2).

Malaysian students did not express the belief that 'Science and technology benefit mainly the developed countries'. In 1991, Malaysia set about transforming the nation's status to become a developed country by 2020. The blueprints for this progress were detailed in a policy called 'Vision 2020' (Prime Minister's Office of Malaysia, 2008). The policy focused on nine missions, the sixth of which was to establish a scientific and progressive society. Vision 2020 argued that to achieve the desired status, Malaysia had to not only be a consumer of technology; its society must also be innovative and progressive and be involved in future developments in science and technology (Amri, 2012). Therefore, this vision may have affected the opinion of Malaysian students, making them believe that science and technology benefit under-developed countries. Also, this point can indicate the role of the government in education and students' attitudes. However, as a result of scientific studies arising from developed countries, Saudi students believed science is more beneficial to these countries, as it contributes to their development, which was also believed by Turkish students (Korkmaz et al., 2017).

From the figures above, it can be seen that both boys and girls in developing countries, especially in poor countries such as Ghana and Lesotho, are interested in science and technology more than others. It is possible that the enthusiasm exhibited by the students for science and technology may stem their perception that science and technology in society offer solutions to their problems and will bring development. An alternative reason may be that the process of developing technology is not risk-free and can have adverse unintended consequences, of which students in developing countries may be unaware, because their societies have not experienced them. However, as the challenges of underdevelopment are likely to outweigh the concerns experienced by people in developing countries, it is probable that the risks perceived by those in developing countries to be worth taking; therefore, science and technology continue to occupy a significant role in these countries. This hypothesis is supported by Schreiner (2006), who notes a correlation between the extent to which a country is developing, and the positive perceptions held by young people about the role of science and technology in their society. Both Schreiner (2006) and (Sjøberg & Schreiner, 2007) detail how students from developing countries are concerned about using science and technology to improve their societies and the welfare of their nation. When viewed from this perspective, it perhaps can be understood why such students hold science and technology in such high esteem. In order to improve quality of life, better health, as well as financial and economic improvement is needed. To take care of themselves, students in developing countries need to learn about issues regarding their health, and science and technology open up an array of opportunities for work (Sjøberg & Schreiner, 2019). Students in these countries also perceive that without the benefits provided by science and technology, the opportunities of future generations will be curtailed.

The results show that the students from developed countries are more hesitant than those in Saudi Arabia, which is a developing country, especially in the least five items. In that regard, and supporting this result, some researchers argue that the interest in science and technology wanes in many school-aged children in very developed societies (Atkin & Black, 2005; Sjøberg & Schreiner, 2004). In contrast, interest in science and technology and learning in general is greater in students from less developed countries (Sjøberg, 2000b). One possible explanation for this is that students in developed countries prefer to study other subjects in preference to science and technology, and this preference does not reflect disrespect for science and technology. It is possible that there is a difference between students from developed and less developed countries in the expectations, images and values they attach to school science and technology. Also, another possibility is that this is a result of

> low public understanding of science, caused by bad teaching as well as a low or negative profile in the media...many young people have a rather well informed sceptical attitude towards certain aspects of modern society. Maybe their doubts are based on real fears about an unknown future [to which] scientists may lead them (Sjøberg, 2002c, p. 96).

Currently, many young people in developed societies are very focused on adverse effects that have been attributed to science and technology, whereas students in less developed countries still perceive science and technology as being wholly beneficial (Anderson, 2006).

## 7.3. **Summary**

In this chapter, the data that was presented and discussed answered Research Question Three. Quantitative and qualitative data indicate that Saudi students held positive attitudes toward science and technology. They believed science plays a significant role in life, because it enables them to realise and understand things about people and expands our knowledge. Also, a number of participants justified the importance of science, because it has a daily relevance, and science helps people understand the world. In addition, students thought society must be familiar with technology in order to know how to use it, which helps protect society from technological risks. Moreover, they regarded science and technology as important to society, because they help people help themselves. They believed science and technology offer a pathway to eliminate or reduce the damage caused by diseases, and recognized the accomplishments of science and technology in regard to improving the quality of human life, especially the progress made by medicine.

The Saudi students considered the media to be a significant source of knowledge on scientific phenomena, that helps facilitate access to and understanding of information. They believed that a broad, balanced curriculum (including science) refines students' skills and knowledge, while also improving their understanding, which helps them develop into well-informed people. Despite the students' positive attitudes toward science and technology, there were a number of items in section G of the ROSE questionnaire that neither girls nor boys agreed with, such as G8, G9, G10, G14 and G15.

In regard to gender differences, both boys and girls appeared to have positive attitudes, and there were no clear differences between them. However, there were statistically significant differences in six of the sixteen items, three for girls and three for boys. As for the international comparison between Saudi students and their peers, who participated in the

ROSE project, the results show agreement between Saudi students' views and those of students from developing and developed countries. Both had positive views toward science and technology in the first five items of the comparison. However, in the last five items, Saudi students agreed with students from developed countries, while a number of students from developing countries had a negative view of these items. Cultural, social and economic factors have an influence on students' attitudes towards science and technology. In developing countries, there is optimism that science and technology will improve social and economic conditions. In developed countries, despite the positive attitude toward science and technology, there are concerns about the risks of science and technology to the environment.

# Chapter 8: Answering Research Question Four

**What are the Saudi students' responses to school science?**

## 8.1. **Introduction**

The fourth research question explored students' views regarding science classes. This chapter answers that question, using both quantitative (the ROSE questionnaire) and qualitative (diamond ranking) data. Where there is a correlation correspondence between them, the students' qualitative views are used to describe and elucidate the reasons behind the quantitative data. The chapter also investigates whether there are differences in the opinions of boys and girls on this matter, using the Chi Square test.

Finally, the chapter compares the responses of Saudi students to school science with the opinions of students in other countries who have also participated in the ROSE project.

## 8.2. **My Science Classes**

As mentioned previously, one of the research aims was to investigate the attitudes of Saudi students towards science classes. In Section F of the ROSE questionnaire students are asked about possible advantages gained from their science studies in school. Section F contains a subset of 16 questions on 'My science classes', to be answered on a four-point Likert-type scale, ranging from 'disagree', to 'agree'. The results of section F are presented, and each point is discussed before moving on to the next.

The Saudi students' answers to section F of the ROSE questionnaire and the mean values of the 16 items are given for girls and boys respectively in Tables 8-1 and 8- 2. The two tables provide a statistical analysis of the Saudi students' responses. In Tables 8-1 and 8-2, a value of 2.5 can be considered 'neutral', meaning that the students neither agreed nor disagreed with the statement.

## 8.2.1. Results

Table 8-1 Girls' responses to statements about their science classes

| N | Items | Frequency | | | | | | | | Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Disagree | | Low disagree | | Low agree | | Agree | | |
| | | Count | % | Count | % | Count | % | Count | % | |
| 1. | F11. School science has increased my appreciation of nature | 7 | 2.4 | 47 | 16.3 | 118 | 41.0 | 113 | 39.2 | 3.18 |
| 2. | F4. School science has opened my eyes to new and exciting jobs | 12 | 4.2 | 41 | 14.2 | 121 | 42.0 | 111 | 38.5 | 3.18 |
| 3. | F12. School science has shown me the importance of science for our way of living | 6 | 2.1 | 50 | 17.4 | 119 | 41.3 | 110 | 38.2 | 3.17 |
| 4. | F10. School science has increased my curiosity about things we cannot yet explain | 16 | 5.6 | 49 | 17.0 | 104 | 36.1 | 116 | 40.3 | 3.13 |
| 5. | F8. I think that the science I learn at school will improve my career chances | 21 | 7.3 | 57 | 19.8 | 107 | 37.2 | 100 | 34.7 | 3.00 |
| 6. | F7. The things that I learn in science at school will be helpful in my everyday | 22 | 7.6 | 45 | 15.6 | 132 | 45.8 | 85 | 29.5 | 3.00 |
| 7. | F2. School science is interesting | 14 | 4,9 | 69 | 24,0 | 128 | 44.4 | 74 | 25.7 | 2.92 |
| 8. | F5. I like school science better than most other subjects | 20 | 6.9 | 77 | 26.7 | 95 | 33.0 | 91 | 31.6 | 2.91 |
| 9. | F6. I think everybody should learn science at school | 18 | 6.3 | 82 | 28.5 | 97 | 33.7 | 88 | 30.6 | 2.89 |
| 10. | F13. School science has taught me how to take better care of my health | 26 | 9.0 | 72 | 25.0 | 118 | 41.0 | 69 | 24.0 | 2.81 |
| 11. | F9. School science has made me more critical and sceptical | 25 | 8.7 | 82 | 28.5 | 107 | 37.2 | 69 | 24.0 | 2.77 |
| 12. | F1. School science is a difficult subject | 17 | 5.9 | 89 | 30.9 | 121 | 42.0 | 59 | 20.5 | 2.77 |
| 13. | F3. School science is rather easy for me to learn | 37 | 12,8 | 99 | 34,4 | 118 | 41.0 | 29 | 10.1 | 2.49 |
| 14. | F14. I would like to become a scientist | 70 | 24.3 | 77 | 26.7 | 70 | 24.3 | 67 | 23.3 | 2.48 |
| 15. | F15. I would like to have as much science as possible at school | 54 | 18.8 | 101 | 35.1 | 81 | 28.1 | 47 | 16.3 | 2.43 |
| 16. | F16. I would like to get a job in technology | 69 | 24.0 | 84 | 29.2 | 74 | 25.7 | 57 | 19.8 | 2.42 |

Table 8-1 shows the mean scores of girl students' views regarding science classes. Generally, the responses to indicate some satisfaction with their science classes. From the table, the items F11, 'School science has increased my appreciation of nature' and F4, 'School science has opened my eyes to new and exciting jobs' had the highest mean values in section F. The percentage of students who agreed with item F11 was 39.2% and for F4, 38.4%, while the mean score was 3.18 for both items. These two items were followed by items F12 and F10, where the numbers of students who agreed with them were 110 and 116 respectively and the mean value was 3.17 for F12 and 3.13 for F10. Items F8 and F7 had the same mean score of 3.00, reflecting students' belief that the science they learned at school would improve their career chances and would be helpful in their everyday life. It is clear that the girls found school science interesting (item F2 scored a mean of 2.92); also, they liked the science they learned in school better than most other subjects (item F5 scored a mean of 2.91). There were 88 students who thought everybody should learn science at school, the mean value for item F6 being 2.89. Moreover, the percentage of students who agreed with F13 was 24.0% and the percentage of students who chose 'Low agree' was 41.0%. Furthermore, both items F9 and F1 had a mean value of 2.77. However, there were some items the girls did not agree with, for example F3 'School science is rather easy for me to learn' (mean value 2.49), F14 'I would like to become a scientist' (mean value 2.48), F15 'I would like to have as much science as possible at school' (mean value 2.43) and F16 'I would like to get a job in technology' (mean value 2.42).

Table 8-2 Boys' responses to statements about their science classes

| N | Items | Frequency | | | | | | | | Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Disagree | | Low disagree | | Low agree | | Agree | | |
| | | Count | % | Count | % | Count | % | Count | % | |
| 1. | F8. I think that the science I learn at school will improve my career chances | 14 | 4.3 | 38 | 11.8 | 110 | 34.2 | 151 | 46.9 | 3.27 |
| 2. | F1. School science is a difficult subject | 16 | 5.0 | 80 | 24.8 | 136 | 42.2 | 85 | 26.4 | 2.91 |
| 3. | F4. School science has opened my eyes to new and exciting jobs | 30 | 9.3 | 68 | 21.1 | 131 | 40.7 | 84 | 26.1 | 2.86 |
| 4. | F6. I think everybody should learn science at school | 41 | 12.7 | 64 | 19.9 | 117 | 36.3 | 89 | 27.6 | 2.82 |
| 5. | F12. School science has shown me the importance of science for our way of living | 27 | 8.4 | 80 | 24.8 | 130 | 40.4 | 76 | 23.6 | 2.81 |
| 6. | F10. School science has increased my curiosity about things we cannot yet explain | 41 | 12.7 | 71 | 22.0 | 119 | 37.0 | 83 | 25.8 | 2.78 |
| 7. | F9. School science has made me more critical and sceptical | 39 | 12.1 | 89 | 27.6 | 106 | 32.9 | 80 | 24.8 | 2.72 |
| 8. | F7. The things that I learn in science at school will be helpful in my everyday | 46 | 14.3 | 71 | 22.0 | 122 | 37.9 | 75 | 23.3 | 2.72 |
| 9. | F11. School science has increased my appreciation of nature | 35 | 10.9 | 93 | 28.9 | 113 | 35.1 | 72 | 22.4 | 2.71 |
| 10. | F2. School science is interesting | 43 | 13.4 | 85 | 26.4 | 138 | 42.9 | 51 | 15.8 | 2.62 |
| 11. | F13. School science has taught me how to take better care of my health | 45 | 14.0 | 91 | 28.3 | 120 | 37.3 | 58 | 18.0 | 2.61 |
| 12. | F16. I would like to get a job in technology | 61 | 18.9 | 83 | 25.8 | 90 | 28.0 | 80 | 24.8 | 2.60 |
| 13. | F5. I like school science better than most other subjects | 50 | 15.5 | 117 | 36.3 | 84 | 26.1 | 57 | 17.7 | 2.48 |
| 14. | F15. I would like to have as much science as possible at school | 76 | 23.6 | 118 | 36.6 | 76 | 23.6 | 46 | 14.3 | 2.29 |
| 15. | F3. School science is rather easy for me to learn | 67 | 20.8 | 130 | 40.4 | 85 | 26.4 | 33 | 10.2 | 2.27 |
| 16. | F14. I would like to become a scientist | 92 | 28.6 | 100 | 31.1 | 70 | 21.7 | 52 | 16.1 | 2.26 |

From Table 8-2, it can be observed that there were only four statements with a mean lower than 2.5. There was low disagreement with item F5, ‘I like science better than most other subjects, and the mean value was 2.48. For items F15, F3 and F14, the mean values were 2.29, 2.27 and 2.26, respectively. On the other hand, there was an agreement that science is relevant to careers, health and everyday life. Items 7, 8, 10 and 13 had mean values of 2.72, 3.27, 2.78 and 2.61, respectively. Also, there was an agreement on the importance of science (statements F6 and F12) and that science is interesting (item F2). Despite this, 136 students answered item F1, ‘School science is a difficult subject’ with ‘low agree’, while 85 students agreed. On the other hand, 131 students chose ‘low agree’ and 84 students agreed that science opened their eyes to new and exciting jobs (item F4).

## 8.2.2. Analysis and Discussion

As mentioned previously, the research data were collected by the use of two tools, the ROSE questionnaire and a diamond ranking activity. In this section, the results from section F of the ROSE questionnaire, giving the participants’ opinions regarding science classes, and the results from the diamond ranking activity, regarding the importance of science, will be discussed in relation to the existing literature.

In general, the responses of Saudi students presented in Tables 8-1 and 8-2 and the perceptions of the Saudi students regarding their science classes indicated a broad range of attitudes. The results show that Saudi students experienced varying levels of satisfaction regarding the science taught in their schools. Although they generally agreed that school science is important, and the overall result of the ROSE questionnaire for section F gave a mean value of 2.84 for the girls and 2.68 for the boys, a number of items, such as F14 and F15, indicate some dissatisfaction with school science teaching. Tables 8-1 and 8-2 indicate that the students agreed with 12 of the 16 items in section F of the questionnaire and disagreed with the other four items.

### 8.2.2.1 Items with mean above 2.50

The items are presented in Tables 8-1 and 8-2 according to their mean value; consequently, the order of the items differs from the original questionnaire. However, the items will be discussed in the order in which they come in the ROSE questionnaire.

1. **F1: 'School science is a difficult subject'**

The results for this item show that the students believed that school science is difficult, as the mean value for the item was 2.77 for girls and 2.91 for boys, as shown in Tables 8-1 and 8-2. These results indicate that the students in the sample experienced difficulty in studying science subjects in school, and they therefore considered science to be difficult. More boys than girl rated science as difficult, contrary to Jenkins and Nelson (2005) and Oscarsson et al. (2009), who concluded that girls have greater difficulty in studying scientific subjects than boys. In the current study, the number of boys who agreed that science is difficult was greater than the number of girls. As shown in Tables 8-1 and 8-2, the number of girls who believed that science subjects are not difficult was 36.8%, while only 29.8% of boys believed that science subjects are not difficult. However, the disparity between girls' and boys' responses in this study was not statistically significant. A possible explanation is that students do not typically encounter gendered stereotypes often linked with STEM subjects from within these educational institutions, which are gender- segregated (Sani, 2018). Research has consistently recognized that gender profiles related to subjects persist in co- educational schools (Archer, Moote, Francis, DeWitt, & Yeomans, 2017; Fryer Jr & Levitt, 2010).

Vygotsky (1962) points out that the learning process is strongly affected by the social environment. He stated that students primarily learn through their interactions with teachers, peers, friends and experts. Thus, teachers should create learning environments in which learners have sufficient opportunities to interact. This can occur through collaboration, discussion, feedback and other interactive methods. In this study, students' opinions were influenced by the educational environment, as they viewed science as difficult for several reasons, including the teacher, the method of teaching, the lack of practical work and the abstract nature of science topics. These points will be elaborated on further:

1.6. <u>Teaching and the teacher</u>

All the principles, styles and processes used by teachers to enable student learning are considered teaching methods. These strategies are determined partly by the subject matter to be taught and partly by the nature of the learners. Analysis of the participants' attitudes toward science and technology subjects suggested that teacher and teaching methods were among the significant factors in participants' attitudes toward science. Saudi students believed that the teacher has the ability to make a positive or negative impact on the student's attitude toward science, depending on the methods they use. Students expressed negative attitudes towards the prevalent teaching methods, which reflect the high power distance culture in Saudi, where teaching is teacher- centred, and “quality of learning depends on excellence of teacher” (Hofstede et al., 2005, p. 72). The quotations below show that participants were annoyed by the teachers who used didactic methods in science subjects.

> “I don’t like dictations because I get bored from listening, I start to daydream, then come back, I want something that makes me move around and focus. I start to feel sleepy like that. The explanations we have are traditional.” (D-G-1).

> “All subjects have hard and easy parts, but it depends on the teacher and the way she explains and the way she gets the information across. How she gets the information across, the level of indoctrination.” (E-G-1).

> “The teacher teaches, and you have to keep track with him.” (C-B-1).

> “The way the lesson goes is the teacher teaches you and you have to listen.” (B-B-1).

Students’ attitudes toward science are affected by the teaching methods and character of the teacher, which must be considered (Raved & Assaraf, 2011). Despite the role that modern and interactive teaching methods can play in supporting students’ achievements and in helping teachers to provide information on scientific topics effectively (Alsuiadi, 2015; Fakhruddin, Nasser, & Jihad, 2006), participants’ comments support previous claims that Saudi education generally, and particularly the teaching of science, still depends on traditional teaching methods. where the teacher is the speaker and students are the audience who are required to memorise whatever they are told, without any interaction with activities or modern methods that can facilitate communication among all parties in the classroom (Kim & Alghamdi, 2019). This is contrary to constructivism, which argues that knowledge is actively constructed by the learner and not passively received from the environment. Also, students build their knowledge internally, in their own way influenced by the surrounding environment, society and language.

Many Saudi teachers still believe that dictation makes students learn what should be learned. This does not facilitate knowledge- building, but causes students to confuse the scientific knowledge they receive from the teacher with the constructed 'knowledge' that they already possess, which is often incorrect (Zeitoun, 2017). Students are placed in a passive role, that encourages memorization instead of an active role in the formation and construction of knowledge. In this way, students fail to relate what they learn in the classroom to previous knowledge. As a result, students in this study viewed science as difficult due to inability to achieve adaptation, i.e. "assimilation and accommodation, where external events are assimilated into existing understanding, but unfamiliar events, which do not fit with existing knowledge, are accommodated into the mind, thereby changing its organization" (Bhattacharjee, 2015, p. 67).

Negative effects on students' attitudes toward science and a lack of recognition of its utility have been associated with reliance upon textbooks and traditional pedagogical approaches (Ali et al., 2013). In this study, Saudi students found science difficult due to traditional teaching. The research respondents mentioned that some of their science teachers conveyed the subject matter without making use of varied teaching methods. However, in Alhammad's study (2015) interviews with Saudi students underlined the significant differences between the established form of teaching and the new emphasis on communication. The students maintained that the new teaching approach was superior to traditional methods because it encouraged interaction and dialogue. Students favoured moving from the lecture type of approach to a more conversational style. Similarly, in this study, students expressed a positive attitude when teachers employed effective teaching methods, as reflected during the discussion. One participant said:

> "It depends on the teacher. our teacher is good at explaining in physics, so she is the one who made it easy for us, so it depends on the teacher that makes you understand." (F-G-1).

Some participants had a positive attitude toward biology because of the methods that the teacher used, such as linking theory to their real life or making the lesson easy and simple.

> "We like biology because the teacher has a simple style. When the teacher explains she does it in a simple way. We like biology because of the teacher. She brings information from outside of the topic and she brings it from the reality of life." (A-G-1).

Such a view is consistent with the principle that learning is related to experience, not indoctrination, so the society in which the students live has a great influence in building knowledge (Zeitoun, 2017). Thus, in this study, students viewed learning science as easy when teachers connected the topics to their previous experiences and real life. According to Tay and Saleh (2019) “Different teaching methods enable students to explore different phenomena in different ways and allow them to relate science concepts to everyday life hence this maximises their understanding in science” (p.132). This implies that science teaching should take into account the learners’ personal curiosity and societal context. In this way, it will be relevant to their experiences and personal needs.

### 1.7. Practical work

According to Millar (2004), practical work refers to those activities which involve the learner in watching or manoeuvring real, or virtual, materials or objects. Suitable practical work enriches students’ experience of science, as well as their understanding, skills and overall enjoyment of the subject. Students’ attitudes towards science in school and their enjoyment of the subject seem to be significantly influenced by the inclusion of practical work. One of the reasons why students in this study believed that science is difficult was lack of practical work, which negatively impacted on students’ attitude toward science. Due to lack of time devoted to teaching, reliance on traditional methods of teaching and lack of resources in the lab, science education in Saudi often focuses on theory and rarely on practical work.

F-B-1 attributed their inability to remember theories to a lack of practical work; because of that, they did not know how and where to apply these theories, which made science difficult for them:

> “...it might help me to understand and the fact would stick. However, these theories, I don’t know where to use them.”

A similar view was expressed by F-B-2:

> “...[it is] hard for us to understand because the teacher explains without doing practicals, so the most important things in scientific subjects are the practicals, for example when he explains, it’s hard for me to understand, but when he shows me it step by step, it will keep it in my mind.”

According to constructivist thinking,

> Knowledge is not merely transmitted verbally but must be constructed and reconstructed by the learner. Piaget asserted that, for a child to know and construct knowledge of the world, the child must act on objects and it is this action which provides knowledge of those objects (Sudha, 2014, p. 113).

However, in Saudi Arabia, many schools do not have science laboratory facilities. In some schools, although buildings have been erected for science laboratories, they are not well equipped. Many schools also lack competent and qualified science laboratory workers to carry out and supervise experiments (Alsharari, 2016). Hence, students in this study were unable to apply science in the laboratory, which made science difficult. Science experiments play a role in students' involvement especially when they have difficulty understanding scientific topics (Kim & Alghamdi, 2019).

1.8. Abstract topics

It is in the nature of some scientific topics to be abstract, and this is one of the obstacles that students face because it is hard for them to exercise their imagination regarding these topics. If the teachers were able to employ practical work in teaching these science subjects, perhaps it would help them to convey the information effectively and enhance the students' achievements. However, the participants complained of a lack of practical work, especially in areas that are difficult to observe in life, as was mentioned previously in the focus group responses related to sections A, C and E. Some of the group participants described how they struggled to understand topics in physics because, to them, it was all "fictional", and not something they could relate to their real lives.

> "…all information in physics is overlapped, it's all imaginary How can I imagine something that doesn't happen in real life?" (H-G).

Other participants also expressed that the elements of physics were less than obvious to them in their daily experience. These participants believed that this made studying physics difficult and this was reflected in their attitude towards physics.

> "There are some things in physics that I have not come across before, which makes them hard." (F-B-1).

> “We studied a theory class in physics about quantum mechanics. In my opinion, I feel that the class was very boring because it’s not realistic for me. Anything that is not realistic, I just can’t process it.” (A-B-1).

Participant’ views recall Piburn and Baker’s (1993) claim that one reason for the negative attitudes students have toward science is that the subject is complex and draws upon abstract concepts. In this study, the abstract nature and complexity of science was one of the reasons students gave for having a negative attitude towards science. Consistent with Butt et al.’s (2010) claim, that students have difficulty in identifying the relationship between science and their daily activities, Saudi students could not related science topics to reality, which made them difficult and boring. This is similar to finding by Sheikh (2016) that a key reason for the difficulty of learning science subjects is the way in which these subjects are presented to students, whether by the teacher or in the academic content, which makes many of them feel that science topics and vocabulary are dry and complex, and that formulae are no more than “talismans” (incantation), so they do not understand them, and do not realize the goal of learning them. This leads to forgetfulness, lack of interest in studying and difficulty acquiring concepts. The scientific language used in textbooks may be a reason for the difficulty of science topics. Since students have difficulty understanding the language of the book, they do not understand scientific topics. According to Albadi, O'Toole, and Harkins (2017), “Difficulties with specialized language may seriously impede the development of physics understanding by Saudi students” (p.639).

These factors may explain why item F3, ‘School science is rather easy for me to learn’, received negative responses. The mean value for that item was 2.49 for the girls, which is near to neutrality, while for the boys the mean value was 2.27, which is negative. The percentage of boys who did not agree with the item was greater than that of the girls, suggesting that more boys struggled with school science than girls. The reason for this negative response may be that the traditional methods of teaching used make it hard for students to understand scientific topics and forced the students to memorise and repeat without understanding.

From the above, it was concluded that Saudi students’ attitudes towards studying science subjects were not wholly positive, as they considered it hard. Such negative perceptions can affect attitudes, performance and achievements (Lindahl, 2003). The Saudi students’ attitudes towards science were impacted by science teaching methods that focused on theoretical information without practical application, a point frequently raised during their discussions in focus groups. In addition, participants referred to the impact that the difficult curriculum had on their ability to understand scientific topics, giving rise to the expressed belief that science subjects were “useless”. A similar result was mentioned by Anzi (2014), who explored the viewpoints of Saudi science teachers towards the constraints on teaching the content of the science books that had been developed in Saudi Arabia. Anzi identified several constraints, such as the difficulty of some of the science topics that the books covered and a lack of supplies and laboratory equipment. Anzi (2014) also mentioned the science teaching method as another obstacle, explaining that teachers tended to avoid using modern teaching methods due to their difficulty and their own lack of time. In contrast, Jenkins and Nelson (2005) in the UK did not find strong evidence to support the opinion that students find school science difficult.

Relating the students’ scientific knowledge to their everyday lives can enhance their beliefs regarding the importance of science to life and society. These would be further enhanced if they realized that science is relevant to problems faced by society as a whole, such as diseases and global warming. Students could then come to feel that what they learn in science can help them to understand themselves, their environment and the surrounding world. This, in turn, could help to solve the problems that they and society face. In addition, teachers should enhance their students’ use of their scientific knowledge in their everyday lives. Instead of focusing on memorising information and theory, teachers could encourage students to use mental processes that increase their ability to understand the facts and principles of science. If they did this, they would also be able to focus on understanding the information in depth, facilitating the interdependence and integration of the information in a way that would facilitate real understanding.

2. **F2, ‘School science is interesting’**

Students responded positively to F2, ‘School science is interesting.’ even though the participants believed that science is difficult, as discussed previously. Tables 8-1 and 8-2 show that the girls’ mean value for item F2 was 2.92 and the boys’ was 2.62. This indicates that girls were more interested in science than boys, and the difference is statically significant. This may be related to the perceptions of difficulty reported above. According to a study by Skamp and Logan (2005), when science is perceived as more difficult, it will be of less interest. Moreover, Logan and Skamp (2008) mentioned that in their study, “All participant students whose science interest scores declined markedly over the transition had an increase in science difficulty sub scores” (p.790). The more science attracts students’ interest and answers their questions and arouses their curiosity, the more positive their attitudes towards it.

Although a number of students considered science to be a complicated subject and hard to understand, others considered science subjects to be less difficult and disagreed with their friends, who said science was difficult. They had been warned that the scientific route was tough because of the nature of scientific subjects, but when they studied science, they found that it was easy, contrary to what they had been told.

> "People made it seem hard, they say that the scientific pathway is really difficult but when I chose it, I found it really interesting" (B-G-1-2).

Connecting science content with students' interests and real-life issues makes science topics easy and interesting. Thus, in this study, the students showed greater enthusiasm for science topics that were related to their real life, and they were more inclined to say that they found school science interesting. As one group mentioned in their discussion around the diamond ranking activity, they were interested and curious to learn more about electricity and rainbows:

> "I feel like physics is interesting and especially electricity." (I-G-1).

> "Physics is interesting; it explains rainbows and things." (G-G).

Furthermore, as mentioned before, human biology attracted the students in several ways, including its ability to help them understand their bodies and the functions of their organs.

> "It [biology] is easier and you come across the things you learn in your everyday life; it is interesting." (F-B-2).

As mentioned in Chapter Five, the topics of electricity, light and human biology were seen as relevant to the lives of Saudi students, which made them enjoy learning them in school. This explains the positive attitude of Saudi students to this item.

To help students engage with the subject and make them enthusiastic about learning science, it is important to make the topic interesting. The learning of science can be made into an adventurous and exciting activity by drawing upon various equipment, materials, methods, laboratory and visual aids that motivate the students to investigate the concepts under consideration, thereby improving their understanding (Bal, 2018).

Consistent with this view, students claimed to feel positive about practical work because they believed that it helped them to learn and understand, making the study more fun and providing an exciting way to learn about science. Participants, confirmed that they found the practical work to be enjoyable and that it helped them to achieve a deeper understanding of the topic.

> "There are experiments; that is why we enjoy practicals." (J-G-1).
>
> "Experiments help students understand more." (C-B).
>
> "It [practical work] helps with education a lot. We understand 90% more with practicals." (H-B-2).

For many years, science educators have suggested that many benefits accrue from engaging students in science laboratory activities (Hofstein & Lunetta, 2004; Tobin, 1990). For example, Tobin (1990) wrote that: "Laboratory activities appeal as a way of allowing students to learn with understanding and at the same time engage in the process of constructing knowledge by doing science" (p.405). Tobin's claim was supported by participants' attitudes, making practical work appear as a significant factor reflecting positively on their attitudes toward the subject. It was clear that participants making positive statements toward science subjects had teachers who employed experiments during their lessons. For example, group A-G-2 had positive attitudes toward physics because they practised experiments that made them feel that their lesson was interesting and understandable.

> "We do experiments with the teacher in physics and we listen and understand."

Participants believed that practical work was useful in helping them understand science subjects, because it gave them the opportunity to learn by doing, and in turn made science interesting. This observation agrees with a study by Bradley (2016) in South Africa, which found that practical work was enjoyed by most learners.

From the participants' discussion, it became clear that practical work played an important role in the students' level of interest in the science subjects and that negative attitudes toward subjects were prompted by a lack of practical work. For example, some participants held negative attitudes towards physics because they did little or no practical work in that subject.

"Physics is very boring; there is only a little bit of practicals in it." (I-G).

It can be concluded from responses to item F2 that an interest in school science will depend on several factors, which include having an interesting topic (the content), being relevant to everyday life and doing practical work. As mentioned before, Saudi students expressed an interest in studying biology because they had a desire to discover unknown facts about their bodies. They believed that learning about human biology was important to know how their bodies were built, which they considered relevant and meaningful. Students were interested in some aspects of science because they involved topics they could see and recognise. For example, girls were interested in physics because it explained rainbows. Moreover, the way they were taught science in school impacted their interest in it. For example, some participants felt that physics was boring because of the didactic teaching style and the lack of practical work. This confirms that the level of interest and the development of interest in science subjects are strongly dependent on the perceived attractiveness of the content of the lessons and on the way the scientific knowledge is presented and taught, as argued by Krapp and Prenzel (2011).

A number of previous studies (Elster, 2007; Osborne & Collins, 2001) have listed the factors that encourage students to enjoy their scientific subjects. Among these factors are participating in practical work, the curriculum content, its relation to the students' daily life and the quality of the teaching methods. The present finding is clearly consistent with the results of Cleaves (2005), who found that students complained of not doing enough practical work in their science classes and that this made their lessons very uninteresting. At the same time, it is evident that the current study results contrast with those of a number of studies that have focused on school science in the UK and Australia (Colley & Comber, 2003; Dawson, 2000; Osborne & Collins, 2001). These studies showed that boys are more interested in science than girls, while the current study shows that, among the participating Saudi Arabian students, at least, the girls were more interested than the boys. Moreover, the current findings add credibility to the results of a previous section of this study. The students in this study, and especially the girls, expressed their willingness to learn or were already interested to learn many of the science subjects, as indicated in the A, C and E sections of the ROSE questionnaire.

3. **F4, 'School science has opened my eyes to new and exciting jobs'**

Although item F4 is fourth in order in the ROSE questionnaire, it was second for the Saudi girls, and Table 8-1 shows that the mean value for girls was 3.18. For the Saudi boys, it came third, with a mean value of 2.86 (Table 8-2). During their discussion of the diamond ranking activity, the girl participants did not identify specific jobs that would become available to them after studying scientific subjects, but they did mention how studying science had opened their eyes and helped them to understand phenomena that occur frequently (like evaporation) from a scientific perspective.

Saudi Arabia has undertaken many reforms to empower women and enhance the equality between them and men, in light of the provisions of Islamic law. The Saudi Vision 2030, which was launched in 2016 to improve the economy, and the '2020 National Transformation Programme' have placed the empowerment of Saudi women among their top priorities (Al-Balawi, 2020). Furthermore, Vision 2030 aims to provide job opportunities for Saudi women by the year 2030, and to end the structural patterns of differentiation between women's work and men's work. Saudi Arabia seeks to encourage Saudi women to study various disciplines, especially science, technology, mathematics, and engineering. This opens up diverse areas in the labour market space (Al-Balawi, 2020). Thus, these reforms may be a cause for the positive attitudes of Saudi students (especially girls) towards school sciences.

The quantitative data from the current research showed that both Saudi boys and Saudi girls —the girls slightly more than the boys—believed that school science had opened their eyes to the possibility of exciting jobs. In addition, some of the girls participating in the diamond ranking activity (for qualitative data) mentioned that they had not yet decided what job they would like to do, but that they had chosen the science route because the job options would be wider after graduation, and this had opened their eyes to the possibility of new and exciting jobs. This finding disagrees with some of the results of other developed countries, perhaps because in some countries these jobs are not new, such as in England (Jenkins, 2005) and Sweden (Oscarsson et al., 2009).

4. **F5, 'I like school science better than most other subjects'**

For this item, the girl participants' answers were positive, as Table 8-1 shows, with a mean value of 2.91, while for boys, the mean value was 2.48, as Table 8-2 shows. The mean values show a significant difference in favour of girls. Regarding item F5, the girl participants preferred science subjects over other school subjects. As mentioned in the focus group, one reason that girls preferred science subjects may be that they require less memorisation than many other subjects. Once they have understood a scientific topic in class, it requires less effort for revision than subjects such as history and literature. Also, they expressed the belief that science subjects describe natural phenomena, such as the human body, while other subjects require interpretation of vocabulary or learning abstract linguistic rules.

However, Saudi culture and limited social mixing between boys and girls have a major effect on Saudi girls choosing to study science (Alghamdi, 2018). Since Saudi cultural and societal norms highlight the difference between males and females, Saudi Arabia provides single-sex schools (Al-Ghamdi, 2019), in which men teach boys and women teach girls. Studies argue that girls are more motivated in single-sex educational environments (Jamjoom & Kelly, 2013). Such environments also lead to academic interest, increased achievement, as well as active classroom participation and confidence (Sani, 2018). Moreover, because the girls were unable to decide on jobs for their futures, they preferred to choose the scientific route, believing it would offer them more options. In contrast, the boys chose the scientific route as they had already chosen their future jobs. During the diamond ranking activity, the participants pointed out that one of the reasons for their choice of the science pathway was that the science subjects explain the natural phenomena that happen in people's lives and are seen every day, and that some of those phenomena are tangible and easy to understand, unlike in other subjects. This made them prefer science subjects over other subjects. Here are some of their comments:

> "I feel like I can touch it (the stuff we learn in science) it's easier because I can feel it and touch it, whereas other subjects like Arabic or grammar, you can't." (J-G-2).

As indicated previously, another reason for choosing the scientific route was to avoid extensive memorising. For example, one of a group of girls commented during their diamond ranking activity:

> "I don't like memorising and that is why I chose scientific subjects." (H-G-1).

Perhaps female students desire and have a curiosity toward exploring planets, and strange phenomena, such as black holes, which is a reason why they prefer science, as mentioned previously, or it may be because they are deprived of some scientific subjects, such as geology. This result is consistent with the girls' higher interest in learning about science subjects in the previous Chapter 5. This result conflicts with Sjøberg and Schreiner (2019) who found that science is rarely students' favourite school subject. Students from developed countries appeared to favour other subject areas (Sjøberg & Schreiner, 2019).

5. **F6, 'I think everybody should learn science at school'**

Tables 8-1 and 8-2 show positive attitudes to item F6. Both boys and girls tended to agree that everyone should learn and study scientific subjects, with 65% of girls and 62.9% of boys expressing this view. The mean value for students, responses to item F6 was 2.89 for girls and 2.82 for boys. This indicates a positive attitude toward the statement. However, in spite of the similarities between the mean values, there is a statistically significant difference in favour of girls. They believed that science has a significant role to play in a country's development and in improving people's lives. Some of the respondents also considered school science to be relevant to people's lives; for example, biology contributes to the treatment of diseases. People cannot dispense with biology because, through it, they will be able to discover and understand how the human body functions, including its organs, cells and vital functions, and thus they can take care of their bodies. A number of participants gave such justifications for believing that everyone should learn science at school.

Referring to the qualitative data for this research, regarding participants' opinions about learning science in schools, the diamond ranking statements included the following: 'To provide a unique contribution to a balanced education, reflecting the fact that science is a major cultural achievement.' This statement was ranked first by three groups of participants, because they believed that studying science could provide a balanced education and encourage a country's development in various fields. Knowledge has become the main engine of production and economic growth, and the focus on information, data and technology has become a recognized factor in modern economies (Al Thaqafy & Abdulraouf, 2015). A Knowledge Economy is one that creates, acquires, adapts and uses knowledge in order to achieve economic and social development (Al-Mutair, 2019). In Saudi, the "Ninth Development Plan" adopts the orientation towards a knowledge-based economy by focusing on education, enabling knowledge transfer and accumulation, and then its generation and investment in various economic and social sectors (Ministry of Economy and Planning, 2014). A positive attitude towards this item may be due to students 'awareness of the role of knowledge and information in economics.

As mentioned previously (Chapter 2), in Saudi secondary schools, students who go through the literature path do not study any science subjects, so participants ranked this statement first because they believed in the importance of teaching science subjects in both pathways. If science were added to the other subjects, it would create a balanced education. For example, A-B-1 made the following comment during their discussions on the diamond ranking activity:

> "It is important because there are no countries that develop without knowledge."

A broad and balanced curriculum provides students with better understanding and wider knowledge, and it is able to improve their skills and produce cadres with a high degree of training and mastery:

> "Learning science is important to students, even students who will continue their studying in a field that doesn't have a link to science, such as Islamic studies. Students must have at least a small idea about science, and none should be ignorant towards science." (G-B-1*)*.

Moreover, there were students who believed that it is important for all students that science—especially biology—is taught in schools, even for those who are on the literature pathway. They justified their opinion by saying that biology is significant in the medical field and has relevance for people's lives, while it also contributes to a balanced education:

> "Biology should be in the literature pathway, because what we learn is also in nature and medicine is based on it." (I-G-1-2).

Besides providing a balanced education, teaching science to all students, in both pathways, can open students' eyes to all scientific fields, enabling them to choose their future jobs wisely. It will enable them to choose an appropriate job and be prepared for the job market after graduation.

> "Anyone who learns in Saudi Arabia has a balanced education, and they would have general information about every subject so that is a good thing: if you want to specialise in something, you would have enough information." (G-B-1).

At the end of the discussion on item F6, with which the participants agreed, they justified their views by saying they believed in the importance of teaching science to all students in schools, even to those who chose the literary pathway, as learning science is one of the best ways to improve students' knowledge of life and help them to choose their future jobs, in addition to the role played by science in the development of the country. Students will be more likely to have a positive attitude towards science classes if they understand the key role played by science and technology in a country's development (Anderson, 2006). Saudi students expressed the belief that development is required in every individual and every nation in all aspects. Also, countries have to apply scientific knowledge in all aspects of development; otherwise the chances of them developing becomes minimal and they could even be rated as undeveloped. Sjøberg (2002c) points out that scientists, engineers and technicians play a major role in improving the lives and welfare of the people living in a developing country, and in driving its growth and improvements. Teaching science at school is a means of nurturing the next generation of professionals. Moreover, students believed that scientific knowledge gained at school was useful for solving real-life problems. Some examples the students gave in this study were subjects concerning disease and medications. This result is in line with Sarjou et al. (2012) in Isfahan and Oscarsson et al. (2009) in Sweden, who found that students believed that everybody should learn science at school.

6. **F7, 'The things you learn in science at school will be useful in my daily life'**

The quantitative data shows that 75% of the participating girls and 61.2% of the boys (Tables 8-1 and 8-2) agreed with item F7. While both girls and boys believed that science subjects are useful in people's daily lives, the mean value 3.00 for girls and 2.72 for boys reveals a statistically significant difference in favour of girls. A number of participants thought they would be able to apply and use what they studied in their daily lives.

Surprisingly, for this point, there was a disparity in the students' opinions as reflected in a comparison of the quantitative and qualitative data. Despite the large number of participants who agreed with item F7 in the ROSE questionnaire, their viewpoints, as indicated during the discussion of the diamond ranking activity, were negative. A number of participants indicated that they did not have the ability to apply the scientific topics they learned at school, except for biology, which could be applied and recognised. Among the benefits of studying biology mentioned by participants was that biology is the gateway through which scientists can explore the body and the treatment of diseases.

There were similar responses on the statements, "To develop practical skills" and "To help with understanding and decision-making in everyday situations"

Participants gave various explanations for their rankings. For example, some groups believed that biology was the only subject that could help people in their everyday lives:

> "It doesn't always help us, there are subjects that help such as biology, and subjects that don't help, such as physics and chemistry." (B-B) and (A-G-1).

Other groups believed that people can come to understand their lives better and make the right decisions through experience and not necessarily through education:

> "I see that it is less important, honestly, because anybody who didn't study or wasn't educated, they can make decisions." (I-G-2).

> "The scientific skills are gained from everyday experiments like I gained it from everyday life and not from school physics." (G-B-1).

There were some groups of students who believed that school science did not help them outside of school, and that they were unable to use it in their daily lives. An example was B-B-1:

> "[science] doesn't help us, we can't use it in our everyday lives."

Another group of participants supposed that the benefit of studying science at school was for general information only (the importance of science in life), and therefore, they would not benefit from it in their real lives.

> "It helps as knowledge and in education; however, it doesn't help in life and in practice." (H-B-1).

Other groups accorded less importance to studying science due to the way science had been taught to them. For example, participant C-G-1 mentioned there was no link between their real lives and what they studied.

> "There is no relation between reality and studying/ education and practicals are what relate them."

The participants in this study seemed to think that the physics topics they studied in school did not match with their realities, even though, in the previous section, they had mentioned that physics is generally important and helps them to understand some of the phenomena that occur in life, such as evaporation and the rainbow. One of the participants mentioned that the chemistry they studied at school could be useful (but did not say how), while physics could not.

> "Chemistry, you can benefit from it in life, but not physics." (J-G-1).

Some students participating in the diamond ranking activity expressed that physics is useless and that they would not use it in their everyday lives. For example, the following comment was made:

> "Physics equations have no purpose. Am I going to use them in my everyday life? It's not going to happen." (H-G-1).

The participants, suggestion that teachers should use practical work to teach students how to apply what they were learning also related to the scientific theories that they learned in school:

> "They are supposed to teach us how to use what I have learnt in my everyday life, like in physics, how do I benefit from it and where do I find it in the first place?" (G-G-1-2).

Teachers in Saudi schools neglect practical work, which might lead to discovery and the proof of facts and focus instead on the memorisation of theories and laws, using traditional teaching methods. Moreover, among the Saudi students, the feeling was expressed that there is a separation between what is studied in school and what they notice outside of school, which had a negative impact on their feelings towards the science subjects. Therefore, a number of the Saudi students expressed the belief that science subjects have no relation to their everyday lives. For example,

> "Here you learn something because of the time of the test and that's it and the facts leave after." (C-B).

The results from item F7 indicate that there were variations in the Saudi students' responses. The quantitative data (ROSE) showed more positive responses, while negative responses were expressed in the qualitative data. In sections A, C and E of the ROSE questionnaire, the students showed positive attitudes to biology because it matched with their everyday lives, and this may illustrate a positive response to that item. The discrepancy between the positive responses in the quantitative data and the negative responses in the qualitative data for this item can be explained by the influence of socio-culture on students. For instance, if scientific topics are related to the students' lives and social issues, such as diseases, then students will be interested in them (e.g., biology), and they believe they can apply them in their daily lives. For example, they expressed interest in energy issues, and wanted to know how to convert solar energy into electricity and how to apply it in their daily lives. Although energy is a physics topic, they mentioned that they could not apply physics in their daily lives, but when topics were related to their lives, they thought that they could apply them. On the other hand, when scientific topics (such as atoms and quantum mechanics) have nothing to do with societal issues, students cannot apply them because they are not related to their daily experiences; therefore, they believe they are useless to them. Another factor is the educational environment; whether it is the teaching methods, the teacher or the imported curricula; if they do not give examples of how the scientific topics relate to students' lives, this had a negative impact on students' attitude towards scientific subjects.

Therefore, considering the negative responses to item F7, the negative comments made by students during the diamond ranking activity may be due to the teaching method that Saudi teachers employ, which focuses only on the theoretical aspects and neglects practical work or linking theory to real life. For example, the students studied chemistry equations, but they did not know how they were actually applied, and this caused them to believe that science is useless. In the Saudi Arabian education system, textbooks form the heart of teaching, with 100 per cent of teachers reporting that they used textbooks and study guides in writing their lesson plans, and when choosing homework assignments and learning activities (Aldahmash, 2016). Teachers are not likely to promote discussions with their students but prefer to impart information - some of which may have no relevance to the lives or experiences of their students. As Allily (2011) pointed out, this results in the current education system being based on a top-down approach, with teachers passing on unchallenged knowledge, and expecting students to learn by rote. This reflects both Saudi Arabia's high power distance, and high uncertainty avoidance that leads to a reliance on established facts and discourages questioning and challenge. This style of education does not develop students' analytical abilities or critical thinking skills. Therefore, students form the impression that science consists of concepts and facts to be "learnt".

Students said that school science is not related to their daily life, but rather that they learn some science from their social life outside of school. Local culture greatly influences the students' life, both outside and within school, including affecting their learning of science subjects. Perhaps the Western (McGraw-Hill) curricula that are not compatible with the culture of the country, made students believe that school sciences are for knowledge and examination purposes, not for application to their daily lives. Rather, they acquired scientific skills from social life, not from school. In this context, Alshammari (2013) notes that non-Western students who are taught Western science will not be equipped with the knowledge they need to understand and explain the observable facts found in their local environment. Accordingly, Saudi students in this study believed that the science in school was for general information only (the importance of science in life), and therefore, they would not benefit from it in their real lives. However, according to George (2006), science and traditional knowledge can be integrated within the science curriculum. Researchers have acknowledged the major role played by culture in science education and recognised ways of incorporating it within curricula. Studies have demonstrated that cultural issues tend to be found in developing, non-Western countries, where people are still attempting to link scientific issues to the reality of their everyday lives. Peat (1994) states that this is true of Saudi Arabia and explains why students may encounter problems when trying to transition from their everyday culture to the culture of science. For this reason, schools have to ensure that the science curriculum reflects the ways in which science is used in everyday life (Bennett et al., 2013b).

7. **F8, 'I think that the science I learn at school will improve my career chances'**

With regard to item F8, the students' responses were positive. It was in fifth position for the girls according to its mean value, which was 3.00, as shown in Table 8-1; while it was in first position for boys, with a mean value of 3.27, as shown in Table 8-2. These results agree with the results of Jenkins and Nelson (2005) and Anderson (2006), both of whom used the ROSE questionnaire and reported that students gave a positive response to item F8. The Saudi students also believed that studying science subjects would improve their career opportunities ('improve my career chances'). The results from item F8 show some gender differences, both in the quantitative and the qualitative data, as explained below.

A major goal of science education is to prepare students for science-related careers in business, health, engineering, education or the industrial sector (Aikenhead, 2005). The results from the focus group support this goal, indicating that the majority of female participants planned to have careers in science, and it was this that led them to choose the science path in high school. Therefore, their career goals affected their attitudes, as the following quotations show:

"We went into the scientific path because of the specialisation that we want to go into at university." (F-G).

"First of all, the ambition is at the end of the day like, a career – scientific level is better." (I-G).

"Scientific subjects give out more than other subjects like, for example, for careers." (C-G).

Saudi culture is steeped in tradition and places high value on family life (Alsalloom, 2015). Therefore, like all working women, Saudi women must contend with challenges. One of these challenges is balancing their roles as wives, mothers and family members along with their roles as employees, managers or business owners. So, many participants in the girl groups were not yet certain about which specific jobs they wanted to do. They chose the scientific path in high school because they believed the field of science would offer more job opportunities from which to choose. These girls had generalised plans that did not specify desired jobs:

"I don't have a specialisation in mind, so I chose the scientific path because it has more options than the literary path." (A-G-2).

"When we're about to university we see which specialisations have jobs and go into them and we don't go into the specialisations that we want." (D-G).

"The scientific field has more departments and more careers, even the level of teaching is better than the literary field." (I-G).

"Despite the absence of any formal structured student career mentoring policies in schools, students are learning from those in their consistent environments highlighting the importance of the social environment for learning (Vygotsky, 1980)" (Sani, 2018, p. 164). In the Saudi social tradition, the financial responsibility is carried by men, which may have motivated boys to emphasise this job-related item. Also, according to Islamic teaching, the financial responsibility for the family is the husband's duty, and he is responsible for providing for the needs of his family, according to his ability (Alsalloom, 2015; Elamin & Alomaim, 2011). Science was perceived to lead to careers which are valued and well paid in Saudi society. Therefore, boy groups also chose the science path due to their career goals, although they were more certain about which specific jobs they wanted, unlike the girl groups. The findings seem to bear out Schreiner's (2006), view that "Boys are more likely to study science with a career in mind, while girls learn science more for the intrinsic interests" (p.58). Similarly, in this study, the male participants chose the scientific path because they specifically wanted to work in fields such as medicine, engineering or computer science:

> "I am going toward Mechanical Engineering." (A-B) and (F-B).
>
> "An officer, hopefully." (G-B).
>
> "I will go into Dentistry." (F-B).
>
> "I am planning to be a pilot, so I will do computer science." (F-B).

Although several factors affected the participants' attitudes towards the science subjects, their future careers played the most significant role. Many participants chose the science path because it was related to their intended future careers, and this gave the students a positive perception of school science. Collins' study (2001) found that students value science because of its career potential, rather than out of a personal interest in the subject.

Another factor to consider for girls in particular, however, is the impact of cultural expectation and constraints. Despite the fact that girls make up more than 50% of university students in the Arab world, with many of them studying science, technology, engineering and maths, few of them engage in jobs or work after university (Keserwani, 2017). Since Saudi women have limited options for careers, most girls go into education as a career. Although girls in Saudi Arabia who graduate from the science pathway in secondary school may study science, maths and computer science at university, actual careers are subject to constructions of women's roles and status that are considered closely related to notions of piety. The Saudi culture attaches a stigma to mixed gender environments, especially for women, which would preclude certain jobs. Conversely it makes computer studies an attractive option, as it gives them more options for their future careers, because computers enable employers to provide jobs for women in separate locations from the men, or else women can work from their own homes (Alwedinani, 2016). This is important in a situation where despite attempts to enhance women's roles and status, laws recently established to support women's mobility are not enforced. Women in Saudi Arabia, for example, can now legally seek employment without requiring their male guardian's consent, but the fear of overstepping existing cultural norms has led to employers continuing to insist on receiving male guardians' approval when they employ women (Tailassane, 2019). Thus, a job must meet not only the girl's expectations but also those of her family and culture. This was reflected in the current research results, where participants' comments during the diamond ranking activity indicated the extent to which families' attitudes influence women's jobs. This is expressed in the following:

> "I like biology and I would like a career in surgery; however, my parents don't approve of this job." (D-G).

Another girl mentioned that society's customs and traditions prohibited her from enrolment in certain university disciplines:

> "There are some specialisations that we would like to go into but we can't because of our customs and traditions." (D-G).

Hofstede's theory of the 'Masculinity' dimension and the high 'power distance' in Saudi Arabia help in explaining these results. In Saudi Arabia, whilst girls grow up under the constraint of many rules and restrictions, many boys enjoy significantly more opportunities to assert their independence. Upon reaching adulthood, every Saudi female's life must be strictly supervised by a legally recognised male guardian, who could be her father, her husband, or a close male family member (Sani, 2018). This explains why another girl expressed an interest in studying architecture, but could not do so, as she would have to move to another city, and her family's customs denied her the right to live alone, away from her family.

> "I want to be an architect, but there is no specialisation in this field in Buraydah" (D-G).

It was evident that both quantitative and qualitative data showed that Saudi students agreed that learning science in school would improve their career opportunities. However, a smaller number of girls than boys agreed with this item. Also, it is clear that the quantitative data shows a statistically significant difference in favour of boys. On investigating the girls' responses, it became clear that they did not have a clear perception of possible future jobs, and they went through the science pathway hoping for greater employment opportunities in the future. In contrast, the boys had a clear perception of their future jobs, so they chose the science pathway to support their future plans. Moreover, Saudi boys have far more choice than girls, because the latter are controlled by social norms and customs that affect their employment options (Alwedinani, 2016). Alasmrai (2016) states that, in Saudi Arabia, women have fewer opportunities to work and less access to training and education than men. Some families will not allow their daughters to live away from home without being supervised. In recent times, the separation of the genders has started to erode, mirroring the integration of the sexes in particular sectors of Saudi society - for example, healthcare (Husain, 2015). However, many female Saudi nurses have responded negatively to this change, and do not accept working in a setting where the genders are mixed (Alghamdi, Topp, & AlYami, 2018), showing how entrenched cultured norms are internalised influencing women's perceptions of the opportunities open to them.

8. **F9, 'School science has made me more critical and sceptical'**

Both girls and boys agreed with item F9, here the mean value was 2.81 for girls and 2.72 for boys (Table 8-1 and 8-2). Most of the respondents believed that school science was useful to them, as it gave them the ability to be more analytical and knowledgeable regarding actions and phenomena that occurred around them. For example, a member of the group (J-G-2) mentioned the following:

> "Beneficial, you will be able to analyse things and know when something happens."

Note that the results for item F9 in this study are similar to those of other studies conducted in the developing countries. For example, Sarjou et al. (2012) studied Iranian middle school students' attitudes towards science and technology, school science and environmental issues and found that they believed that studying science enhanced their critical and analytical capacity. Amri (2012) investigated Malaysian students and found similar results.

9. **F10, 'School science has increased my curiosity about things we cannot yet explain'**

In the current research, participants agreed with item F10. The percentage of girls who agreed was 76.4%, with a mean value of 3.13. Although the majority of boys agreed with item F10, the percentage was lower than the girls', at 62.8%, with a mean value of 2.78. Having conducted a similar study, Amri (2012) mentions that giving curious minds an opportunity to explore new things is of interest to participants and increases their scientific skills. This opinion is supported by the girls' results in this research. According to the qualitative data, the girls felt that school science enhanced their curiosity to know and understand things around them. The interest of students (especially girls) in some science subjects may have sparked their curiosity to know things. As mentioned previously, in

Chapter 5, girls were interested in light, the planets, and the origin of the earth. The following quotation shows this:

> "We learnt how the camera works, we learnt how the light is reflected and there are some things that I want to understand." (E-G- 2).

In the Saudi middle school, students study science in one curriculum, which includes chemistry, physics, biology and astronomy, but at a simple level. However, in secondary school, science is divided into separate curricula, where chemistry, physics and biology are taught as separate subjects, but the boys have an additional subject, geology. In their discussion during the diamond ranking activity, the girls mentioned that they were curious to know more about astronomy and the earth, and this is consistent with the item F10 statement. Sample comments were:

> "I want to learn about what planets are made of and what's in them as well as how the stars are formed." (H-G).

> "I want to know how the earth was made." (A-G-1).

As mentioned in Chapter 5, in the Saudi science curricula, topics such as planets and the earth are not taught much, and this deprivation may be a reason for the girls' curiosity to learn more about these subjects. According to Anderson (2006), it is possible that a lack of education is a cause for curiosity in science learning.

Therefore, the positive attitude for item F10 indicates that Saudi students are similar to students from other countries, such as Malaysian (Amri, 2012), or Britain. where Jenkins and Nelson (2005)found that boys and girls agreed that school science taught them to be more curious 'about things we cannot yet explain.' In Jenkins' (2005) study, he found that boys wished to learn about black holes, supernovae and other spectacular objects in outer space, more than girls. However, in this study, the opposite is true.

10. **F11, 'School science has increased my appreciation of nature'**

This item was one that was agreed upon by most of the participating girls. For them, it was in first place in terms of mean value (Table 8-1). The mean value for that item was 3.18 for girls and 2.71 for boys, for whom it was in ninth place (Table 8-2). The holy Qur'an encourages Muslims to contemplate nature and the universe where it says, 'Observe what is in the heavens and earth' (Qur'an, 10: 100-101), and "Indeed, in the creation of the heavens and the earth and the alternation of the night and the day are signs for those of understanding" (Qur'an, 3: 189-190).

Muslims believe that nature is one of Allah's (God's) gifts to people and that reflecting on nature and thinking about it increases their faith. They also believe that this contemplation will lead them to thank Allah for his blessings and to glorify him for his creation. In consequence, the research participants mentioned during their discussion that school science reinforced their appreciation of nature as created by Allah.

> "[Science] opens the eyes to observe God's creations that are in the human body or in space and these things make me observe more, it makes me think more, when I see the stars or the trees. I don't just see them in a general perspective; no, I think about what happens within them" (G-G).

The association of scientific understanding with faith is not unique to Islam. Greenfield (1996) in the USA, reports that students argued that they were learning science to validate and bolster their religious beliefs. The citation of Islamic texts is one of the aspects that Islamic scholars have paid attention to in their lessons and books, because of the high position of these texts in deepening Muslims' faith, including achieving understanding and reasoning, stimulating thinking, and contemplation (Al-Ahmadi, 2020). In the Saudi science curricula, there are many Quranic verses that contribute to deepening faith in God and appreciation of nature. Also, the Quranic texts in science link between the Islamic text and natural phenomena, so students can understand them (Abdal-Salam, Nawwaf, & Maher, 2014). According to Nasrallah (2006) the citation of Islamic texts contributes to correcting misconceptions related to natural phenomena, for example, the eclipse, in addition to helping humanity in building the earth as God has commanded and protecting and preserving the environment from corruption. Thus, the linking of scientific subjects with Quranic verses may be the reason for Saudi students' appreciation of nature in this item. So, school science has a role to play in increasing an appreciation of nature among Saudi students. This could make them feel they are part of the environment, so that they might work to preserve it from damage.

11. **F12, 'School science has shown me the importance of science'**

The data in Tables 8-1 and 8-2 indicate that the students believed that school science opened their eyes to the importance of science in their lives, as mentioned in item F12. The mean values for that item indicate a high correspondence (agreement) between the girls (3.17) and the boys (2.81). This was confirmed in the qualitative data indicating that school science had led participants to recognise the importance of science in their lives, even if it had not taught them how to use science. These results helped to interpret the discrepancy between the quantitative data and the qualitative data in the students' responses to item F7. The interpretation is that the Saudi students in this study saw that school science as for general knowledge and that it showed them the importance of science in life, but perceived that school science could not be applied in real life. However, there are some school subjects more directly related to students' lives that may explain this positive attitude to this item. For example, students believed that biology is important and relevant to their lives because studying biology helps to treat the diseases afflicting society. Issues related to society are relevant to students, particularly in a collectivist culture. Therefore, students are interested in learning about topics that relate to social problems, and they perceive their importance in their daily life.

12. **F13, 'School science has taught me how to take better care of my health'**

Tables 8-1 and 8-2 show that both the boys and girls who participated in this research supported item F13. The mean value for this item was 2.81 for boys and 2.61 for girls. During the diamond ranking activity, several participants mentioned that biology contributes positively to students' health by causing them to pay attention to their health. This is possibly why most agreed with item F13. The interest in science topics related to health was reflected in their response in this item; since these topics appeared to have relevance to students, they attracted students to school science.

Also, health and combating disease are priorities of the Saudi government (Ministry of Health, 2021). The tangible results of science in health as a cure for diseases may be the reason for the positive attitude to this item.

The results of items F11, F12 and F13 indicated that participants were positive about school science, and this agrees with the results of other researchers, such as Sarjou et al. (2012) and Amri (2012), who also conducted research in developing countries. In contrast, in the developed countries, for example in Europe and Japan, Sjøberg and Schreiner (2010) note that student responses indicate that school science fails in various ways, including:

a. "Has not taught me how to take care of my health."
b. "Has not shown me the importance of science and technology for our way of living" (p.11).

13. **F16, ‘I would like to get a job in technology’**

Although the boys’ responses to item F16 were generally positive, they were also close to neutrality because the mean value for their responses was 2.60, which is not much larger than 2.50. In contrast, the girls’ responses were largely negative, as their mean value was 2.42. Gardner (1995) and Greenfield (1995) argue that technology is a common interest for boys, as boys are likely to be interested in learning practical skills and the way that devices work. The current study lends support to this argument, as technology-related items were among boys’ top ten interests (see Chapter Five). A possible explanation for the boys’ interest may be that in Saudi culture, jobs such as repairing electronic and electric devices are typically male fields. In Saudi Arabia, 57% of science graduates are women, but women’s share of the total labour force was only 16% in 2015. Among the greatest impediments that prevent women from joining the workforce are culture, religion and industry needs, along with the absence of solid and practised anti-discrimination policies. Social perceptions and prejudice determine which types of employment are particularly suitable for women or men (Islam, 2017).

Although Saudi Arabia is a developing country, these results are similar to those of Sjøberg and Schreiner (2007), who noticed that the responses of boys in the more modern countries tended to be close to neutral, while most girls in these countries had no preference for technological work. Moreover, there is no statistically significant difference between boys and girls, although the boys’ mean value is more than 2.50 and girls’ is less than 2.50. The items of section F of the ROSE questionnaire that have a mean value greater than 2.50 have all been discussed in the section above, so in the following, we will discuss those items that had a mean value of less than 2.50.

#### 8.2.2.2 Items with mean less than 2.50

Section F of the ROSE questionnaire contains 16 items, including three items on which the girls and boys did not agree, and the mean value of these items was less than 2.50, as shown below:

1. **F14, ‘I would like to become a scientist’**

There was a clear negative attitude toward item F14, as the mean value was 2.49 for girls and 2.27 for boys, with no statistically significant difference between girls and boys. However, the qualitative data showed that the reason behind the negative attitudes expressed in relation to item F14 could be that the participants believed that it was impossible to be a scientist, for several reasons. These were mentioned during their discussion in the diamond ranking activity.

One reason was the use of traditional teaching methods and limited ability to do practical work because the curriculum is overly theoretical:

> "Our curriculums don't produce scientists because they bring terms to be read then memorised for the exam. And there is no practical, like, in all the subjects we've never done a practical." (C-B).

> "There are a lot of reasons [that prevent me from being a scientist] like the lack of experimentations/ experiments. Also, most of them are just theory. The only thing you can be is either a teacher or a doctor" (B-B).

This investigates the reasons behind the small proportion of students hoping to work as scientists. The respondents' comments on that statement help to clarify why they did not agree with item F14. The participants were not concerned with scientists' duties inside the lab or in their jobs, and they showed less interest in this than in other statements. They justified their opinion through different viewpoints, such as that expressed by group A-B-3, who were only concerned with what scientists produced, or group H-G-2, who cared only about the results of a discovery. Groups E-G-1 and A-B-1 expressed similar sentiments:

> "We do not need to know what scientists do; we need to learn what scientists have presented." (A-B-1).

> "It doesn't interest me that much; what interests me is the information and the discoveries. Something that I don't care about" (H-G-2).

> "You want to know what scientists offer, not what their jobs are." (E-G-1).

The students mentioned during the interviews that schools' scientific curricula do not prepare students to be scientists. One reason that was given is the method of teaching and the lack of practical work in schools, as mentioned previously in item F1. However, from the diamond ranking, students ranked statement 'To help young people become aware of the jobs scientists do' towards the end. They explained this was because they were not interested in knowing what scientists do, but only wanted to know about their discoveries and achievements. This signifies that Saudi student may believe that a scientist's only job is to work in a laboratory and discover scientific theories and produce technological inventions. Consequently, they did not want such a job that would isolate them (in the laboratory) and that would limit their contact with people. Also, perhaps the students' lack of awareness in schools about the work of scientists made them not interested in it. Moreover, young people in the Arab world often want a "government" job because, in their perception, it is safe and involves less work (Al-Fawzan, 2014). Also, some are looking for jobs that give them social status and stability (Odeh, 2021).

It seems that the participants did not consider doctors and engineers who are continuing their research and studies to be scientists. This seems to be the case for students in other countries as well. For example, according to (Stefánsson, 2006), students did not consider doctors, engineers and those who work in biogenetics (geneticists) to be scientists, in the proper meaning of the word. In addition, it appears that factors such as age, culture, gender and social status play a part in forming stereotypes about scientists (El Takach & Yacoubian, 2020).

A study done on secondary school students in Saudi Arabia showed that the students described scientists to be intelligent, inventors, and famous (Kim, 2020). These stereotypes are also seen by students in other studies such as Akcay (2011) and Fralick, Kearn, Thompson, and Lyons (2009).

**2. F15, 'I would like to have as much science as possible at school'**

Finally, the participants in the current research did not want to add more science in school, as is evident from Tables 8-1 and 8-2, where results are given for the item F15. Here, the mean value for girls was 2.43 and for boys it was 2.29. The percentage of girls who agreed with item F15 was greater than the percentage of boys. Perhaps the reason for this was that the boys disagreed with Saudi boys' secondary education having four science subjects (Biology, Chemistry, Physics and Geology), while the girls' schools excluded Geology, as some girls' participants said, "*Why are the boys studying geology while we do not*". The girls wanted to have additional science topics, such as astronomy and geology, as mentioned in the comments on earlier sections. Nevertheless, there is no statistically significant difference between girls and boys in this item.

The results indicate that participants in the current research believed that school science is not easy. In addition, they did not want more subjects or topics to be added to the current science curriculum, although the girls in the qualitative data expressed their desire to study some of the topics of astronomy and geology. This discrepancy in the results may be due to the fact that students' interest in science is influenced by many factors, including the scientific content, the teacher's personal characteristics, and the teaching methods, as mentioned before. Interesting scientific content may be a reason for students wanting to learn more about scientific topics in school. For example, the students in this study wanted to know about astronomy and Earth. Also, the appropriate teaching method for students (so that the teacher links the scientific topic with real life, which facilitates the understanding of the topic) may be a reason for students' desire for more school sciences, and vice versa, as in current study. This matched the results of studies by Jenkins and Pell (2006) in UK but did not agree with Sarjou's study (2012) in Iran.

### 8.2.3. Gender Differences

It is frequently argued that there are gender differences in relation to science; however, the current study was concerned only with students' attitudes and interest in relation to science, and it therefore explored gender difference in terms of interest in and attitudes towards science. This section will investigate gender differences by analysing and discussing Saudi students' responses to section F of the ROSE questionnaire. To analyse these, the Chi-square test was used on section F items as a whole, and a similar test was done on each section of item F individually. The main purpose of using the Chi square test was to determine whether there were significant gender differences in the boys' and girls' opinions regarding science and technology. Where differences exist, p will less than 0.05, but if it is greater than 0.05, there is no significant difference. The results are shown in the two right hand columns of Table 8.3.

#### 8.2.3.1 Result

Table 8-3 The gender differences between girls (G) and boys (B) in science class

| N | Items | Gender | | Chi-Square | p |
|---|---|---|---|---|---|
| | | Mean B | Mean G | | |
| 1. | F1. School science is a difficult subject | 2.91 | 2.77 | 4.732 | 0.193 |
| 2. | F2. School science is interesting | 2.62 | 2.92 | 19.498 | 0.000 |
| 3. | F3. School science is rather easy for me to learn | 2.27 | 2.49 | 18.073 | 0.000 |
| 4. | F4. School science has opened my eyes to new and exciting jobs | 2.86 | 3.18 | 19.462 | 0.000 |
| 5. | F5. I like school science better than most other subjects | 2.48 | 2.91 | 28.387 | 0.000 |
| 6. | F6. I think everybody should learn science at school | 2.82 | 2.89 | 10.857 | 0.013 |
| 7. | F7. The things that I learn in science at school will be helpful in my everyday | 2.72 | 3.00 | 14.434 | 0.002 |
| 8. | F8. I think that the science I learn at school will improve my career chances | 3.27 | 3.00 | 14.262 | 0.003 |
| 9. | F9. School science has made me more critical and sceptical | 2.72 | 2.77 | 2.189 | 0.534 |
| 10. | F10. School science has increased my curiosity about things we cannot yet explain | 2.78 | 3.13 | 20.714 | 0.000 |
| 11. | F11. School science has increased my appreciation of nature | 2.71 | 3.18 | 41.627 | 0.000 |
| 12. | F12. School science has shown me the importance of science for our way of living | 2.81 | 3.17 | 25.733 | 0.000 |
| 13. | F13. School science has taught me how to take better care of my health | 2.61 | 2.81 | 7.075 | 0.070 |
| 14. | F14. I would like to become a scientist | 2.26 | 2.48 | 6.906 | 0.075 |
| 15. | F15. I would like to have as much science as possible at school | 2.29 | 2.43 | 3.282 | 0.350 |
| 16. | F16. I would like to get a job in technology | 2.60 | 2.42 | 4.427 | 0.219 |

#### 8.2.3.2 Discussion

The overall mean value for section F shows that girls felt more positively than boys towards school science because the girls' mean value is 2.84 and for boys it is 2.67. However, according to the overall mean value for section F, it is evident that there is no significant difference between boys' and girls' opinions towards science, as the P value is greater than 0.05, being 0.174. However, when the Chi Square test was employed for the individual items in section F, the results showed that there were some gender-based differences of opinion regarding school science for some items. According to the results shown in Table 8-3, nine of the 16 items show statistical significant differences in favour of girls, while only one item is statistically significantly in favour of boys.

According to the results of section F, the girls tended to see the importance of teaching school science to all students because they found it interesting. In addition, they differed from the boys in that they preferred to study school science rather than other school subjects, although the jobs associated with science are mostly reserved for boys, as mentioned previously. Moreover, the girls agreed that school science increased their curiosity to know and understand scientific things that had not yet been explained. It also contributed to their appreciation of nature. School science opened the Saudi girls' eyes to the importance of science in people's everyday lives and to new and exciting jobs. Furthermore, they agreed that the school science subjects taught them things that helped them in their daily lives. The results of this study showed that the majority of Saudi girls who participated in the study had a more positive attitude towards science than boys in some of items. Perhaps the reason for this is that schools in Saudi Arabia are single- sex. It has been reported in Kenya that the attitudes of boys and girls towards subjects depends on wither or not they attended a single-sex school. Fewer boys and girls who go to single-sex schools have gender-stereotypical attitudes to science subjects, as opposed to students who attend co-educational schools. The study found that the majority of Kenyan girls voiced a positive view of studying science, with girls in single-sex schools having a more positive attitude than their peers who went to co-educational schools. However, Brown and Ronau (2012) in the USA carried out a study of single-gender and mixed-gender classes, in relation to their attitudes to science and found very little difference between them.

Although there is nothing in Saudi regulations that stipulates that females are not allowed to occupy jobs in science and mathematics, and despite the optimistic and positive attitudes towards science that the girls expressed in the current study, once they graduate from secondary school, they face the obstacle of limited options for their university specializations. The results showed statistically significant differences in favour of boys in item F8, ‘I think that the science I learn at school will improve my career chances’. Having a job is the major means of acquiring money, and in Saudi social tradition and Islamic teaching, the financial responsibility is carried by men, which may have motivated boys to emphasise that item. According to Islamic teaching, the financial responsibility the family is the husband’s duty and he is responsible for providing for the needs of his family, according to his ability (Alsalloom, 2015; Elamin & Alomaim, 2011). According to Sharia (Islamic) law, there is nothing to prevent women from economic and political involvement. However, there is a very low level of participation by Saudi women in the labour force (Al-Asfour, Tlaiss, Khan, & Rajasekar, 2017). Culture and tradition affect the work of women in Saudi Arabia, which reflects negatively on gender equality (Syed, Ali, & Hennekam, 2018), as the Saudi people believe that men are able to work better; they therefore receive better pay than women, who are considered to be more suited to doing housework (Budhwar et al., 2010).

A number of items show no statistically significant differences between girls and boys; for example, the boys and girls agreed that school science is difficult. Furthermore, there were no gender differences in items F9 and F13. Neither the girls nor the boys wished to be scientists or to study more science in school. However, regarding jobs in technology, the boys showed more interest, but, according to the results of the Chi square test, this was not a statistically significant difference. The findings of the current study agree with the results of Wang and Berlin (2010), and Sarjou et al. (2012), who found no gender difference in student attitude toward science.

This short discussion has indicated the gender differences evident from the current research results concerning the views of Saudi students on school science. In the following section, the views of Saudi students’ regarding school science will be compared with the opinions of students in other countries that have also participated in the ROSE project.

### 8.2.4. A Comparison of the Opinions of Saudi Students on School Science with Those of Students from Other Countries

In this section, a comparison is made between the responses of the participants in the current research to section F of the ROSE questionnaire and those of respondents in other countries who also participated in the ROSE project. All the charts in this section present the mean values for girls and boys, aged 14 to 16 years, from different countries that used the ROSE questionnaire to investigate the students' opinions. This includes the views of the Saudi students. Each item contained a statement, and the students were asked to answer on a 4-point Likert scale to show if they agreed (code 4) or disagreed (code 1) with the statement. This means that the value 2.5 is located in the middle of the scale, so any result equalling 2.5 indicates that the students' responses are neutral; they neither agree nor disagree with the statement.

This comparison makes use of the results from five items that had a mean value greater than 2.5 for both girls and boys (i.e., agree) and from five items that had mean values of less than 2.5 (i.e., disagree). It was easy to choose five items with a mean value greater than 2.5 for both boys and girls, but there were not five items common to both boys and girls that had a mean value of less than 2.5. For this reason, three items held in common by Saudi girls and boys as having a mean value of less than 2.5 were chosen, and one item with a mean value less than 2.5 for girls and one other item with a mean value of less than 2.5 for the boys were chosen, in order to complete the number of items that could be employed in the comparison.

#### 8.2.4.1 Results

Notice (Red indicates the response of girls, blue the response of boys).

Figure 8-1 The mean of item F4: School science has opened my eyes to new and exciting jobs

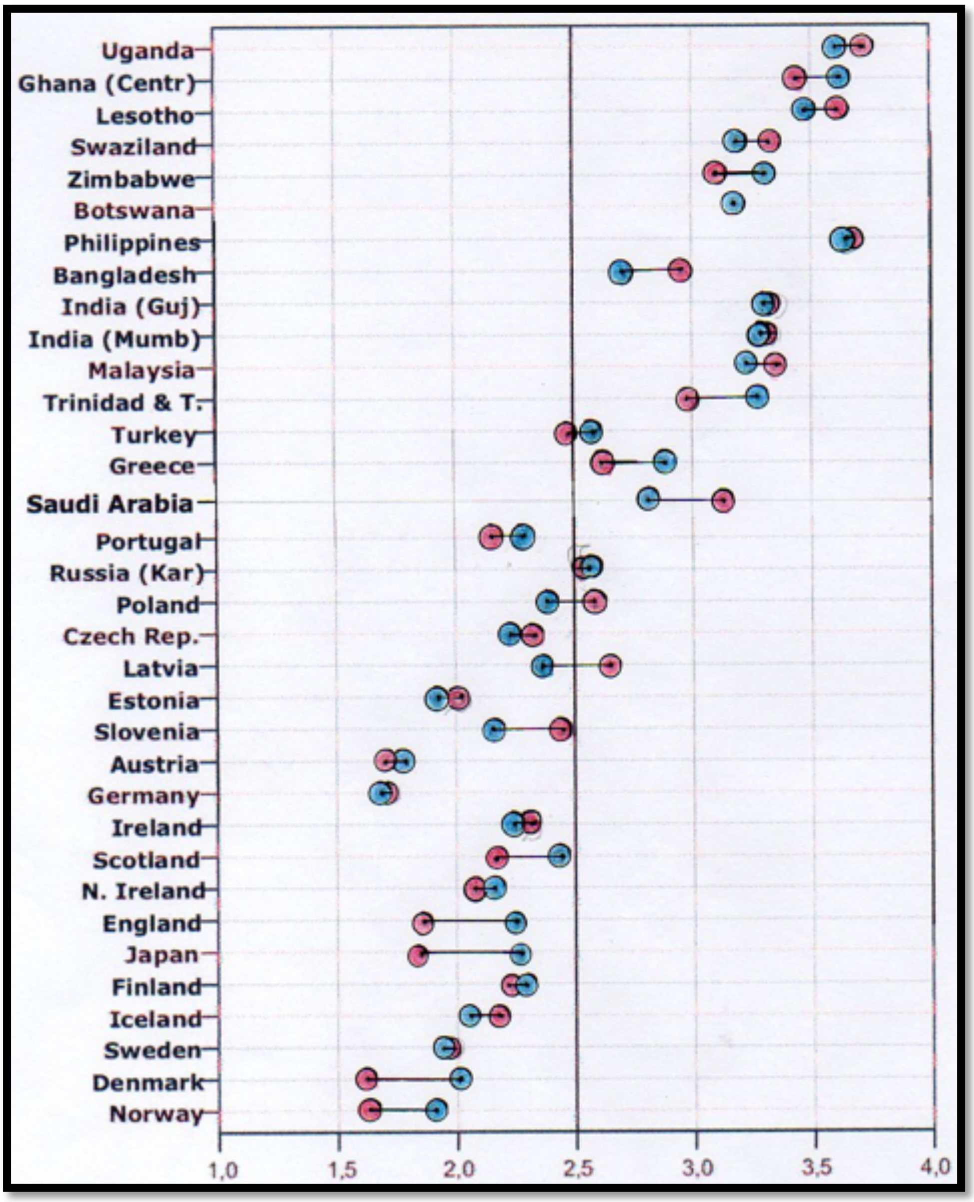



Figure 8-1 shows the students' responses to item F4 of the ROSE questionnaire. This indicates that Saudi students gave more positive responses compared to their peers in the developed countries, but they were less optimistic than students in poor developing countries. The students in the developed countries did not believe that school science opened their eyes to new jobs, and the mean value for item F4 was less than 2.5 in these countries, as shown in Figure 1. In addition, the gender difference appeared less in the developing countries such as Uganda and Ghana countries than in developed countries such as Denmark and Japan. Although Saudi Arabia is one of the developing countries, the results show that the gender difference was statistically significant, although both boys and girls agreed that school science opened their eyes to new job possibilities.

Figure 8-2 The mean of item F8: I think that the science I learn at school will improve my career chances

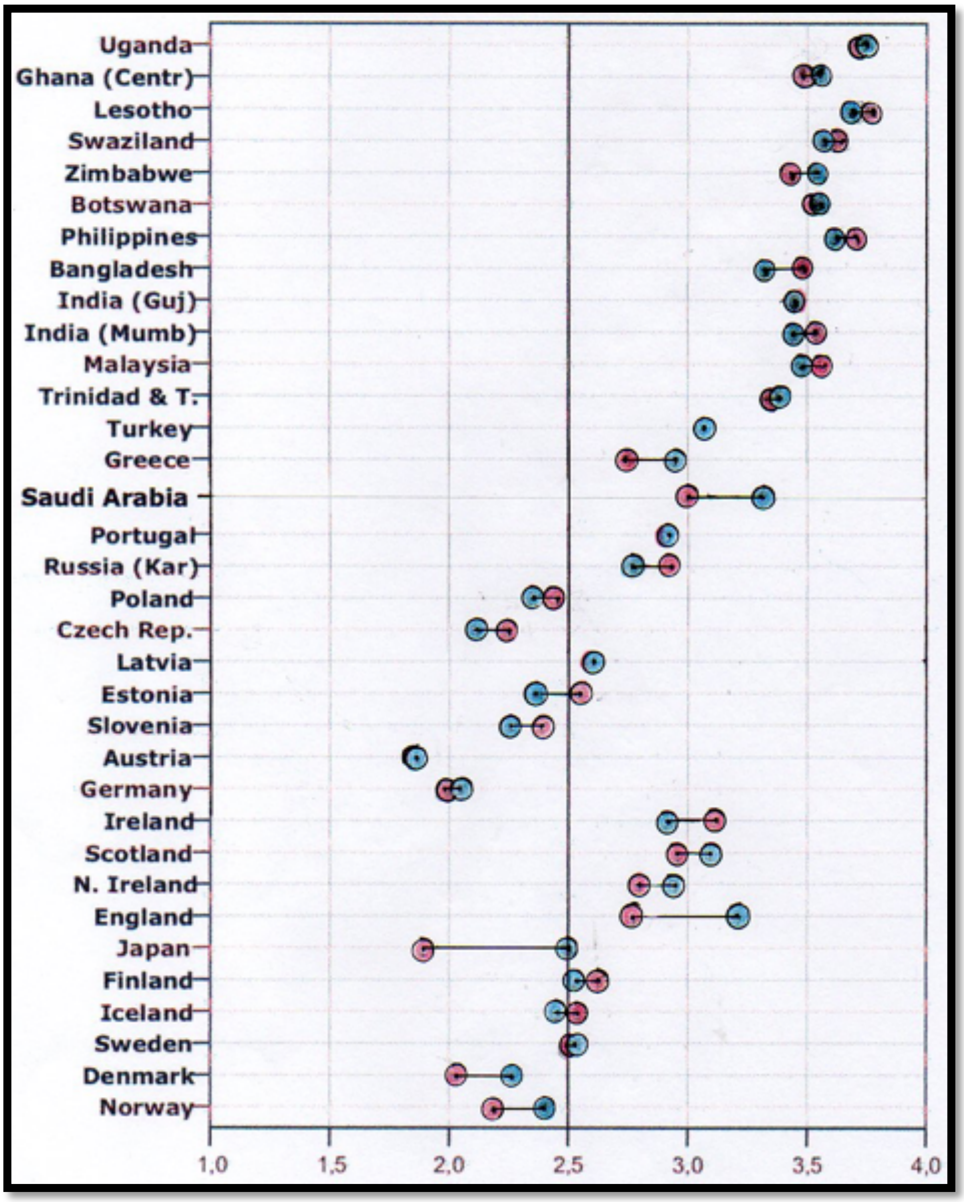



Figure 8-2 shows the students' responses to item F8. In the developing countries, including Saudi Arabia, the students agreed that school science would improve their chances of finding a job. However, in the developed countries, the responses varied, for example, in Scotland, and Portugal agree, in Iceland and Sweden neutral, in Austria and Germany disagree. The gender difference was small in most developing and developed countries, but in Saudi Arabia, Japan and England, there were statistically significant gender differences, as evident in Figure 8-2.

Figure 8-3 The mean of item F10: School science has increased my curiosity about things we cannot yet explain

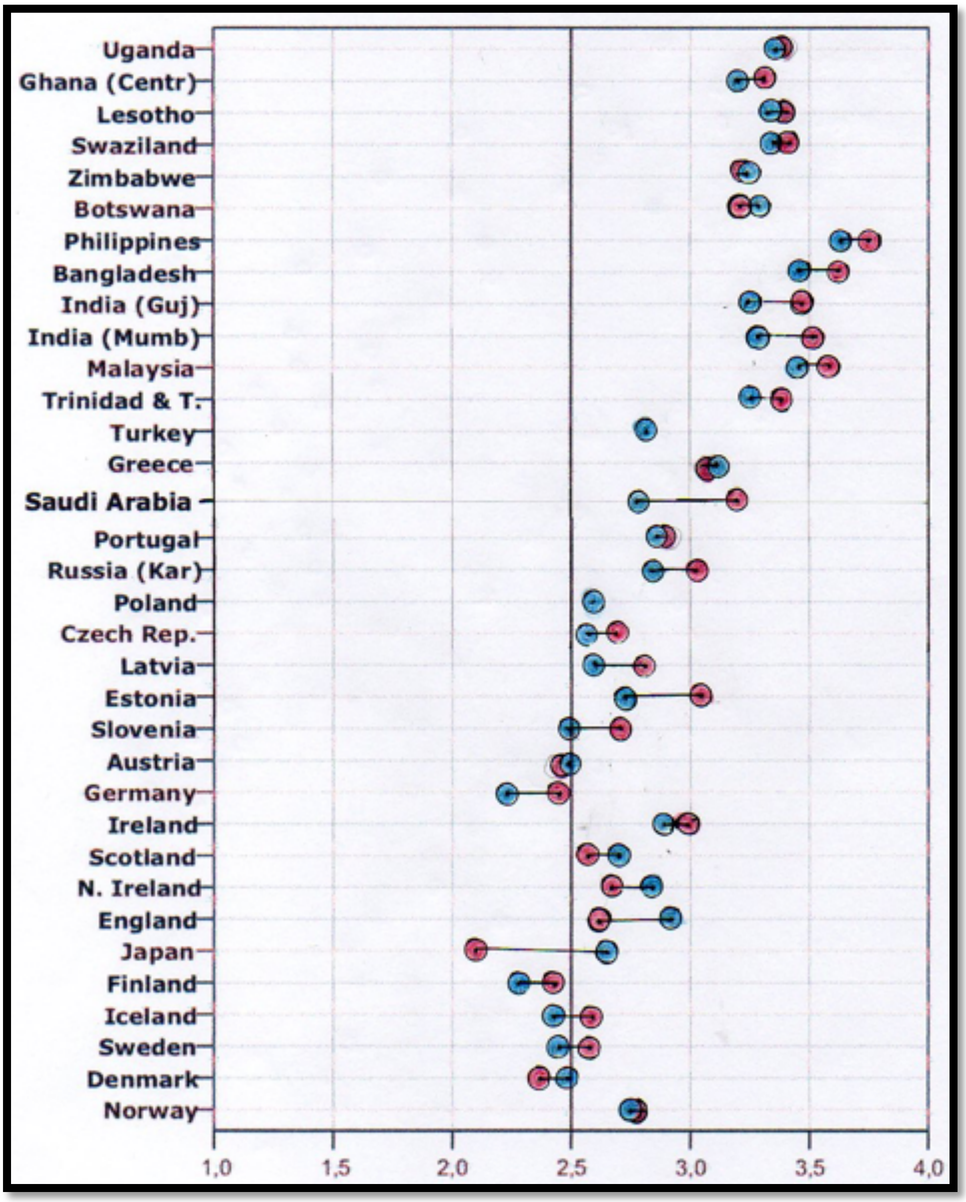
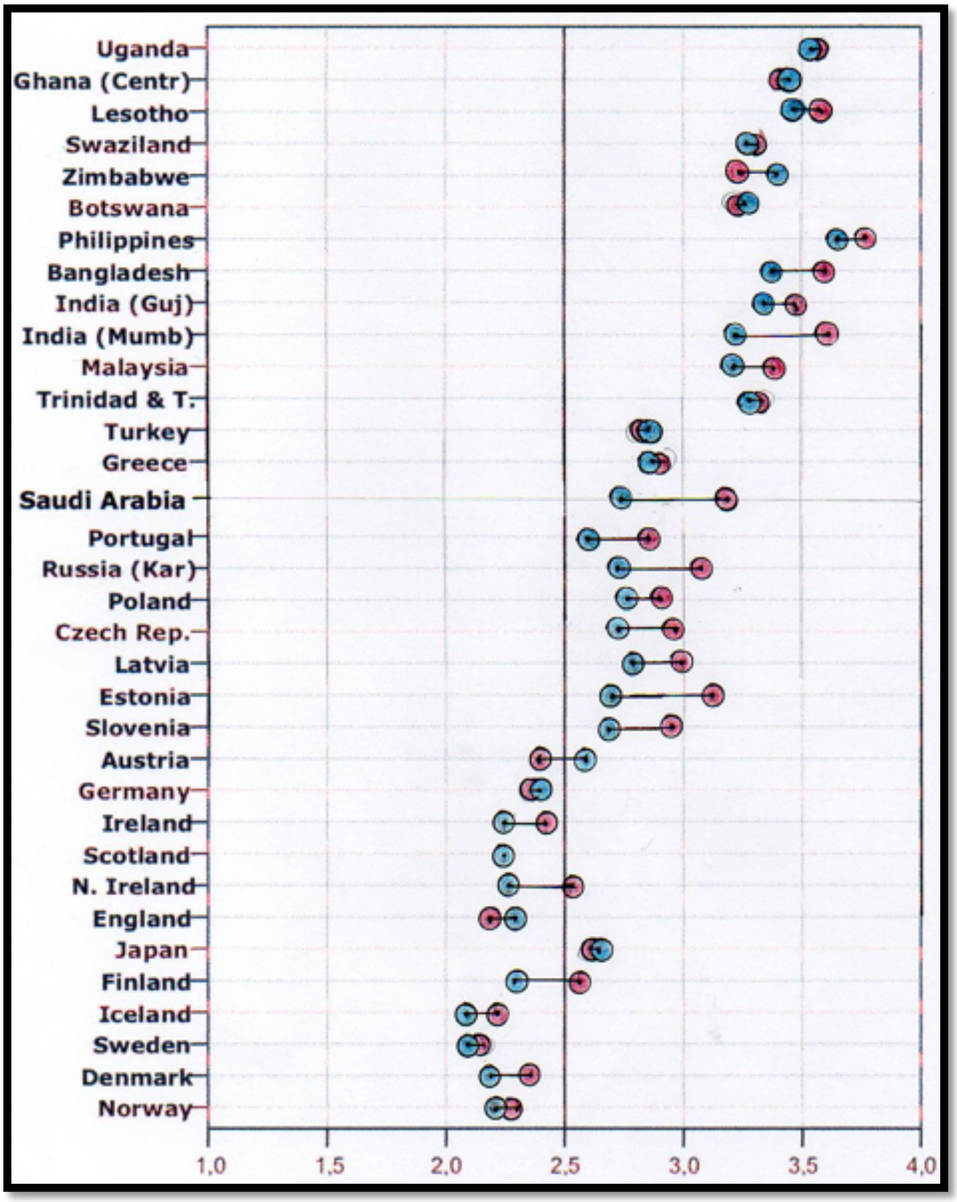



Figure 8-3 shows that the majority of students in the developing countries agreed with item F10, which said that 'School science has increased my curiosity.' However, in the developed countries, students were mostly more reluctant to agree, and their answers varied between agree and disagree and were close to neutral. The responses of Saudi students and of some students from developing countries such as Turkey, with medium human development, were more positive than those from the developed countries such as Denmark, but less positive than in the developing countries with low human development, such as

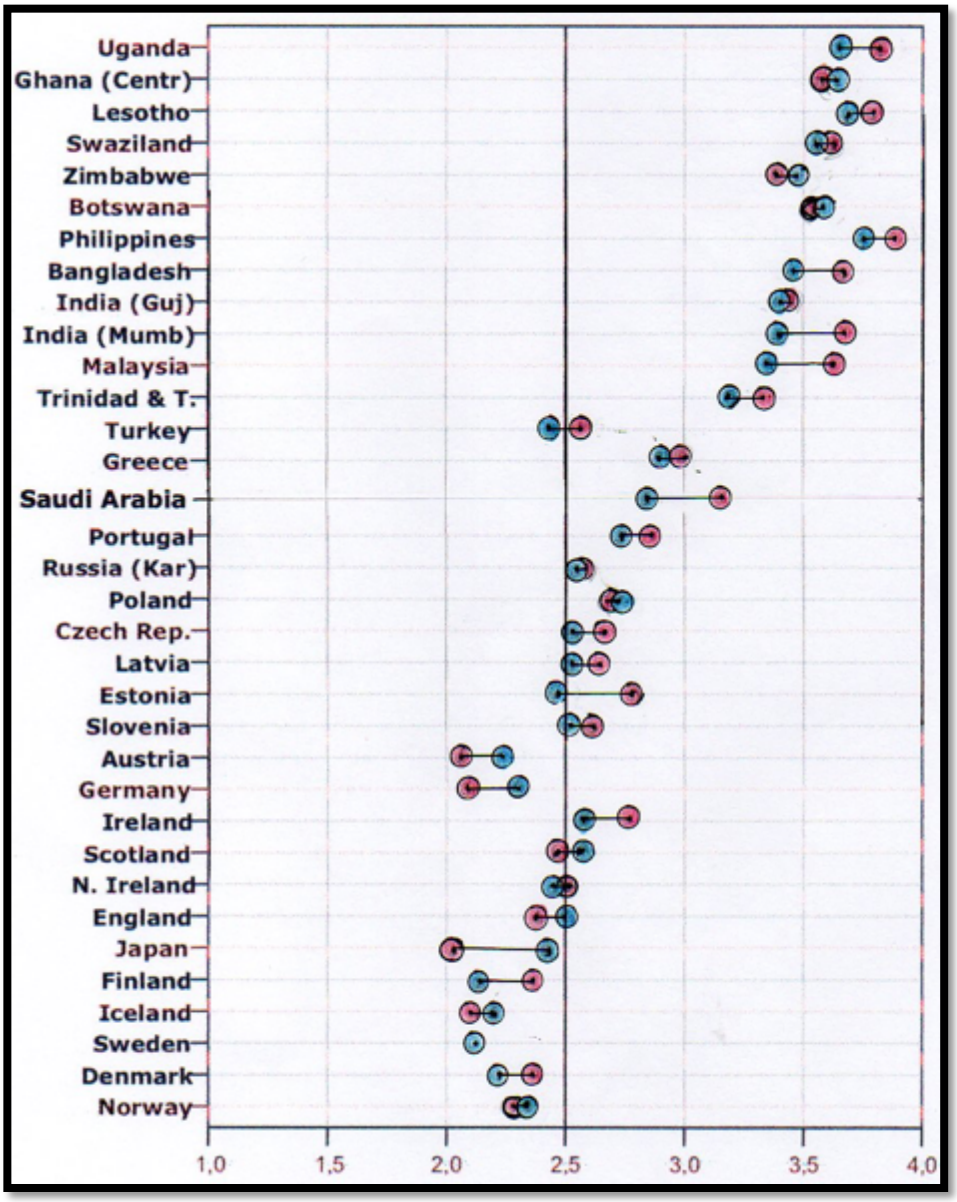
Philippines. Gender differences in Saudi Arabia, Japan and England were all statistically significant.

Figure 8-4 The mean of item F11: School science has increased my appreciation of nature




The responses to item F11, as shown in Figure 8-4, were almost the same as the responses to item F10 (Figure 8-3). The students in the developing countries strongly agreed that school science increased their appreciation of nature. Students from countries with less human development, such as Turkey and Greece, agreed with item F11, but less positively than those in the developing countries such as Lesotho and Philippines and more positively than those in the developed countries like Norway and Iceland. Students from the developed countries expressed neutral or close to neutral views, or even disagreed. However, it can be seen that in most countries the girls had more positive attitudes than the boys. In some countries, such as Ghana and Scotland, gender differences did not exist, while they were very small in countries such as the Philippines and England. However, gender differences were statistically significant in countries such as Saudi Arabia and Estonia.

Figure 8-5 The mean of item F12: School science has shown me the importance of science for our way of living




The students' responses to item F12 are shown in Figure 8-5. There is similarity between the students' responses to this item and their responses to the two previous items, and it is evident that there is strong agreement that the science subjects were perceived as important to lifestyle in the developing countries. In contrast, students in the developed countries had neutral attitudes or else disagreed with the statement. The responses of girls and boys to item F12 show that gender differences are small, but in Saudi Arabia and in some other countries, such as Japan, there are statistically significant gender differences.

The opinions of Saudi students that had a mean value greater than 2.5 have been compared for five items of section F of the ROSE questionnaire with the opinions of students from other countries. The following paragraphs will present a comparison of the Saudi students' opinions in relation to five items of section F of the ROSE questionnaire, which all had mean values of less than 2.5, with the opinions of students in other countries that participated in the ROSE project.

Figure 8-6 F3: School science is rather easy for me to learn

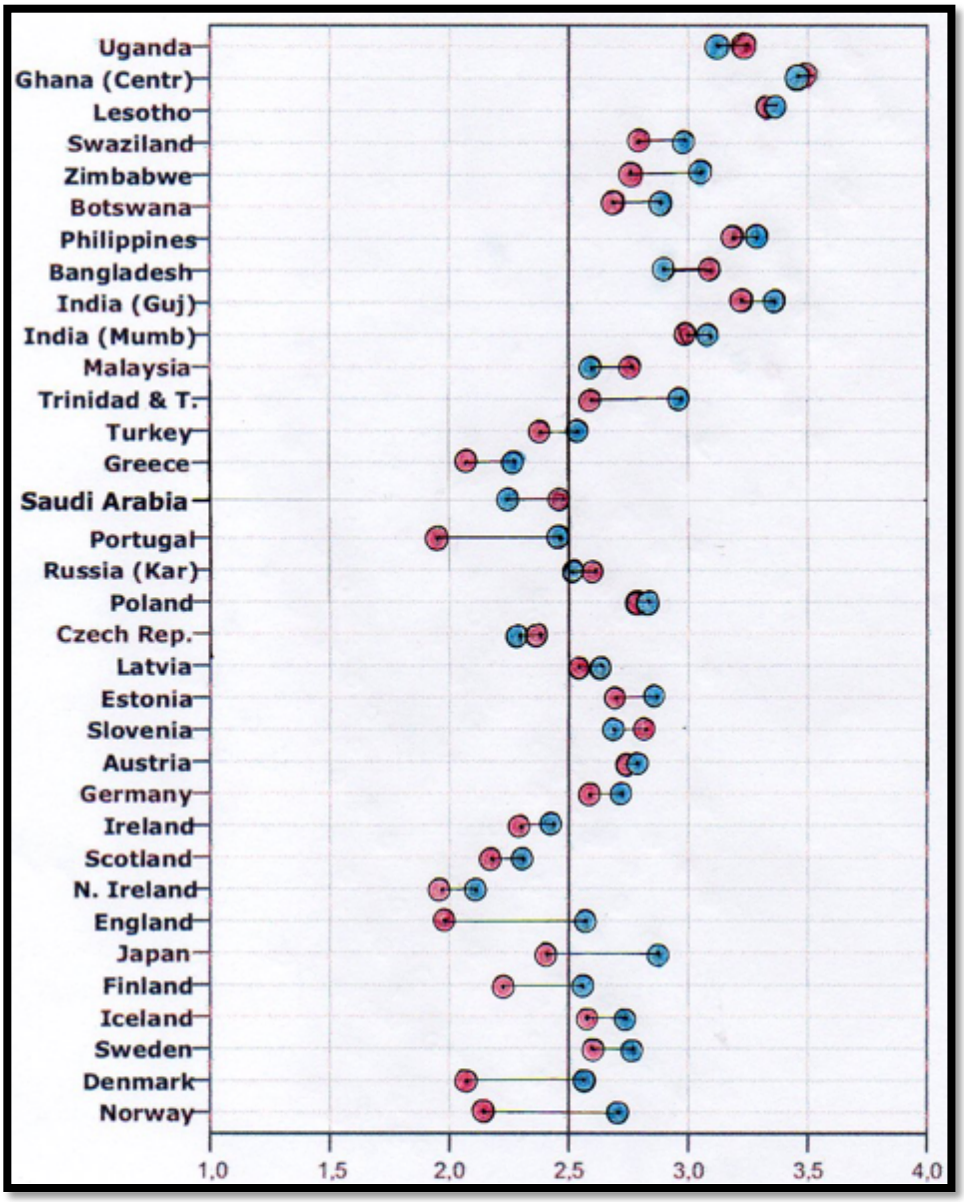
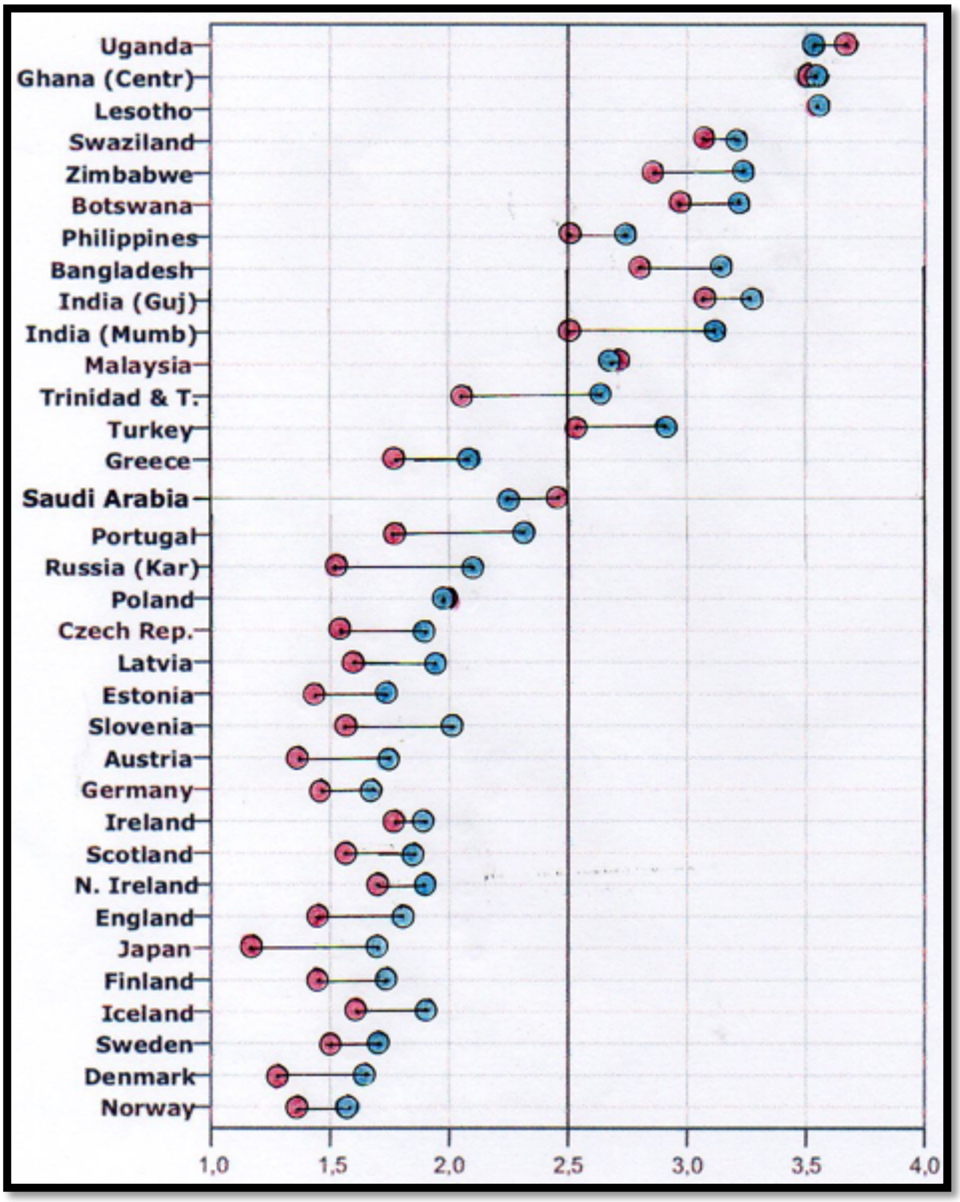


Figure 8-6 presents the students' responses to item F3 of section F of the ROSE questionnaire. From this it appears that students in the developed countries had varied opinions in relation to the statement. Generally, students in the developing countries agreed with the statement, although the Saudi students' responses were negative. In addition, there were statistically significant differences for boys and girls. Although, in most countries, the boys' responses were more positive than the girls', in Saudi Arabia, the results were reversed, and the girls were more positive than the boys.

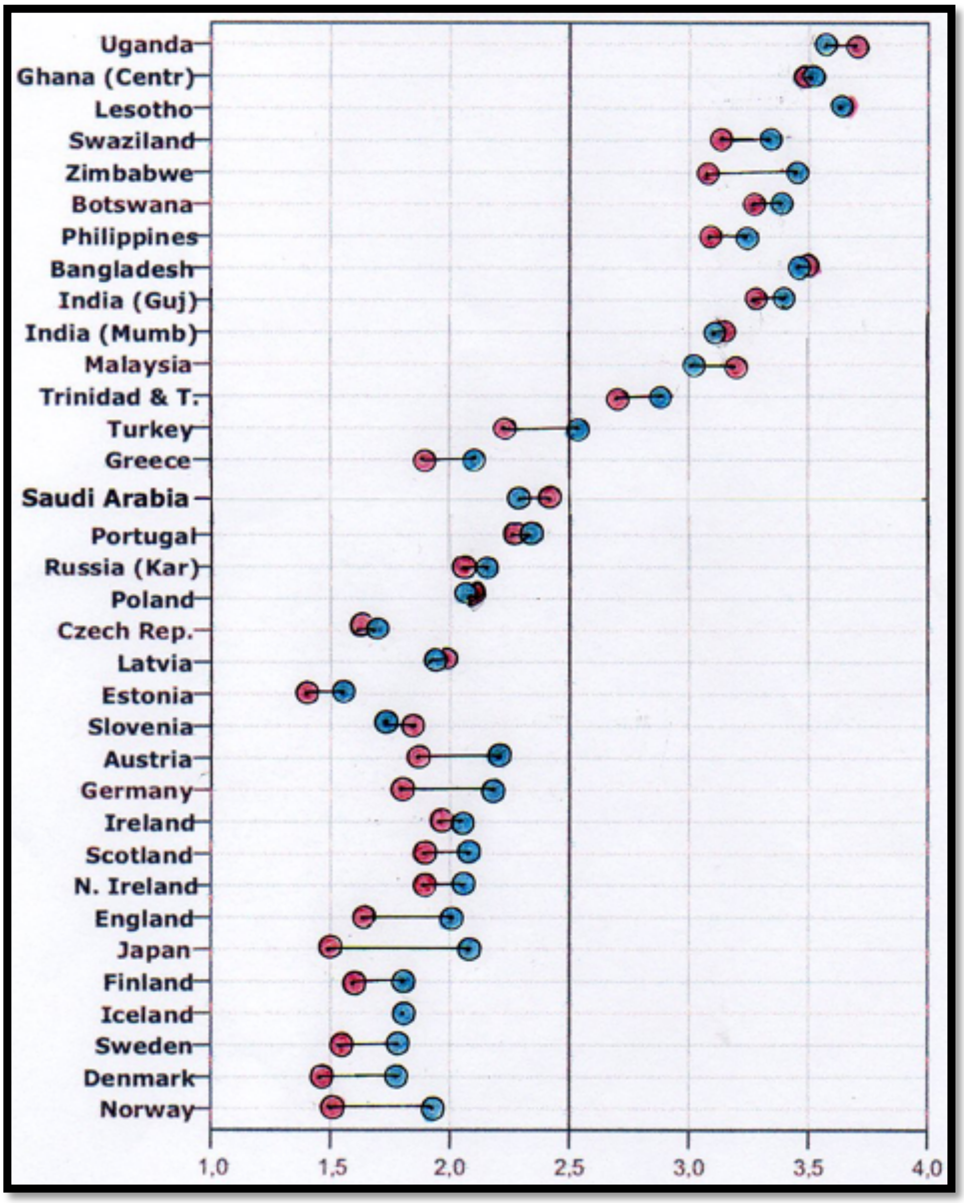
Figure 8-7 The mean of item F14: I would like to become a scientist




The mean value of students' responses to item F14 in Figure 8-7 shows that students in the developed countries did not want to be scientists, and neither did the Saudi students.

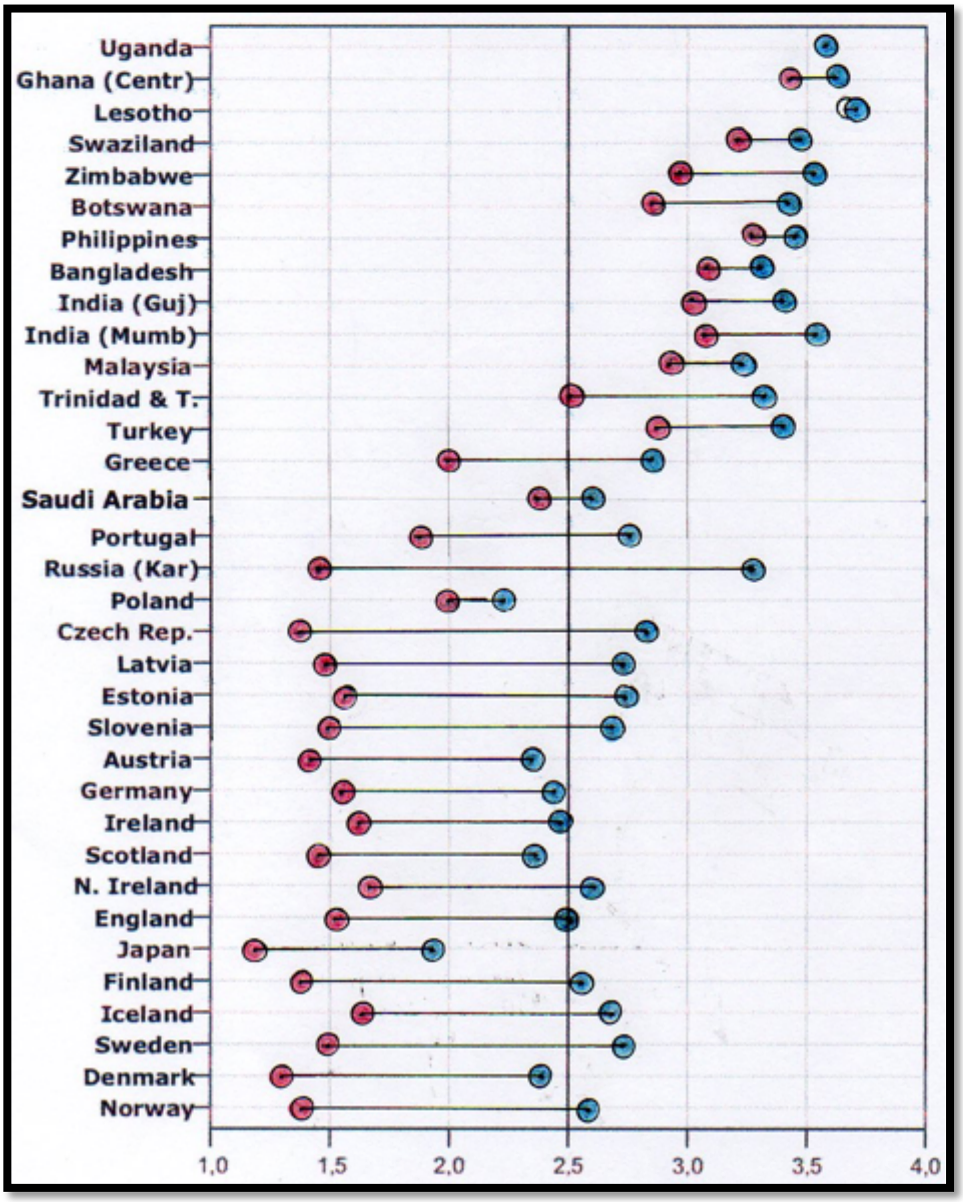
Although the students in the developing countries were more positive in a number of countries such as Uganda and Ghana, the girls were neutral in India (Mumbai) and Philippines. So, the more developed the country, the less desire students had to be scientists. Gender differences on item F 14 were obvious in some countries, for example, India (Gujarat) and Turkey, where the boys desired to be scientists more than the girls, but in Saudi Arabia there were no statistically significant gender differences.

Figure 8-8 The mean of item F15: I would like to have as much science as possible at school



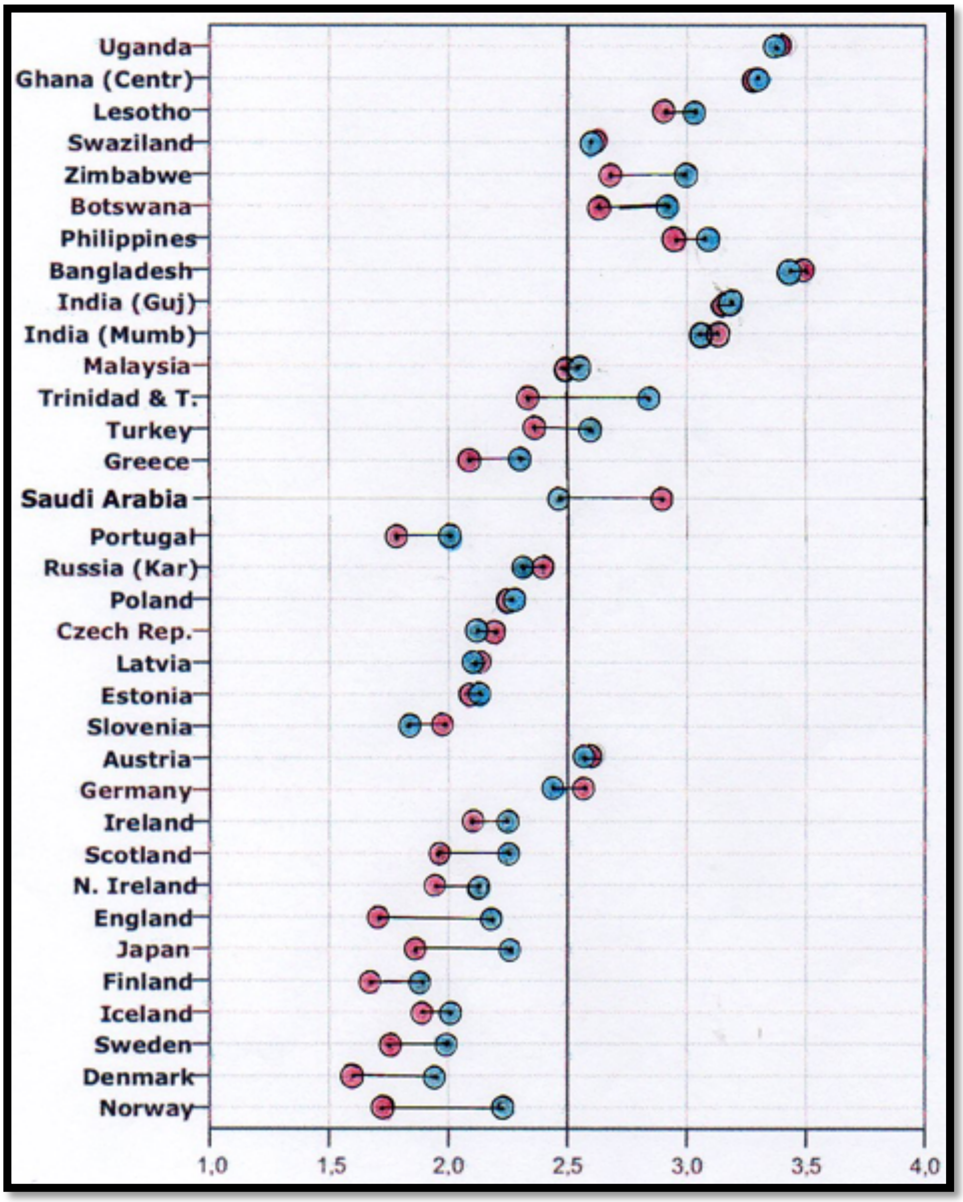

The results shown in Figure 8-8 indicate that students in all the developed countries and some of the developing countries such as Finland, England and Saudi did not wish to have more school science subjects, or topics, as suggested in item F15. In contrast, students in some other developing countries, such as Uganda and Lesotho and Bangladesh and India, did desire to be taught more science at school. For this item, the boys were more positive than the girls in most countries, and the gender differences varied between being extremely small in countries such as Saudi Arabia and the other developing countries, and statistically significant in some of the developed countries, such as Japan.

Figure 8-9 The mean of item F16: I would like to get a job in technology




The mean values for item F16, as presented in Figure 8-9, indicate that students (both boys and girls) in the developing countries, and especially the African and Asian countries, would like to find jobs in a technological field. In contrast, few of the boys in the developed countries wished to have jobs in technology, and for them, the mean value was close to neutral, while girls in the developed countries definitely did not wish to work in the field of technology. However, the mean value of Saudi students' responses to item F16 show that the boys agreed with the item statement more than the girls did, although the girls' responses were approaching neutral. While gender differences for item F16 were clear in most countries, in Saudi Arabia, there was not a statistically significant difference.

Figure 8-10 The mean of item F5: I like school science better than most other subjects




The final item used in the comparison is item F5, and Figure 8-10 presents the students' responses to this item. From these, it appears that most students in the developed countries did not prefer school science over other school subjects, whereas in the developing countries, students did prefer school science over most other subjects. While this was true of the Saudi girls, it was not true of the boys. The gender difference varied; in some countries the difference was small, such as Estonia and Malaysia, but in others it was distinct, like Norway and England. In Saudi Arabia, there are statistically significant gender differences, as the girls expressed greater preference for science than the boys.

#### 8.2.4.2 Discussion

In most of the items, the results indicate that both Saudi boys and girls expressed more positive views about learning science in school than students in the developed countries, but they were less enthusiastic about science than students in most developing countries, for example, F4, 'School science has opened my eyes to new and exciting jobs', F12, 'School science has shown me the importance of science for our way of living' and F14, 'I would like to become a scientist'. Reiss (2004) has argued that students' attitudes towards science are influenced by conditions external to the school setting, such as cultural factors, government-led policies, overall technological skill proficiency levels and the national economy. Although several factors affected participants' attitudes towards science subjects, their future careers seemed to play a significant role. Many participants chose the science path because it was related to their intended future careers, and this gave the students a positive perception of school science. This is consistent with Schreiner and Sjøberg's (2019) argument that among students who find school science interesting, their motivation is often extrinsic or instrumental, e.g., for passing an examination or for their further education and career.

In item F4, 'School science has opened my eyes to new and exciting jobs.' Saudi students had more positive attitudes than Turkish students and less so than Malaysian students. However, there was no difference between boys and girls among Turkish and Malaysian students but there was a significant difference between Saudi boys and girls. Although the result shows that science and engineering are attractive to Saudi girls, Saudi culture has traditionally confined jobs in science and engineering to men, which is why the number of Saudi girls in that field is limited (Al-Gazali, 2013). It may be that girls had not previously had a clear perception of possible future jobs in the science field but went through the science pathway hoping for greater employment opportunities in the future. This may explain why the item, 'School science has opened my eyes to new and exciting jobs' was highly chosen amongst girls. In addition, socio-economic changes in recent years may have impacted this result. For example, the Saudi government's Vision 2030, which was launched in 2016, aimed to raise the rate of women's participation in the labour market from 22% to 30%, and provided several jobs in the field of science for women (Naseem & Dhruva, 2017).

In contrast, the boys had a clear perception of their future jobs, so they chose the science pathway to support their future plans. Perhaps, this explains why the item, 'I think that the science I learn at school will improve my career chances' was highly chosen amongst boys. Moreover, Saudi boys have far more choice than the girls because the latter are controlled by social norms and customs that affect their employment options (Alwedinani, 2016). In addition, these differences can be explained by the cultural dimensions of these countries. Saudi Arabia has a higher 'Masculinity' dimension than Turkey and Malaysia. In Turkey, the 'power distance' is less than that of Saudi Arabia and Malaysia.

Although Turkish students gave neutral responses in item F4, there is no difference between gender. In Turkish culture, there is no difference between Turkish males and females in pursuit of science and science-related professions and careers. Therefore, the attitudes that students have towards science and science-related careers may be produced by the melded influence of culture and gender (Örnek, 2015). In Malaysia, the economic situation may be the cause of the positive attitudes of students, especially girls, regarding item F4. For example, there is an increased likelihood that women in Malaysia will pursue higher education and be economically active as the nation experiences a rise in the cost of living. Women are motivated to participate in higher education so as to attain a well-paid job or worthwhile second income. Another factor that may account in part for the trend of the predominance of females enrolling in Malaysian universities is that they are out-performing males in school and the performance of male students is in decline. Across many science disciplines, the number of females exceeds that of males; these include agriculture, applied sciences, basic sciences, computer science, dentistry, environmental science and medicine (Ahmad, 2009).

It may not be surprising that the Saudi, Turkish and Malaysian students had positive attitudes toward item F8; 'I think that the science I learn at school will improve my career chances', as all these countries are developing countries, so socio-economic status and the aspiration toward further development may explain this result. In the case of Saudi Arabia, it is a developing but wealthy country, so Saudi students are looking for prestigious jobs of social value such as medicine and engineering. Thus, one reason why the Saudi students had positive attitudes towards school science was because of the availability of jobs in the scientific field, which are still required in Saudi society. For example, a career in medicine has some of the best-paid jobs in Saudi Arabia, and Saudi Arabia supports doctors' education. This is because Saudi Arabia is suffering from a shortage of graduates in the medical field (making the study of medicine a goal for many students), which is driving the Saudi government to give its medical students a great deal of attention and appreciation (EasyUni, 2021). The job of Petroleum Engineering also attracts Saudi students, as it is one of the important jobs in the Saudi economy. Furthermore, as suggested by Örnek (2015), there may be cultural reasons that tempt Turkish students into science-related careers. Such jobs are considered highly prestigious in Turkish culture, and those who work in science fields are perceived as making valuable contributions towards the development of the country. This could account for the very positive attitude shown by Turkish students towards science. Similarly, according to Halim et al. (2009), Malaysian society places a high value on careers in the engineering, medicine and science fields, which is reflected in a high level of interest and participation in science education.

The high level of interest shown by young people in developing countries for working in science and technology jobs may reflect the importance they place on science and technology. In developing countries, a central focus is to address widespread conditions of impoverishment, health and welfare system inadequacies and to promote economic growth. Furthermore, a key public issue, especially in collectivist societies, is the material development of society; science and technology are regarded as essential to this. There may be an assumption that because working in a science and technology related job is considered important to society, it is similarly important to the individual undertaking the work (Inglehart, 2018).

Referring to the current result F8, positive attitudes and interest in science and technology are not limited to students in developing countries. Some students in developed countries such as Greece and Portugal also showed positive attitude and interest, due to their hopes for their future jobs. In Western society, the demand for places on courses in medicine, biology and environmental studies continues to remain high, with a larger proportion of females enrolling, as opposed to male students. This trend could signal that young people living in developed nations are of the opinion that some of the major problems modern society has to contend with are health and environment-related. Thus, gaining knowledge in these areas provides a greater prospect of subsequently engaging in worthwhile employment (Sjøberg & Schreiner, 2007).

Despite Saudi girls' attitudes being more positive than these of boys toward science according to the current study, Saudi boys had more positive favourable attitudes than girls toward a job in technology (F16). A possible explanation for the boys' interest may be that in Saudi culture, jobs such as repairing electronic and electrical devices are typically male fields. Moreover, Gardner (1995) and Greenfield (1995) argue that technology is a common interest for boys, as boys are likely to be interested in learning practical skills and the way that devices work. Nevertheless, their attitudes were still close to neutral. Maybe the ambivalence is because a lot of jobs in technology are manual jobs, which are traditionally disdained in Saudi culture (Al-Asmari, 2001). In contrast, students in Turkey and Malaysia would like to get a job in technology. A possible explanation is that, as mentioned above, careers centred on science are regarded as being valuable to the development of the country and are consequently prestigious positions. The pursuit of science and science-related careers is equal for males and females. Places in the curriculum are awarded on merit; therefore, female students are not limited in the educational choices that they can make (Goy et al., 2018).

Despite the perception that science offers careers opportunities, the results show that students in the developed countries did not want to be scientists (F14), and neither did the Saudi students. Although the students in the developing countries were more positive, in a number of countries, the girls showed less interest. It seems that the more developed a country is, the less passionate the students are about being scientists. Sjøberg and Schreiner (2005) mentions that, unlike the perceptions held by young people in highly developed Western societies, the image that their counterparts in poorer countries have of scientists as people tends to be laudable. For example, Anderson's study (2006) argued that students in developing countries believe that scientists have the potential to help people. Thus, they have positive attitudes towards scientists. It could also be interpreted that science which the students relate to at school inspires, excites and meets their aspirations. Another possible interpretation may be that in a less developed society, like Ghana, science and technology is regarded as the solution to accelerated development of the country. Science and technology-related professionals, such as scientists, engineers, technicians, technologists, agriculturists and medical doctors are still considered very important and respected personalities in society (Anderson, 2006).

Youth in developed countries hope to get a job in which they can do something they find important and meaningful. The job should offer opportunities for using and developing their talents and abilities, and for making their own decisions. They also want to earn good salaries, and to have ample time for their hobbies, interests, friends and family. One interpretation of the low interest in science and technology studies may be that students believe that these aspects, which they apparently value so highly, will not be found in science and technology subjects and careers. For example, science is perceived as difficult, and maybe as a subject demanding persistent, concentrated and determined hard work. This means little leisure time for their hobbies, interests, friends and family. Another interpretation may be that young people do not want to have the identity that seems to be associated with being a researcher in the natural sciences or with working with technology (Sjøberg & Schreiner, 2019).

Another possibility is that some students in developed countries are disenchanted with science. Sjøberg (2002b) proposes various reasons why this may occur. These include the perception of science having no relationship with human needs, the absence of mutual understanding between scientists and society, and the public adhering to a problematic stereotypical image of scientists, such as "white males wearing lab coats, eyeglasses, with facial hair, and an eccentric appearance" (Thomson, Zakaria, & Radut-Taciu, 2019, p. 2). According to Hillman, Zeeman, Tilburg, and List (2016) adverse perceptions of science discourage students from considering science-based careers, although experiencing pleasure from learning science in school may cause students to think about going on to science-based careers (Taskinen et al., 2013). Thus, the students in developed countries may not interested to be scientists.

The stereotypical image of scientists is largely the product of popular culture (Akcay, 2011). Gardner (1980) explains that the cultural models to which students are exposed shape their mental schema. For example, figure 8-7 shows that male students in Turkey would like to be scientists more than girls. The reason may be that in Turkish, the word 'scientist' means "science man", which could create a stereotype of scientists being males (Akcay, 2011), which may explain the Turkish result. Conversely, there are some indications which imply that Malaysian women do not consider science-related jobs to be masculine (Lagesen, 2008), which explains the similarly in the responses of male and female Malaysian students. Another possible explanation for this positive attitude towards science careers of Malaysian and Turkish students is that they hold a broader view of science, believing that science is creative, involves teams of researchers and offers solutions to many problems in life. Griethuijsen et al. (2015) found that Turkish, Malaysian and Indian students viewed science as a more creative and less 'fact-based' activity than Dutch, British and Lebanese students. Also, students who believed that scientists had a creative job were also more interested in a career in science than those who believed that scientists only dealt with 'facts'.

As mentioned in the literature review chapter, which showed the role of culture in education, Islam calls on adherents to seek knowledge (Halstead, 2004). It is therefore reasonable to conclude that Muslims would hold science and Muslim scientists who conduct scientific experiments in high esteem. Örnek (2015) asserts that the religion of Islam is dynamic and that it charges its adherents to study science, perform scientific experiments and to undertake beneficial work. In several tracts of the Qur'an, readers are directed to observe the natural world in its entirety, that is, all life and lifeless entities. This may help to understand why in this study students had positive attitudes towards items F10, F11, and F12. Many participants believed that studying science is useful for knowing about the natural phenomena in the universe and knowing about their bodies. Also, school science reinforced their appreciation of nature as created by Allah. Likewise, because they follow the same religion, perhaps one of the reasons that students in Turkey choose to study science is religion. These students observe the teachings of their religion, thus accept the value of science to human life as set out in Islam. Science is critical to both the development of the nation and the essential social benefits required by its citizens (Örnek, 2015). Regarding religion's influence, according to Kasmo, Possumah, Hassan, Yunos, and Mohamad (2015), Malaysians regard science as a tool that can reinforce belief in the existence of God. God's greatness might be explained by science, which together with religion, might help people. This finding therefore supports the suggestion that religion has a strong influence on the attitudes of students towards science. Depending upon the degree of integration between religion and science that is tolerated by society, attitudes can be positive or negative. Since "religion is a part of culture" (Rahmani, 2016, p. 596), this interpretation of the result is consistent with the Sociocultural theory of Lev Vygotsky, which focuses on how attitudes and people's beliefs derived from culture affect instruction and learning, and also "how adults and peers influence individual learning" (Calabar, 2014, p. 154). Moreover, since, according to Sullins (2006) "women are generally and usually more religious than men" (p.873); this might explain girls' attitudes toward these items in Saudi Arabia and Malaysia. Certain groups in Western societies have embraced an almost religious approach to the environment, and Strumse (1998) points out that people's environmental anxiety is driven by eco-centric and anthropocentric attitudes and beliefs. Some people see the environment as a source of beauty which needs to be safeguarded, while others view it as a resource that must be administered and built upon, a problem to tackle or just somewhere to live and discover (Jenkins, 2003). Nevertheless, the major motivation behind environmental protection in Western societies is an awareness of personal risk and, to a lesser degree, appreciation of the significance and importance of nature itself (Skjåk & Bøyum, 1993).

Students in the developed countries varied in response to item F3, 'School science is rather easy for me to learn'. Generally, students in the developing countries agreed with the statement, although the Saudi students' responses were negative, while their peers in Turkey and Malaysia had negative or near neutral attitudes. Their situation is close, and the result may explain the influence of teaching methods, teacher, or practical work. Negative effects on students' attitudes toward science and a failure to perceive in its utility have been associated with reliance upon textbooks and traditional pedagogical approaches (Ali et al., 2013). Furthermore, students' attitudes toward science are affected by the teaching methods and character of the teacher, which must be considered (Mihladiz & Duran, 2014). These reasons may lead to difficulty of school science. The use of traditional teaching methods, lack of opportunity to do practical work and curricula based on the theoretical, all contributed to negative attitudes towards school science expressed in this study. These reasons, also, could push students to prefer other subjects over school science or not wish to have as much science as possible at school, as in the next item.

Another finding from the current study, is that girl students did not prefer subjects such as Arabic language and history, so they preferred school science (F5). In addition, Saudi female students had more positive attitudes towards science than boys. Some of the science topics such as the human body, health and space may have attracted girl students' interest, so they wanted to learn more about these topics at school. Related to that, Alghamdi (2018) believed that school science gives Saudi students (especially girls) three important benefits. They acquire scientific knowledge and their understanding of science increases; the relationship between life and science becomes easier for female Saudi students to understand, and it encourages Saudi girls to want to work in science-related fields. This is unlike the boys, whose interest in science was due to likely job prospects. This result confirms that boys are more likely to study science with a career in mind, while girls learn science more for the intrinsic interests (Sjøberg & Schreiner, 2019). Students from developed countries appeared to favour other subject areas. This may be a reflection of the greater range of choices of different subject areas that these students have access to, which may lead them to choose subjects they are more interested in than they are in school science. Therefore, students from developed countries may dismiss the science options (Anderson, 2006).

## 8.3. Summary

This chapter has answered Research Question Four. The results presented here show that, in general, the participating students had positive attitudes towards school science. The chapter also highlighted differences in students' responses, as reflected in both the quantitative data and the qualitative data. While the results of several items on section F of the ROSE questionnaire coincided with the students' opinions expressed during discussion, there were contradictions in other areas. The relationship between school science and the students' real and everyday lives increases their interest in studying science. This causes students to become enthusiastic to learn about scientific subjects, and this enables then to gain a better understanding of the subject and a positive attitude towards science. Also, once learners have realised the importance of the scientific content, they will discover how useful it is in solving practical problems. The process of science curriculum development needs to take into account technology, natural phenomena, social and scientific issues, the nature of science and the relationships between science, technology and society.

Students' interest and attitudes towards science are adversely influenced by science curricula, teachers and their teaching style and textbooks. Typically, these present science in a manner that is divorced from the context of life as it is commonly experienced, instead accentuating its abstract, academic and intellectual nature. The lack of context and connection to everyday life leads students to regard science at school as purposeless and without value to daily life. Students have the perception that science taught in school is merely a series of facts and ideas that need to be learned. Students' enthusiasm for science and their achievements in the subject might be improved by learning more about the students' perceptions of science and science lessons. Approaching science education with methods that appeal to students may promote their engagement with science.

Moreover, Saudi culture is one of the factors that has a negative influence on the Saudi girls' selection of scientific careers. A comparison of the Saudi students' responses to section F of the ROSE questionnaire with those of students in other countries who also participated in the ROSE project showed that the Saudi students' opinions about school science were generally more positive than those of students in the developed countries. However, students in the developing countries were frequently more positive than the Saudi students.

In conclusion, although this study presented a number of positive messages about science, technology and society, these positive attitudes were generally not reflected in the Saudi students' responses to a series of statements about school science.

# Chapter 9: Conclusion

## 9.1. Introduction

This chapter concludes the thesis by presenting a summary of the research findings that answer the research questions, leading to answering the main research question:

**What are the views of Saudi secondary school students about science and technology?**

To answer that question, the ROSE questionnaire was used to collect quantitative data, and a diamond-ranking activity was used to collect qualitative data. The research question was addressed via four sub-questions as follows:

- What is the students' interest in science and technology?
- What is the students' experience of out of school science and technology?
- What are the Saudi students' responses to science and technology?
- What are the Saudi students' responses to school science?

Each of these questions is addressed in a separate section including consideration of gender difference in students' views. The implications of the research, and its contribution to knowledge, will also be discussed. Finally, the limitations of this research will be identified, along with recommendations for further research.

## 9.2. Research Sub-Question One:

**What is the students' interest in science and technology?**

This research question was answered and discussed in Chapter Five, which explored the Saudi students' interest in science, based on sections A, B and C of the ROSE questionnaire, 'What I want to learn about', in addition to the participants' discussions during the diamond ranking activity. The purpose of these queries was to obtain insight into the types of problems that intrigue individuals, which may help in assessing how science syllabi may be composed to meet the needs or concerns of the various segments of students.

The results showed that the Saudi boys and girls who participated in this research were interested in learning about most of the topics covered in the questionnaire, with no significant differences between boys and girls in general, although the mean scores indicated that girls had greater interest in science overall than boys. It is likely that the single-sex school system influenced Saudi students' interest in science, especially for girls, who have a greater opportunity in this system to study the purportedly male subjects, such as maths and science, whereas their opportunity may be less in mixed schools.

Constructivist theory claims that if a science topic is relevant and connected to familiar things, students are more likely to find it interesting and worthy of study. Consistent with this theory, participants rated the items linked to human biology as of more importance to learn about. In particular, they were interested in health and fitness topics, and understanding the working of the human body-topics that were relevant to their own live. For example, the ROSE questionnaire results indicated that participants demonstrated high (though varying) levels of interest in learning about diseases and how to treat them, which links to health topics. Also, the participants showed strong interest in studying aspects of human biology, such as 'How the human body is built and functions', 'How babies grow and mature' and 'How my body grows and matures.' The results, also, showed the participants' interest in learning about 'Why we dream while we are sleeping, and what the dreams may mean.' During their discussions in the diamond ranking activity, participants expressed a sense of the importance of helping others by learning how to use medical equipment, which explains why the item, 'How to perform first-aid and use basic medical equipment' had a high mean value. Current issues in Saudi society, such as diseases, influenced Saudi students' interest in biology. This result is consistent with many previous studies that found that students are interested in human biology and health (Bybee & McCrae, 2011; Jenkins & Nelson, 2005; Murray & Reiss, 2005).

In contrast, the results showed that both boys and girls had a lack of interest in a number of items linked to botany, such as those related to agriculture and farming. They also showed little interest in learning about some of the zoology-related topics, for example, 'Cloning of animals' and 'Animals in my area'. Students expressed displeasure with the inclusion of zoology in the biology curriculum because they considered it irrelevant. In Saudi Arabia, raising animals occurs mostly in rural areas, whereas this study was conducted in an urban region. The environment affected students' interest in learning about botany and animals, which had little connection to their day-to-day experience and likely career paths. Similarly in Finland, topics on botany and agriculture are often less popular among students (Uitto et al., 2006).

Space and the solar system were areas of interest for students who participated in this research. Watching scientific broadcasts appeared to have led to awareness and interest in such subjects, and eventually to a desire to study science. Some students mentioned they watched science programmes about space on YouTube to learn about science topics and enjoy them. However, in Saudi, Islam is a major influence on the way science is taught (Alanazi, 2018). Islam has prohibited astrology, because it is based on illusions that, it is argued, have no truth. As all students who participated in this research were Muslims, which influenced their interpretations of certain items. For example, participants expressed a lack of interest in matters rejected by Islam such as Astrology.

However, the students were more interested in topics related to daily activities, such as energy or electricity. Both boys (more than girls) and girls were interested in environmental topics, as shown by the item ‘New sources of energy from the sun, wind, tides, waves, etc.’ The results showed community service was one of the factors that stimulated boys’ interest in physics, so they could learn how to create solar energy for human benefit. Also, technology was found to be a common interest for boys, who were interested in learning practical skills, such as ‘How to use and repair everyday electrical and mechanical equipment’ and ‘How computers work’. This finding is consistent with previous studies such as Elster (2007) and Oscarsson et al. (2009) showing that girls are less interested than boys in technological innovations and modern technology.

Regarding the participants’ interests in chemistry, the result showed that students were not interested in ‘atoms and molecules’. The abstract nature of chemistry makes chemistry concepts difficult to imagine, so less interesting. This appeared to be partly due to lack of practical experience in chemistry. This finding is consistent with other studies which have suggested that students were uninterested in topics in chemistry that did not link to their reality (Barmby et al., 2008; Murray & Reiss, 2005). However, some results were consistent with prevailing gender stereotypes. For example, ‘The ability of lotions and creams to keep the skin young’ was one of girls’ top ten most interesting subjects. Also, girls were more interested than boys in topics linked to the human body, such as the effect of poisons on the body.

In regard to gender differences, the findings indicated that interest in human biology, showed a statistically significant difference in favour of girls. Gender stereotypes that are supported by Saudi culture and Islam affected Saudi students’ interest in science. Girls had a particular interest in topics related to beauty and mystery, whereas boys did not. Girls were interested in some physics topics, including space (e.g., stars) and light (e.g., rainbows) but less interested in technology (e.g., mechanical equipment, computers and games) than boys. There were no statistically significant gender differences in some areas, such as electricity, geology, and chemistry in general, although within these subjects, some items showed differences between girls and boys.

When comparing the Saudi students' results in the current research with those of other students who participated in the ROSE project, it is clear that the items of higher interest to Saudi students corresponded with the interests of students in developing and developed countries. At the same time, the Saudi students shared with students in developed countries lower levels of interest in some items, conflicting with the attitude of students in some of the developing countries, such as those of Africa and Asia. Socio-economic status, climate, lifestyle and prevailing problems influenced students' interest in those countries. In this respect, findings showed students' interest in biology (health), due to its social relevance in all countries. Saudi students and students from developed countries were less interested in agriculture than some students from developing countries. Also, the impact of religion is stronger in Saudi than in other countries.

## 9.3. **Research Sub-Question Two:**

**What is the students' experience of out of school science and technology?**

The second research sub-question concerned the students' science-related activities outside school based on Section H 'My out-of-school experiences' of the ROSE questionnaire. This question was addressed in Chapter Six.

Cooking and technology particularly the latter, were the experiences that both girls and boys most commonly practised outside school science classes. For example, students reparteed frequently using ICT on different devices, for various purposes: communication, information search and leisure. The socio-economic situation impacted on the activities of students outside school. These results are consistent with the results of studies conducted in rich countries, such as Badri et al. (2017) and Mannienen, Miettinen, and Kiviniemi (2005) and contradict studies conducted in poor countries, such as Anderson (2006). Moreover, both girls and boys were familiar with measurement devices and tools, such as a saw, screwdriver or hammer. Students also were engaged in activities such as 'watched nature programmes on TV or in a cinema', 'visited a zoo' and 'used a wheelbarrow.' Students who suffered from illnesses and/or had medical treatment had experience in that area.

The area in which the current study was conducted, dependence on foreign workers and religion all affected Saudi students' activities, which prevented students from doing some activities outside school. The results reveal that both girls and boys had little experience of nature and outdoor activities, reflected in similar results for items such as 'made dairy products like yoghurt, butter, cheese or ghee', 'made compost of grass, leaves or garbage', 'made an instrument (like a flute or drum) from natural materials', and 'made a bow and arrow, slingshot, catapult or boomerang'. Similar results were found by Lavonen et al. (2005b) in Finland. Other activities among the 10 least experienced outside-school activities for students, were 'milked animals like cows, sheep or goats.' and 'knitted, weaved, etc.' Lack of experience in these areas may reflect Saudi reliance on foreign housemaids for many domestic activities. Religion affected the item, 'read my horoscope (telling future from the stars)' which was among the 10 least experienced outside-school activities for both boys and girls.

The results of the current research also showed some gender differences. These appear to reflect gender stereotypes, with the boys showing more interest in repairing light bulbs or valves, repairing a bicycle tube and opening a device such as a radio, computer or phone to see how it works, which are viewed as male activities. Also, boys were statistically more likely to have prepared food over a campfire, open fire or portable fireplace. Reflecting girls' relative lack of freedom outside the home. The tendency for girls to be confined to the home may explain their greater experience with digital application.

The results of section H indicated that some of the activities students practised outside their science class were linked to their interest in science subjects. For example, the results of sections A, C and E indicated that both girls and boys had an interest in learning about health and medical topics, while the results of section H indicated the students' experience of health-related activities outside their science class, such as 'taken medicines to prevent or cure illness or infection' and 'been to a hospital as a patient.' Similarly, the boys' experience of physics activities, such as exploring the working of various devices was linked to their interest in science subjects as reported in sections A, C and E. The results of sections A, C and E also revealed that girls had less interest than boys in learning about 'how to use and repair everyday electrical and mechanical equipment'. Although in section H, girls reported being more involved in using technology outside their science class than boys, the technology concerned was more social media, not mechanical or electrical appliances.

Referring to the comparison of Saudi students with peers in other countries who participated in the ROSE questionnaire, the Saudi students' experience in technology was matched by the experience of students in developed countries and some of the developing countries, while the Saudi students' limited outdoor experiences were similar to those of students in other high-density developed countries. At the same time, Saudi students' rare or infrequent knitting and weaving experience matched the experience of students in developing countries such as Malaysia and in some developed countries such as Scotland.

The answers to this question will help teachers, curriculum makers and textbook authors understand and acknowledge the expectations of students regarding the subjects of science and technology, as well as the ways that they differ between girls and boys.

## 9.4. **Research Sub-Question Three:**

**What are the Saudi students' responses to science and technology?**

Chapter Seven answered research question three by analysing and discussing the data of section G of the ROSE questionnaire, 'My opinion about science and technology', as well as opinions expressed during the diamond-ranking activity, on the importance of science to participants and their communities, and its value in their daily life.

The participants considered that science and technology are important factors for society, which help people to understand others and expand their knowledge. They justified their positive attitude towards science and technology, based on their daily relevance. Also, they believed that society must be familiar with technology in order to know how to use and benefit from it. Participants were optimistic that science and technology will improve the treatment of serious diseases such as HIV / AIDS and cancer. Saudi students' responses and expressions were similar to those of their peers from other countries who, in similar studies, expressed the belief that science and technology had a significant role in the discovery and development of treatments for diseases such as HIV / AIDS, cancer, and other diseases (Najafi et al., 2012; Sjøberg & Schreiner, 2010).

The results show that students believed that countries should rely on themselves and not foreign countries, to ensure continuity in building and improving their knowledge through their own research and theories. Therefore, students believed that science and technology played critical roles in a country's development. In addition, the findings show that participants believed that the advantages of science outweigh its disadvantages. They thought that scientists follow a scientific approach, which always steers them toward proper answers that can help other people to solve problems, improve their life and treat diseases.

However, students disagreed with some section G items. For example, Saudi students did not believe that science and technology have the ability to solve all problems, and only a were convinced that science and technology can help to eradicate poverty and famine in the world. Also, they did not believe everything scientists say. The results agree with a number of studies such as Jenkins and Pell (2006) and Rashed (2019). Students disagreed that science and technology are the cause of environmental problems. The participants showed their belief in the importance of the media in education, for facilitating access to and understanding of information, as well as providing equal education opportunities. They also considered that science education should be compulsory for all students in secondary school, because a balanced curriculum has the advantage of refining the students' skills and knowledge and also improving their understanding.

Examination of gender differences showed no clear difference between girls and boys in their attitude towards science and technology in general. Both genders held positive attitudes towards science and technology. However, three items were more favoured by girls, namely, 'Science and technology will find cures to diseases such as HIV/AIDS, cancer, etc.', 'A country needs science and technology to become developed' and 'Scientific theories develop and change all the time.' Another three were more favoured by boys, namely, 'Science and technology can solve nearly all problems', 'Science and technology are the cause of the environmental problems' and 'We should always trust what scientists have to say.'

The comparison between Saudi students and their peers in other countries who participated in the ROSE project shows the Saudi students and other students had a positive attitude toward science and technology, consistent with the view of Bennett et al. (2013b) that many students believe that science has an important role to play in society, although they do not have a desire to study scientific subjects personally. The attitudes of Saudi students were similar to those from developing and developed countries. All student groups presented positive attitudes about science and technology in the first five items of the comparison, 'Science and technology are important for society', 'Science and technology will find cures to diseases such as HIV/AIDS, cancer, etc', 'Thanks to science and technology there will be greater opportunities for future generations', 'A country needs science and technology to become developed' and 'Science and technology benefit mainly the developed countries.'

However, in the last five items, Saudi students' disagreement accorded with students from developed countries, whereas students from some developing countries had a more positive view of these items, for example, 'Science and technology can solve nearly all problems', 'Science and technology are helping the poor', 'Science and technology are the cause of the environmental problems', 'We should always trust what scientists have to say', and 'Scientists are neutral and objective'. There are multiple factors that contribute to differences between developing and developed countries, including geographic features, cultural, economic and social elements, history, international relationships and political situations (Korkmaz et al., 2017a).

## 9.5. **Research Sub-Question Four:**

**What are Saudi students' responses to school science?**

Chapter Eight presented the Saudi students' views about school science and the importance of their learning science. According to the data of section F, 'My science class', of the ROSE questionnaire and the views expressed during the diamond ranking activity, the Saudi students had positive attitudes towards school science. The results showed a correspondence between the responses to a number of items of section F, and the opinions expressed during the discussion in the diamond ranking activity. However, some opinions expressed modified the picture emerging from the ROSE items. Participants suggested that the teaching methods used by their teacher, in addition to the lack of practical work and the difficulty of the curriculum, all contributed to the difficulty of school science. There were also links between the interest in school science and the interest in specific topics, as well as relevance to everyday life and doing practical work. Both girls and boys saw school science as important for all students, specifically, to improve their job opportunities and to contribute in the development of countries.

Girl participants expressed a preference for science subjects over other subjects, which encouraged them to study the science pathway. As mentioned previously, when asked about their interest in science, girls justified their choice of studying science and technology because it mostly focuses on tangible phenomena and explains the natural phenomena that happen in their life. Saudi culture highlights the difference between males and females, Saudi Arabia provides single-sex schools (Al-Ghamdi, 2019), and girls are reportedly more motivated in single-sex educational environments (Jamjoom & Kelly, 2013).

Although Saudi students found some science useful in their everyday lives, in the diamond-ranking, some indicated they did not have the ability to apply science topics in their daily life, and did not see the relevance of some topics. On the other hand, they believed that biology was related to people's life, so it was easy to recognise or apply what they learned in their everyday life. Also, the results revealed the compatibility between the ROSE and diamond-ranking data in the Saudi students' views towards the role of studying 'the science I learn at school' as a way of enhancing their career opportunities. In spite of that view towards future jobs, girls had an unclear view of their future jobs, in contrast to boys, who had clear plans for their future jobs. Therefore, they decided to choose a science pathway because they believed that science would give them wide opportunities for their future jobs. These results agree with the results of Jenkins and Nelson (2005) and Anderson (2006), both of whom used the ROSE questionnaire and reported that students gave a positive response to item F8.

An unexpected result was the conflict of students' situations, where nether girls nor boys wanted to be scientists; however, a number of them, especially boys, expressed a wish to participate in technology in their future career. As regards the influence of science on their personality, both girls and boys agreed that school science encouraged their curiosity about 'things we cannot explain yet', increased their appreciation of nature and made them 'more critical and sceptical.' Saudi students believed that contemplation of nature would lead them to thank God for his blessings and to glorify him for his creation. This result is in line with other studies conducted in Muslim countries such as Sarjou et al. (2012) in Iran and Rashed (2019) in Egypt.

Teaching methods, practical work and teaching qualifications or competence were the main factors influencing the participants' attitudes towards science and technology. Participants faced obstacles to a deep understanding of science subjects, when the teacher employed traditional teaching methods that did not emphasise practical work, and saw this as a reason for their weak ability to apply the science topics that they had studied. Also, they suggested that the use of traditional teaching methods was due to the low competence of their teachers, resulting in boredom and lack of enjoyment. This confirms that the learning process is strongly affected by the social environment (Vygotsky, 1962). Also, this view reflected the high power distance culture in Saudi, in which teaching is teacher- centred, and "quality of learning depends on excellence of teacher" (Hofstede et al., 2005, p. 72).

While both girls and boys held positive attitudes towards science and technology, as investigated in section F of the ROSE questionnaire, there was a slight difference in the total scores. Also, 10 of the 16 items of section F had statistically significant gender difference, with the girls scoring higher in nine items, and the boys in one. Among the items statistically favoured by girls were item F2, 'School science is interesting', F11, 'School science has increased my appreciation of nature', and F10, 'School science has increased my curiosity about things we cannot yet explain.' However, boys were more positive than girls in relation to item F8, 'I think that the science I learn at school will improve my career chances.'

Girl participants mentioned that they had limited job options because their choices were restricted by Saudi social and cultural values and traditions. However, their situation is changing, now that several changes have been made to laws that restricted women's movements or rights. For example, at the time of the current research, Saudi women were not allowed to drive cars, but in May 2018, the Saudi government removed this prohibition (Alrasheed, 2017).

In comparison to students in other countries who participated in the ROSE questionnaire, the Saudi students' responses to section F of the ROSE questionnaire indicated that their attitude towards school science was generally more positive than those of students in the developed countries. At the same time, the Saudi students were frequently less positive than students in the developing countries. Students' attitudes towards science are influenced by conditions external to the school setting, such as cultural factors, government-led policies, overall technological skill proficiency levels and the national economy (Reiss, 2004). In developed countries, students hope to get a job in which they can do something they find important and meaningful, and that offers opportunities for self-actualization and autonomy. They also want to earn good salaries, and to have ample time for their hobbies, interests, friends and family. In developing countries, a central focus is to address widespread conditions of impoverishment, health and welfare system inadequacies and to promote economic growth. A key public issue is the material development of society; science and technology are regarded as essential to this.

## 9.6. The Students' Views Toward Science

The students' views that were investigated in the current research show interest towards science topics inside and outside of school. Also, the results reveal gender differences in their interests and the activities that they practise outside of school. Both boys and girls showed interest in biology topics, but were more interested in health issues, such as diseases and how to prevent them. Also, both boys and girls showed an interest in physics topics, but their interests differed, with girls being interested in light, electricity and space, while boys were more interested in mechanics. In regard to chemistry, girls' and boys' interests converged, but girls' interest in chemical topics was more related to the human body than that of boys, while boys were more interested in mechanical topics.

The result of examining the students' views indicated that electronic experiments and cooking are the activities most often practised outside the school for both girls and boys. However, despite the similarity of girls and boys in their outside school activities, they differed in some activities, such as astronomy, which attracted girls more than boys, while boys were more attracted to activities related to physics, such as electricity, batteries, lamps, motors, pulleys and cranes.

Also, the Saudi students' views that were investigated in the current research reflected the Saudi students' attitudes towards science subjects inside and outside of school. It emerged that the participants had positive attitudes towards science subjects; specifically, they believed science has benefits in their daily lives, and in society. These benefits include the treatment of diseases and problem-solving and facilitating people's life. Overall, there was no difference between girls and boys in attitudes towards science in and out of school.

The study reveals the views of Saudi students towards the importance of teaching science in the secondary school years for all pathways (science and literature). They believed that studying science is important for everyone, and that the study of science plays a key role in improving people's knowledge about their life, as well as in promoting future employment opportunities. The current research gave the Saudi students the opportunity to report the problems that they faced in school science, including the difficulty of scientific subjects, the lack of practical work and the traditional teaching method, which relies on memorising theories and the prescribed textbooks. They suggested that these problems contribute to the difficulty of Saudi school science, causing students to struggle to understand how to apply theory and what they study, in reality and in their lives.

Giving students the opportunity to express their opinions about education in general and science in particular will enhance their respect for science and technology and will also induce them to think seriously and deeply about the importance of science in their lives.

Participants' views on science and technology were shaped by the teaching methods they experienced. Those participants whose teachers used a traditional didactic teaching methodology, and provided little opportunity for participating in practical work, found it difficult to gain a clear understanding of science subjects and to apply what they had learned about science to the real world. Participants expressed the view that less competent teachers favoured traditional teaching methods and stated that they found this approach tedious and uninteresting. This validates the view that the social setting has a major impact on the learning process (Vygotsky, 1962). In addition, this also reflects the high power distance culture which prevails in Saudi Arabia, where instruction is teacher-centred and, as noted by Hofstede, Hofstede et al. (2005) the skills and competencies of the teacher determine the quality of the learning offered to students.

## 9.7. Changes in the Saudi Law Related To Women

It was mentioned by a number of girl participants in the current research, that gender inequality exists in Saudi Arabia, where restrictions are imposed by law on females compared to males. For example, the male guardianship system rules that women cannot travel abroad without their father's or husband's permission, while boys can travel unrestricted at age 22. Moreover, the Saudi community is a masculine society, and, until recently, Saudi Arabia was the only country that did not allow women to drive. Recently, however, the Saudi government has revised several regulations to give women their rights, most of which came into effect after the data for the current research were collected. Therefore, these restrictions were mentioned by participants because the data were collected before the new regulations. These are described in the following points:

1- In 26/09/2017, Saudi King Salman Bin Abdelaziz issued a high order to permit the issuance of driving licences to women in Saudi Arabia. On 24/06/2018, the Saudi authority started issuing driving licences for women and enabling them to drive cars.
2- Also, in August 2018, the Saudi government modified some of the regulations related to the system of male guardianship over women. The regulation amendment gave both males and females over 21 years of age were given permission to travel abroad without restriction. Thus, women can be issued a passport without the permission of their guardians. Another amendment now allows a woman to represent herself in court for divorce.
3- The amendment also included protection against discrimination in employment. The new regulation states that citizens are equal in the right to work without any discrimination on the basis of sex, disability, age or any other form of discrimination. Therefore, it is illegal for employers to require women candidates for jobs to obtain the consent of their male guardians to work. The new amendment could facilitate girls studying the disciplines they want, whereas there were numerous girl participants whose parents were preventing them from studying some disciplines, such as surgery.

These amendments will have positive impacts on Saudi women, in that they are in support of women's autonomy and ensure their formal rights to work on an equal basis with men. Also, these new reforms will have a positive impact on the social reality of Saudi women by ensuring their legitimate rights.

## 9.8. Implications

Despite the importance of students' views on education, and the great number of students in educational organisations, students' views have mostly been neglected. As Hopkins (2010) believes, this violates the students' democratic rights. Listening to students' views and giving their opinions particular importance is a means of protecting the democratic rights of students. Although a number of studies showed the importance of students' views and their role in education, there has been a lack of Saudi students' view in education, largely because the Saudi education system lacks regulations that enable students to convey their opinions. There are no student unions in Saudi schools, and students do not participate on school boards. Furthermore, no student representatives exist to represent their peers' views to the relevant educational bodies in the education system, such as school administration or educational councils. Therefore, the current research gives the Saudi students the opportunity to express their opinions and views towards science and technology subjects, which could potentially influence the views of academics and managers (Freeman, 2014). In addition, to informing Saudi education policy makers of Saudi students' views and opinions towards science and technology, it demonstrates the importance of students' views and urges policy makers to give Saudi students the opportunity to express their views and become involved in education development.

The current study is the first in Saudi Arabia to employ the ROSE questionnaire to identify Saudi students' interest towards science and technology. This study thereby provides a basis for informed discussions on how to improve school science curricula and enhance students' interest in science and technology. Currently, the Saudi science curriculum's design and structure depend on the views of Saudi education policymakers, which oblige students to study topics that do not hold their interest. It is argued here, that it would be better and more logical to appreciate and recognise students' contribution to the debate about science curriculum design. However, that does not mean science curricula should be designed depending solely on the students' perspective and interests. Rather, balancing the students' views with those of the specialists and the aims of the Saudi education authority for the science curricula would enhance the students' attitude towards science and technology. According to the current research results, students are interested in studying topics relevant to their daily life, such as health, light and electricity. What the participants considered relevant to their daily life resulted in their interest in these topics and produced the desire to have more knowledge about them, as indicated by their responses.

It has been noted that effective education focused on the learners' interests and the society's needs should be matched to their daily life. Such education would link science with the learner' interests, and society's needs to produce qualified individuals able to meet the needs of their society and country. This would increase students' interest in science and technology and offer them future career opportunities. Moreover, science teachers believe that science curricula should be developed based on people' needs to meet their own purposes through education (Anderson, 2006), and acknowledged the importance in education of the interests and experiences of the child (Sjøberg, 2000b) After all, when the educational content is well fitted to children's social context, the students will be interested and their education relevant. The current research showed that the Saudi students' interests and their views on the topics that are relevant to their social context are influenced by culture and religion. Consistent with the collectivist culture. Students were interested in topics offering tangible benefit to their community and the opportunity to help other. On the other hand, students had less interest in learning about scientific topics that were of less clear community relevance or conflicted with their religious beliefs. This provides a clear picture which can help Saudi education policy makers to design a school science curriculum that is interesting and relevant to contextual factors of the Saudi Arabia, such as religion, culture, and tradition.

Among the factors influencing the success of education development, especially curriculum improvement, are teachers' skills, teaching methods and the ways they use these in the teaching of science subjects. In the current research, the data indicated that students were dissatisfied with the traditional teaching. Also, most of the Saudi educational authorities' efforts to improve the education system are focused on developing textbooks, rather than developing teachers' skills (Alwahhabi, Almeraikhi, Alzahrani, & Altuwaijri, 2020). Saudi science teachers teach students by using white boards, ignoring practical work, which, according to the current research results, had a negative impact on students' attitudes. This should indicate to the Saudi authorities the need to work to improve science teachers' teaching skills. Also, science teachers can contribute by developing their ability to vary their science teaching methods to suit the scientific content and help students understand science subjects. Such an approach is sure to be reflected positively in students' interest and lead to positive attitudes towards science and technology.

According to the current research results, gender differences existed in some science subjects, where girls showed more interest towards biology while boys tended to gravitate to electronic and electrical areas. As the Saudi education system is gender-segregated, it would be useful for Saudi students if the science curriculum designers were to take into account gender-based differences in developing content. Designing a science curriculum in line with gender needs can enhance the Saudi students' attitudes towards the science subjects they study.

Another point that Saudi girls mentioned in this research was the limited range of undergraduate majors available for girls in Saudi universities. Some indicated, for example, their desire to study engineering, but they could not because there were no engineering schools for girls in the universities near where they lived, so to study it, they would have to move to another city, which their families would not allow. This study, by highlighting Saudi girls' needs and wishes, can help the Saudi education authority to promote equality between boys and girls in the availability of scientific majors in all universities.

## 9.9. **Limitations**

The present research data, for practical reasons, was collected from a single region (Qassim Region) of Saudi Arabia. While the Saudi education system imposes a high degree of similarity among regions, investigating the students' attitudes and interest towards science and technology in other regions or all regions would provide a more complete picture. Therefore, it is recommended that future studies investigate the Saudi students' view in other regions to determine if location or community can affect the result.

In the present research, the descriptive data were collected using the ROSE questionnaire, which was translated from English to Arabic, while qualitative data were collected in Arabic then translated to English. In both cases, translation issues might have affected the outcomes.

The research sample was selected from Saudi students who were studying in year 12 (third year of secondary school). They had chosen in year 11 to focus on science, maths and technology subjects. In contrast, year 10 has a wider range of subjects, including science, maths, technology, literature and others, as year 10 students, have get to choose between the two pathways. Accordingly, it would be useful to research the attitudes and interest towards science and technology of students in year 10.

The situation of girl participants regarding science and their future employment opportunities, according to the results of the present research, were affected by the Saudi government regulations, enabling women to drive travel and work without needing a guardian's consent. It is therefore advisable to re-examine the views of girls to explore if their future career prospects have changed, and if this influences their attitudes toward science.

Although the present research focused on the investigation of Saudi students' attitudes and interest towards science and technology, the results showed the impact of factors such as teacher and curriculum on the students' attitudes. It is therefore advisable to include teachers in interviews to explore their views on what the students talked about or to give them the chance to share their experience

## 9.10. **Recommendation for the Saudi Education Ministry**

As the current research gave the students the opportunity to speak about science and technology, it has demonstrated that students are capable to contribute to the education development process. Therefore, the researcher advises the Saudi Education Ministry to pay attention to the students' view and give them the chance to be part of the team developing its policies.

The students had complaints related to problems linked to the curricula, teaching methods, teacher qualification and laboratory equipment, all of which problems have been solved in many countries. Therefore, the researcher recommends the Saudi Education Ministry to draw upon the experience of these countries to deal with these problems.

The research results indicated that opportunities between boys and girls are unequal in universities, thus depriving some girls of the opportunity to study in the major they want. Since the ministry is the sponsor of higher education in Saudi Arabia, the researcher recommends that efforts be made to give girls and boys equal opportunity in universities.

## 9.11. **Contribution**

Children have the right to express their views, feelings and desires on everything affecting them, and to have their views taken seriously by adults, according to Article 12 of the United Nations Convention on the Rights of the child.

However, the UN Committee mentioned that Article 12 was not adequately addressed in legislation or practice in general and specifically in Saudi Arabia, as has been made clear by the results of the current research. However, employing the students' view for improving schools, for example, is potentially an important contribution to discussion. Without that view, any strategies developed will eventually be ineffective. Mitra (2003) considered students' view to be a key factor in the teaching approach; accordingly, it is increasingly important to involve students in education improvement, where their views can contribute positively to the development, evaluation and consultation process in schools.

This study contributes to fill a gap in knowledge regarding Saudi students' views, given the lack of a platform in the Saudi education system giving students the opportunity to express their opinions or views towards education, and the absence of previous research in Saudi Arabia concerning the students' views, to investigate their attitude and interest towards science and technology. This research, therefore, makes a significant contribution by offering Saudi educationalists' understanding of Saudi students' views and opinions towards science and technology. In this way, it can contribute to the education improvement process. It also analysed students' viewpoints and opinions regarding the factors that influenced their attitudes and interests, positively or negatively, which similarly can help inform policy and practical measures to enhance facilitating factors and overcome issues that produce negative attitudes.

Methodologically the current research reveals significant data related to the Saudi students' attitudes and interest towards science and technology through two data collection instruments: the ROSE questionnaire and diamond-ranking. The current research is the first study in Saudi Arabia to investigate students' views towards science and technology using the ROSE questionnaire, as an appropriate instrument to achieve the researcher's aims. Thus, the current research will contribute to the ROSE project, which adds to knowledge by using the ROSE questionnaire in a new context and also adds to the literature for further research for those who need data about Saudi students.

The researcher's employment of the diamond ranking activity was to interpret the Saudi students' responses to the ROSE questionnaire, where they showed their criticism of teaching methods, what they believed to be interesting in science and what they thought they did not benefit from during their study journey. Employing the diamond ranking activity together with the ROSE questionnaire to deduce the students' attitudes is a contribution to research methodology in the use of data collection instruments to interpret the attitudes of respondents. One of the challenges faced by the researcher was how to encourage the young people to talk and express their views without feeling uncomfortable, in a country that rarely gives them the opportunity to express their opinions about official matters. Employing diamond ranking succeeded in enhancing students' ability to discuss among themselves, which resulted in rich qualitative data. Moreover, the groups of students participating in the research demonstrated a good ability to use and discuss the statements that were used in the diamond ranking activity, which indicated the effectiveness of using this activity to encourage young students to talk.

Despite some similarities in the responses of Saudi students to those of their peers in other countries who participated in the ROSE project, the views of the Saudi students as expressed in this particular research can open the eyes of the Saudi educational officials to understand the factors that help students learn better and what they need to learn about, in addition to their observations on the teaching methods that their teachers used.

Due to the ability of the researcher to collect data from girls and boys, despite the segregation applied in the Saudi education system, the results of the current research reveal the gender differences in their interests and attitudes, which will be helpful to future researchers who are concerned about gender issues and single-sex schools.

## 9.12. **Summary**

This study investigated Saudi students' view towards science. It used mixed methods to answer the research question, with the ROSE questionnaire used to collect quantitative data and focus group interviews conducted to collect qualitative data. The main research question was answered by answering four sub-research questions, and the current chapter outlined the answers and discussed how this data answered the main research question to achieve the research aims.

Furthermore, the current chapter showed the importance of the students' views to the Saudi education authorities by providing research implications. As with any human work, the current research has limitations, and this chapter acknowledged the research's limitations and provided recommendations for future researchers. The chapter concluded by discussing the present research's contributions to the existing literature.

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# Appendices

## Appendix 1: The ROSE Questionnaire - Arabic Version

### أ. ماذا أود أن آتعلم عن؟

**(امام كل عبارة مجموعة خيارات ضع علامة صح في الخيار المناسب لك، و اذا لم تفهم العبارات اترك الخيار فارغاً)**

| | ما مدى اهتمامك بتعلم ما يلي؟ | مهتم جداً | مهتم | مهتم نوعاً ما | غير مهتم |
|---|---|---|---|---|---|
| ١ | هل انت مهتم بالتعلم عن النجوم و الكواكب و الكون (الفضاء)................................ | | | | |
| ٢ | هل انت مهتم بالتعلم عن المواد الكيميائة و خصائصها و كيف تتفاعل.......................... | | | | |
| ٣ | هل انت مهتم بالتعلم عن باطن الأرض (الجيولوجيا) ........................................ | | | | |
| ٤ | هل انت مهتم بالتعلم عن كيفية تطور و تغير الجبال و الأنهار و المحيطات.................. | | | | |
| ٥ | هل انت مهتم بالتعلم عن السحب و الامطار و الطقس.......................................... | | | | |
| ٦ | هل انت مهتم بالتعلم عن أصل الحياة على الأرض و تطورها................................. | | | | |
| ٧ | هل انت مهتم بالتعلم عن كيفية بناء جسم الانسان و كيفية عمله................................ | | | | |
| ٨ | هل انت مهتم بالتعلم عن علم الوراثة و كيفية تأثير الجينات في تطورنا........................ | | | | |
| ٨ | هل انت مهتم بالتعلم عن كيفية نموا الأطفال و نضجهم.......................................... | | | | |
| ٩ | هل انت مهتم بالتعلم عن استنساخ الحيوانات.................................................. | | | | |
| ١٠ | هل انت مهتم بالتعلم عن الحيوانات في أنحاء أخرى من العالم ( كافة الحيوانات حول العالم).. | | | | |
| ١١ | هل انت مهتم بالتعلم عن الدينسورات و كيف عاشت و لماذا انقرضت........................ | | | | |
| ١٢ | هل انت مهتم بالتعلم عن كيفية نمو النباتات وتتكاثرها......................................... | | | | |
| ١٢ | هل انت مهتم بالتعلم عن كيفية إعتمد الناس والحيوانات والنباتات والبيئة على بعضهم البعض. | | | | |
| ١٣ | هل انت مهتم بالتعلم عن الذرات والجزيئات................................................ | | | | |
| ١٤ | هل انت مهتم بالتعلم عن كيفية تأثير النشاط الإشعاعي على جسم الإنسان.................... | | | | |
| ١٥ | هل انت مهتم بالتعلم عن الضوء من حولنا والذي لا نستطيع أن نراه (الأشعة تحت الحمراء، الأشعة فوق البنفسجية)........................................................ | | | | |
| ١٦ | هل انت مهتم بالتعلم عن كيفية إستخدم بعض الحيوانات للألوان من اجل لإختباء اوالجذب او التخويف......................................................................... | | | | |
| ١٧ | هل انت مهتم بالتعلم عن الثقوب السوداء، السوبرنوفا (النجم المتفجر الأعظم) وغيرها من الأجسام المدهشة في الفضاء الخارجي................................................ | | | | |
| ١٨ | هل انت مهتم بالتعلم عن كيف يمكن أن تتسبب النيازك والمذنبات أو الكويكبات في الكوارث على الأرض......................................................................... | | | | |
| ١٩ | هل انت مهتم بالتعلم عن الزلازل والبراكين................................................ | | | | |

# أ. ماذا أود أن آتعلم عن؟

(امام كل عبارة مجموعة خيارات ضع علامة صح في الخيار المناسب لك، و اذا لم تفهم العبارات اترك الخيار فارغاً)

| | ما مدى اهتمامك بتعلم ما يلي؟ | مهتم جداً | مهتم | مهتم نوعاً ما | غير مهتم |
|---|---|---|---|---|---|
| ٢٠ | هل انت مهتم بالتعلم عن الأعاصير بأنواعها المختلفة.................................... | | | | |
| ٢١ | هل انت مهتم بالتعلم عن الأوبئة والأمراض التي تتسبب في خسائر كبيرة في الأرواح........ | | | | |
| ٢٢ | هل انت مهتم بالتعلم عن الحيوانات المتوحشة و الخطرة................................ | | | | |
| ٢٣ | هل انت مهتم بالتعلم عن النباتات السامة في منطقتي........................................ | | | | |
| ٢٤ | هل انت مهتم بالتعلم عن السموم القاتلة و تأثيرها على جسم الإنسان......................... | | | | |
| ٢٥ | هل انت مهتم بالتعلم عن الأسلحة البيولوجية والكيميائية و تأثيرها على جسم الإنسان.......... | | | | |
| ٣٤ | هل انت مهتم بالتعلم عن تأثير الصدمات الكهربائية القوية والصواعق على جسم الإنسان...... | | | | |
| ٣٥ | هل انت مهتم بالتعلم عن ما هو الشعورعندما تفقد وزنك في الفضاء........................ | | | | |
| ٣٦ | هل انت مهتم بالتعلم عن كيفية استخدام النجوم لتحديد الاتجاهات و معرفة الطريق اثناء السير. | | | | |
| ٣٧ | هل انت مهتم بالتعلم عن كيفية رؤية العين للضوء والألوان ................................ | | | | |
| ٣٨ | هل انت مهتم بالتعلم عن ما الذي يجب أن تأكله لتبقى بصحة وشكل بدني جيد................ | | | | |
| ٣٩ | هل انت مهتم بالتعلم عن اضطرابات الأكل مثل فقدان الشهية أو شراهة الاكل المرضية....... | | | | |
| ٤٠ | هل انت مهتم بالتعلم عن قدرة المستحضرات المرطبة والكريمات للحفاظ على بشرة شابة..... | | | | |
| ٤١ | هل انت مهتم بالتعلم عن كيفة تأثر ممارسة التمارين الرياضية على قوة الجسم و تناسقه....... | | | | |
| ٤٢ | هل انت مهتم بالتعلم عن الجراحة التقويمية والجراحة التجميلية................................ | | | | |
| ٤٣ | هل انت مهتم بالتعلم عن كيفة تأثر اشعة الشمس والأشعاعات من البيوت الشمسية على البشرة | | | | |
| ٤٤ | هل انت مهتم بالتعلم عن كيف تستطيع الاذن تمييز الأصوات المختلفة........................ | | | | |
| ٤٥ | هل انت مهتم بالتعلم عن الصواريخ والأقمار الصناعية و الذهاب إلى الفضاء................ | | | | |
| ٤٦ | هل انت مهتم بالتعلم عن استخدام الأقمار الصناعية في الإتصال والأغراض الأخرى......... | | | | |
| ٤٧ | هل انت مهتم بالتعلم عن كيفة استخدم الأشعة السينية و الموجات فوق الصوتية وغيرها من الأشعات في الطب.......................................................................... | | | | |
| ٤٨ | هل انت مهتم بالتعلم عن كيفة عمل محركات البنزين و الديزل............................. | | | | |

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**(امام كل عبارة مجموعة خيارات ضع علامة صح في الخيار المناسب لك، و اذا لم تفهم العبارات اترك الخيار فارغاً)**

| | ما مدى اهتمامك بتعلم ما يلي؟ | مهتم جداً | مهتم | مهتم نوعاً ما | غير مهتم |
|---|---|---|---|---|---|
| ١ | هل انت مهتم بالتعلم عن كيف يتم تحويل النفط الخام إلى مواد أخرى، مثل البلاستيك والمنسوجات | | | | |
| ٢ | هل انت مهتم بالتعلم عن الأجهزة البصرية وكيفية عملها (التلسكوب، الكاميرا، المجهر، وما إلى ذلك)........................................................................................................ | | | | |
| ٣ | هل انت مهتم بالتعلم عن استخدامات الليزر للأغراض التقنية مثل (مشغل الأقراص المدمجة -CD Players، قارئ الباركود، و غيرها)............................................................................ | | | | |
| ٤ | هل انت مهتم بالتعلم عن كيف يتم تخزين الصوت على الاقراص المدمجة CD و الرقمية DVD واشرطة الكاسيت و تشغيله............................................................................................ | | | | |
| ٥ | هل انت مهتم بالتعلم عن كيفية عمل الأشياء مثل الراديو و التليفزيون.................................. | | | | |
| ٦ | هل انت مهتم بالتعلم عن كيف يمكن للهاتف الجوال إرسال و استقبال الرسائل......................... | | | | |
| ٧ | هل انت مهتم بالتعلم عن كيفية عمل جهاز الحاسب الألي (الكمبيوتر)...................................... | | | | |
| ٨ | هل انت مهتم بالتعلم عن إمكانية العيش خارج كوكب الأرض............................................... | | | | |
| ٩ | هل انت مهتم بالتعلم عن علم التنجيم والأبراج، وما إذا كانت الكواكب يمكن أن تؤثر في البشر...... | | | | |
| ١٠ | هل انت مهتم بالتعلم عن الأسرار الغامضة و التي لم تحل في الفضاء الخارجي.......................... | | | | |
| ١١ | هل انت مهتم بالتعلم عن الحياة و الموت و روح الأنسان.................................................. | | | | |
| ١٢ | هل انت مهتم بالتعلم عن العلاجات البديلة (الوخز بالأبر والمعالجة المثلية واليوغا، والتداوي ومدى فاعليتها............................................................................................................ | | | | |
| ١٣ | هل انت مهتم بالتعلم عن لماذا نحلم حينما نكون نائمين وماذا يمكن أن تعني الأحلام ............... | | | | |
| ١٤ | هل انت مهتم بالتعلم عن حقيقة وجود السحرة و الاشباح ....................................................... | | | | |
| ١٥ | هل انت مهتم بالتعلم عن انتقال الأفكار (التخاطر) و قراءة أفكار الأخرين و الحاسة السادسة و الحدس الخ ................................................................................................................ | | | | |
| ١٦ | هل انت مهتم بالتعلم عن لماذا تومض النجوم و لماذا السماء زرقاء........................................ | | | | |

## ج.ماذا أود أن آتعلم عن؟

**(امام كل عبارة مجموعة خيارات ضع علامة صح في الخيار المناسب لك، و اذا لم تفهم العبارات اترك الخيار فارغاً)**

| | ما مدى اهتمامك بتعلم ما يلي؟ | مهتم جداً | مهتم | مهتم نوعاً ما | غير مهتم |
|---|---|---|---|---|---|
| ١٧ | هل انت مهتم بالتعلم عن لماذا يمكننا مشاهدة قوس قوزح.................................................. | | | | |
| ١٨ | هل انت مهتم بالتعلم عن خصائص الأحجار الكريمة والبلورات وكيف يمكن استخدامها للتجمل..... | | | | |

# هـ.ماذا أود أن آتعلم عن؟

**(امام كل عبارة مجموعة خيارات ضع علامة صح في الخيار المناسب لك، و اذا لم تفهم العبارات اترك الخيار فارغاً)**

| | ما مدى اهتمامك بتعلم ما يلي؟ | مهتم جداً | مهتم | مهتم نوعاً ما | غير مهتم |
|---|---|---|---|---|---|
| ١٥ | انا مهتم بالتعلم عن كيفية تحسين الحصاد (المحصول الزراعي) في الحدائق والمزارع....... | | | | |
| ١٦ | انا مهتم بالتعلم عن الاستخدام الطبي للنباتات............................................ | | | | |
| ١٩ | انا مهتم بالتعلم عن الزراعة العضوية والبيئية دون استخدام المبيدات الحشرية والأسمدة الصناعية | | | | |
| ٢٠ | انا مهتم بالتعلم عن كيفية توفير الطاقة أو استخدامها بطريقة أكثر فعالية.................... | | | | |
| ٢١ | انا مهتم بالتعلم عن المصادر الجديدة للطاقة من الشمس و الرياح و المد و الجزر و الامواج و غيرها.................................................................................... | | | | |
| ٢٢ | انا مهتم بالتعلم عن كيفية انتاج وحفظ و تخزين أنواع مختلفة من الطعام................... | | | | |
| ٢٣ | انا مهتم بالتعلم عن كيفية نموا جسمي و كيفية نضوجه..................................... | | | | |
| ٢٤ | انا مهتم بالتعلم عن الحيوانات في منطقتي.................................................... | | | | |
| ٢٥ | انا مهتم بالتعلم عن النباتات في منطقتي...................................................... | | | | |
| ٢٦ | انا مهتم بالتعلم عن المنظفات والصابون وكيفية عملها....................................... | | | | |
| ٢٧ | انا مهتم بالتعلم عن كيفية إنتاج الكهرباء واستخدامها في المنزل............................. | | | | |
| ٢٨ | انا مهتم بالتعلم عن كيفية استخدام وإصلاح الأجهزة الكهربائية والميكانيكية ذات الاستخدام اليومي..................................................................................... | | | | |
| ٢٩ | انا مهتم بالتعلم عن أول هبوط على سطح القمر وتاريخ استكشاف الفضاء.................. | | | | |
| ٣٠ | انا مهتم بالتعلم عن تأثير الكهرباء على تنمية مجتمعنا........................................ | | | | |
| ٣١ | انا مهتم بالتعلم عن الجوانب البيولوجية و الانسانية للإجهاض.............................. | | | | |
| ٣٢ | انا مهتم بتعلم كيف يمكن لتقنية الجينات أن تحد من الأمراض (كيف يمكن لتكنولوجيا الجينات أن تحد من الأمراض) ........................................................................ | | | | |
| ٣٣ | انا مهتم بالتعلم عن الفوائد والمخاطر المحتملة للأساليب الحديثة في الزراعة................ | | | | |
| ٣٤ | انا مهتم بتعلم الأسباب التي تجعل الدين والعلم في بعض الأحيان قد يتباينان................ | | | | |
| ٣٥ | انا مهتم بالتعلم عن فوائد و مخاطرالمضافات الغذائية........................................ | | | | |
| ٣٦ | انا مهتم بالتعلم عن أسباب الخلاف بين علماء الطبيعة (فيزياء، كيمياء،إحياء) في بعض الأحيان..................................................................................... | | | | |
| ٣٧ | انا مهتم بالتعلم عن العلماء المشاهير و معرفة جوانب من حياتهم........................... | | | | |
| ٣٨ | انا مهتم بالتعلم عن الأخطاء الفادحة في المجال البحثي و الاختراعات...................... | | | | |
| ٣٩ | انا مهتم بمعرفة الأسباب التي تجعل بعض الأفكار العلمية احياناً تتعارض مع الدين والسلطات و التقاليد أو العادات............................................................................ | | | | |

## هـ.ماذا أود أن آتعلم عن؟

**(امام كل عبارة مجموعة خيارات ضع علامة صح في الخيار المناسب لك، و اذا لم تفهم العبارات اترك الخيار فارغاً)**

| | ما مدى اهتمامك بتعلم ما يلي؟ | مهتم جداً | مهتم | مهتم نوعاً ما | غير مهتم |
|---|---|---|---|---|---|
| ١٥ | انا مهتم بالتعلم عن كيفية تحسين الحصاد (المحصول الزراعي) في الحدائق والمزارع....... | | | | |
| ١٦ | انا مهتم بالتعلم عن الاستخدام الطبي للنباتات.............................................. | | | | |
| ١٩ | انا مهتم بالتعلم عن الزراعة العضوية والبيئية دون استخدام المبيدات الحشرية والأسمدة الصناعية | | | | |
| ٢٠ | انا مهتم بالتعلم عن كيفية توفير الطاقة أو استخدامها بطريقة أكثر فعالية........................ | | | | |
| ٢١ | انا مهتم بالتعلم عن المصادر الجديدة للطاقة من الشمس و الرياح و المد و الجزر و الامواج و غيرها.................................................................................... | | | | |
| ٢٢ | انا مهتم بالتعلم عن كيفية انتاج وحفظ و تخزين أنواع مختلفة من الطعام..................... | | | | |
| ٢٣ | انا مهتم بالتعلم عن كيفية نموا جسمي و كيفية نضوجه.......................................... | | | | |
| ٢٤ | انا مهتم بالتعلم عن الحيوانات في منطقتي.......................................................... | | | | |
| ٢٥ | انا مهتم بالتعلم عن النباتات في منطقتي............................................................ | | | | |
| ٢٦ | انا مهتم بالتعلم عن المنظفات والصابون وكيفية عملها......................................... | | | | |
| ٢٧ | انا مهتم بالتعلم عن كيفية إنتاج الكهرباء واستخدامها في المنزل............................. | | | | |
| ٢٨ | انا مهتم بالتعلم عن كيفية استخدام وإصلاح الأجهزة الكهربائية والميكانيكية ذات الاستخدام اليومي................................................................................................ | | | | |
| ٢٩ | انا مهتم بالتعلم عن أول هبوط على سطح القمر وتاريخ استكشاف الفضاء.................... | | | | |
| ٣٠ | انا مهتم بالتعلم عن تأثير الكهرباء على تنمية مجتمعنا........................................... | | | | |
| ٣١ | انا مهتم بالتعلم عن الجوانب البيولوجية و الانسانية للإجهاض.................................. | | | | |
| ٣٢ | انا مهتم بتعلم كيف يمكن لتقنية الجينات أن تحد من الأمراض (كيف يمكن لتكنولوجيا الجينات أن تحد من الأمراض) ................................................................... | | | | |
| ٣٣ | انا مهتم بالتعلم عن الفوائد والمخاطر المحتملة للأساليب الحديثة في الزراعة.................. | | | | |
| ٣٤ | انا مهتم بتعلم الأسباب التي تجعل الدين والعلم في بعض الأحيان قد يتباينان................... | | | | |
| ٣٥ | انا مهتم بالتعلم عن فوائد و مخاطر المضافات الغذائية.......................................... | | | | |
| ٣٦ | انا مهتم بالتعلم عن أسباب الخلاف بين علماء الطبيعة (فيزياء، كيمياء،إحياء) في بعض الأحيان.................................................................................................. | | | | |
| ٣٧ | انا مهتم بالتعلم عن العلماء المشاهير و معرفة جوانب من حياتهم............................ | | | | |
| ٣٨ | انا مهتم بالتعلم عن الأخطاء الفادحة في المجال البحثي و الاختراعات........................ | | | | |
| ٣٩ | انا مهتم بمعرفة الأسباب التي تجعل بعض الأفكار العلمية احياناً تتعارض مع الدين والسلطات و التقاليد أو العادات.................................................................... | | | | |

## هـ.ماذا أود أن آتعلم عن؟

**(امام كل عبارة مجموعة خيارات ضع علامة صح في الخيار المناسب لك، و اذا لم تفهم العبارات اترك الخيار فارغاً)**

| | ما مدى اهتمامك بتعلم ما يلي؟ | مهتم جداً | مهتم | مهتم نوعاً ما | غير مهتم |
|---|---|---|---|---|---|
| ٤٠ | انا مهتم بالتعلم عن الإختراعات والإكتشافات التي غيرت العالم.............................. | | | | |
| ٤١ | انا مهتم بالتعلم عن لاختراعات والاكتشافات الحديثة جدا في مجال العلوم والتكنولوجيا........ | | | | |
| ٤٢ | انا مهتم بالتعلم عن الظواهر التي لا يزال العلماء عاجزون عن تفسيرها...................... | | | | |

## و. موادي العلمية الطبيعية (الفيزياء، الكيمياء، الآحياء)

(امام كل عبارة مجموعة خيارات ضع علامة صح في الخيار المناسب لك، و اذا لم تفهم العبارات اترك الخيار فارغاً)

| | إلى أي مدى تتفق مع العبارات التالية حول المواد و المواضيع التي تدرسها او درستها في المواد العلمية (الفيزياء و الكيمياء و الآحياء) بالمدرسة؟ | موافق جداً | موافق | موافق نوعاً ما | غير موافق |
|---|---|---|---|---|---|
| ١ | المواد العلمية مواضيعها صعبة............................................................... | | | | |
| ٢ | المواد العلمية ممتعة......................................................................... | | | | |
| ٣ | المواد العلمية اعتبرها مواد سهلة للمذاكرة و التعلم.......................................... | | | | |
| ٤ | تعرفت على وظائف جديدة ومثيرة من خلال المواد العلمية.................................. | | | | |
| ٥ | أفضل المواد العلمية على كافة المواد الأخرى................................................ | | | | |
| ٦ | أعتقد انه يجب على كل شخص دراسة المواد العلمية......................................... | | | | |
| ٧ | الأشياء التي اتعلمها في المواد العلمية في المدرسه سوف تساعدني في حياتي اليومية........ | | | | |
| ٨ | دراسة المواد العلمية سيعزز فرص حصولي على وظيفة...................................... | | | | |
| ٩ | المواد العلمية جعلتني شخصية اكثر تحليل و ناقدة بشكل اكبر............................... | | | | |
| ١٠ | المواد العلمية زادت من فضولي لمعرفة و فهم الأشياء التي لم تفسر حتى الأن............. | | | | |
| ١١ | المواد العلمية زادت من تقديري للطبيعة........................................................ | | | | |
| ١٢ | المواد العلمية أظهرت لي أهمية العلم في إسلوب حياتنا..................................... | | | | |
| ١٣ | تعلمت من المواد العلمية كيفية الاهتمام بشكل افضل بصحتي................................ | | | | |
| ١٤ | ارغب ان أكون عالماً في العلوم الطبيعية ( الفيزياء، الكيمياء، الآحياء)...................... | | | | |
| ١٥ | ارغب في دراسة اكبر قدر ممكن من الموضوعات العلمية في المدرسة...................... | | | | |
| ١٦ | أود الحصول على وظيفة في مجال التقنية والتكنولوجيا........................................ | | | | |

## ز. وجهة نظري تجاه العلوم الطبيعية (الفيزياء، الكيمياء، الآحياء) و التكنولوجيا

(امام كل عبارة مجموعة خيارات ضع علامة صح في الخيار المناسب لك، و اذا لم تفهم العبارات اترك الخيار فارغاً)

| | إلى أي مدى تتفق مع العبارات التالية: | موافق جداً | موافق | موافق نوعاً ما | غير موافق |
|---|---|---|---|---|---|
| ١ | العلوم والتكنولوجيا مهمة للمجتمع.......................................................... | | | | |
| ٢ | بفضل العلم والتكنولوجيا، وسوف يكون هناك المزيد من الفرص للأجيال القادمة............ | | | | |
| ٣ | بفضل العلوم والتكنولوجيا اصبحت حياتنا أكثر صحة وأسهل وأكثر راحة.................. | | | | |
| ٤ | التقنية الحديثة ستجعل بيئة العمل اكثر متعة.............................................. | | | | |
| ٥ | فوائد العلوم الطبيعية (الفيزياء، الكمياء، الاحياء) تفوق الاضرار التي قد يتسبب بها......... | | | | |
| ٦ | يمكن ان تساعد العلوم و التكنولوجيا في القضاء على الفقر و المجاعات في العالم........... | | | | |
| ٧ | العلوم والتكنولوجيا يمكن أن تحل المشاكل كلها تقريبا...................................... | | | | |
| ٨ | العلوم والتكنولوجيا تساعد الفقراء........................................................... | | | | |
| ٩ | العلوم والتكنولوجيا هي السبب في المشاكل البيئية.......................................... | | | | |
| ١٠ | تحتاج الدولة للعلوم الطبيعية (الفيزياء، الكيمياء، الأحياء) والتكنولوجيا لكي تتطور.......... | | | | |
| ١١ | العلوم الطبيعية (الفيزياء، الكيمياء، الأحياء) والتكنولوجيا يفيدان بشكل اساسي الدول المتقدمة | | | | |
| ١٢ | العلماء الذين يستخدمون الطرق العلمية دائم يقودهم ذلك للإجابات الصحيحة................ | | | | |
| ١٣ | يجب علينا دائماً ان نثق بما يقوله العلماء.................................................... | | | | |
| ١٤ | العلماء دائماً محايدون و موضوعيون......................................................... | | | | |
| ١٦ | النظريات العلمية دائمة التطور و التغير...................................................... | | | | |

# ح. خبراتي خارج المدرسة

(امام كل عبارة مجموعة خيارات ضع علامة صح في الخيار المناسب لك، و اذا لم تفهم العبارات اترك الخيار فارغاً)

| | كيف تقوم بهذه الاعمال دائماً خارج المدرسة؟ | دائماً | أحياناً | نادراً | لا أقوم بها ابداً |
|---|---|---|---|---|---|
| ١ | أنا أحاول العثور على تشكيلات (مجموعات) النجوم في السماء............................ | | | | |
| ٣ | أتعرف على طريقي من خلال الاطلاع على الخريطة.................................... | | | | |
| ٤ | أستخدم البوصلة لمعرفة الاتجاه.............................................................. | | | | |
| ٥ | أجمع الأحجار و القواقع (الصدف) المختلفة.............................................. | | | | |
| ٦ | شاهدت بشكل مباشر (ليس عبر التليفزيون) حيوان يلد..................................... | | | | |
| ٧ | سبق لي رعاية و تربية حيوانات في مزرعة................................................... | | | | |
| ٨ | سبق ان زرت حديقة الحيوان................................................................... | | | | |
| ٩ | زرت مراكز او متاحف علمية.................................................................. | | | | |
| ١٠ | قمت بحلب الحيوانات مثل البقر أو الغنم أو الماعز ......................................... | | | | |
| ١١ | أصنع الزبادي أو الزبدة أو الجبن أو السمن من منتجات الألبان............................ | | | | |
| ١٢ | أقرأ عن الطبيعة أو العلوم الطبيعية (الفيزياء،الكميمياء، الأحياء) في الكتب أو المجلات...... | | | | |
| ١٣ | أشاهد برامج تلفزيونية عن الطبيعة............................................................ | | | | |
| ١٤ | أجمع أو أقطف بعض الفواكه مثل التوت الصالح للأكل او الفطر ( العرجون، الفقع) أو النباتات............................................................................................ | | | | |
| ١٥ | أشارك في رحلة صيد............................................................................ | | | | |
| ١٦ | أشارك في رحلة صيد اسماك..................................................................... | | | | |
| ١٧ | أزرع (زرعت) البذور وتباعتها أثناء نموها..................................................... | | | | |
| ١٨ | أقوم (قمت) بعمل سماد من الحشائش وأوراق الشجر أو القمامة............................... | | | | |
| ١٩ | أصنع بعض الأدوات ( مثل الطبل او قوس و نبال) من المواد الطبيعية....................... | | | | |
| ٢٠ | أقوم بعمل النسيج و المحبوكات...الخ......................................................... | | | | |
| ٢١ | أقوم بنصب خيمة أو بناء عشة.................................................................. | | | | |
| ٢٢ | أشعل (أوقد) النار من الحطب و الفحم.......................................................... | | | | |
| ٢٣ | أطبخ طعام على الحطب او على موقد........................................................... | | | | |
| ٢٤ | أقوم بفرز القمامة لاعادة التدوير او للتخلص المناسب........................................ | | | | |
| ٢٥ | أقوم بتضميد و تنظيف الجروح................................................................... | | | | |
| ٢٦ | أشاهد اشعة ( اشعة سينية) لاحد أجزاء جسمي.................................................. | | | | |
| ٢٧ | أتناول دواء لعلاج مرض او للوقاية من مرض.................................................. | | | | |

# ح. خبراتي خارج المدرسة

(امام كل عبارة مجموعة خيارات ضع علامة صح في الخيار المناسب لك، و اذا لم تفهم العبارات اترك الخيار فارغاً)

| | كيف تقوم بهذه الاعمال دائماً خارج المدرسة؟ | دائماً | أحياناً | نادراً ما | لا أقوم بها ابداً |
|---|---|---|---|---|---|
| ٢٨ | أتناول الأدوية العشبية أو العلاجات البديلة (الوخز بالإبر واليوغا، وتضميد الجراح وغيرها).. | | | | |
| ٢٩ | أذهب للمستشفى كمريض.................................................................... | | | | |
| ٣٠ | أستخدم المنظار.............................................................................. | | | | |
| ٣١ | أستخدم الكاميرا............................................................................. | | | | |
| ٣٢ | أصنع القوس والسهم،مقلاع، منجنيق، نبيله............................................ | | | | |
| ٣٣ | أستخدم بندقية الصيد الهوائية او بندقية الصيد....................................... | | | | |
| ٣٤ | أستخدام مضخة الماء او انبوب سحب الماء من وعاء لآخر (السيفون) .................... | | | | |
| ٣٥ | أصنع نماذج الألعاب مثل طائرة او قارب و غيرها...................................... | | | | |
| ٣٦ | أستخدم الأدوات العلمية (مثلاً في الكيمياء أو البصريات او الكهرباء) .................... | | | | |
| ٣٧ | أستخدم الطاحونة الهوائية او الطاحونة المائية او العجلة المائية............................ | | | | |
| ٣٨ | أقوم بالتسجيل على الفيديوا او الديفي دي او شريط المسجل............................... | | | | |
| ٣٩ | أثبت و أغيير المصباح الكهربائي او الفيوز............................................... | | | | |
| ٤٠ | أوصل سلك جهاز كهربائي الى القابس ( الفيش الكهربائي) ................................ | | | | |
| ٤١ | أستخدم ساعة التوقف......................................................................... | | | | |
| ٤٢ | أستخدم مقياس الحرارة (الثيرموميتر) لقياس درجة الحرارة................................. | | | | |
| ٤٣ | أستخدم المسطر للقياس و شريط القياس (المتر) ......................................... | | | | |
| ٤٤ | أستخدم الجوال (الهاتف المتنقل) ............................................................ | | | | |
| ٤٥ | أرسل و أستقبل رسائل نصية على جوالي (رسائل اس ام اس) ............................... | | | | |
| ٤٦ | أبحث في الانترنت عن المعلومات التي أريد.................................................. | | | | |
| ٤٧ | ألعب في العاب الكمبيوتر........................................................................ | | | | |
| ٤٨ | أستخدم القاموس و الموسوعة و غيرها الموجودات على الكمبيوتر.............................. | | | | |
| ٤٩ | أحمل المقاطع الصوتية من الانترنت............................................................ | | | | |
| ٥٠ | أرسل وأستقبل الأيميلات........................................................................ | | | | |
| ٥١ | أستخدم برامج معالجة النصوص (مثل ميكروسوفت وورد) على الكمبيوتر........................ | | | | |
| ٥٢ | سبق لي أن فتحت (فككت) الاجهزة (مثل الراديوا او الساعة او الكمبيوتر او التليفون و غيرها) لمعرفة كيف تعمل.............................................................. | | | | |
| ٥٣ | سبق لي أن طبخت خبز او معجنات أو كعكاً وغيرها.............................................. | | | | |
| ٥٤ | طبخت الوجبة اليومية يوما ما............................................................... | | | | |

# ح. خبراتي خارج المدرسة

(امام كل عبارة مجموعة خيارات ضع علامة صح في الخيار المناسب لك، و اذا لم تفهم العبارات اترك الخيار فارغاً)

| | كيف تقوم بهذه الاعمال دائماً خارج المدرسة؟ | دائماً | أحياناً | نادراً ما | لا أقوم بها ابداً |
|---|---|---|---|---|---|
| ٥٥ | سبق لي ان حاولت ان امشي و أضع شيئاً فوق رأسي و أحافظ على توازنه من السقوط و انا امشي........................................................................................ | | | | |
| ٥٦ | سبق لي أن إستخدمت العربة اليدوية........................................................... | | | | |
| ٥٧ | سبق لي أن إستخدمت العتلة................................................................... | | | | |
| ٥٨ | سبق لي أن إستخدمت الحبل و البكرة لرفع الأشياء الثقيل..................................... | | | | |
| ٥٩ | سبق لي أن أصلحت عجلة الدراجة............................................................. | | | | |
| ٦٠ | سبق لي أن إستخدمت العدة مثل المنشار أو مفك البراغي أو المطرقة....................... | | | | |
| ٦١ | سبق لي أن شحنت بطارية السيارة............................................................ | | | | |

# Appendix 1: The ROSE Questionnaire - English Version

## A. What I want to learn about

**How interested are you in learning about the following?**

(Give your answer with a tick on each line. If you do not understand, leave the line blank.)

| | | *Not interes-ted* | | | *Very interes-ted* |
|---|---|---|---|---|---|
| 1. | Stars, planets and the universe | ☐ | ☐ | ☐ | ☐ |
| 2. | Chemicals, their properties and how they react | ☐ | ☐ | ☐ | ☐ |
| 3. | The inside of the earth | ☐ | ☐ | ☐ | ☐ |
| 4. | How mountains, rivers and oceans develop and change | ☐ | ☐ | ☐ | ☐ |
| 5. | Clouds, rain and the weather | ☐ | ☐ | ☐ | ☐ |
| 6. | The origin and evolution of life on earth | ☐ | ☐ | ☐ | ☐ |
| 7. | How the human body is built and functions | ☐ | ☐ | ☐ | ☐ |
| 8. | Heredity, and how genes influence how we develop | ☐ | ☐ | ☐ | ☐ |
| 9. | Sex and reproduction | ☐ | ☐ | ☐ | ☐ |
| 10. | Birth control and contraception | ☐ | ☐ | ☐ | ☐ |
| 11. | How babies grow and mature | ☐ | ☐ | ☐ | ☐ |
| 12. | Cloning of animals | ☐ | ☐ | ☐ | ☐ |
| 13. | Animals in other parts of the world | ☐ | ☐ | ☐ | ☐ |
| 14. | Dinosaurs, how they lived and why they died out | ☐ | ☐ | ☐ | ☐ |
| 15. | How plants grow and reproduce | ☐ | ☐ | ☐ | ☐ |
| 16. | How people, animals, plants and the environment depend on each other | ☐ | ☐ | ☐ | ☐ |
| 17. | Atoms and molecules | ☐ | ☐ | ☐ | ☐ |
| 18. | How radioactivity affects the human body | ☐ | ☐ | ☐ | ☐ |
| 19. | Light around us that we cannot see (infrared, ultraviolet) | ☐ | ☐ | ☐ | ☐ |
| 20. | How animals use colours to hide, attract or scare | ☐ | ☐ | ☐ | ☐ |
| 22. | Black holes, supernovas and other spectacular objects in outer space | ☐ | ☐ | ☐ | ☐ |
| 23. | How meteors, comets or asteroids may cause disasters on earth | ☐ | ☐ | ☐ | ☐ |

| | | *Not interes-ted* | | | *Very interes-ted* |
|---|---|---|---|---|---|
| 24. | Earthquakes and volcanoes | ☐ | ☐ | ☐ | ☐ |
| 25. | Tornados, hurricanes and cyclones | ☐ | ☐ | ☐ | ☐ |
| 26. | Epidemics and diseases causing large losses of life | ☐ | ☐ | ☐ | ☐ |
| 27. | Brutal, dangerous and threatening animals | ☐ | ☐ | ☐ | ☐ |
| 28. | Poisonous plants in my area | ☐ | ☐ | ☐ | ☐ |
| 29. | Deadly poisons and what they do to the human body | ☐ | ☐ | ☐ | ☐ |
| 30. | How the atom bomb functions | ☐ | ☐ | ☐ | ☐ |
| 31. | Explosive chemicals | ☐ | ☐ | ☐ | ☐ |
| 32. | Biological and chemical weapons and what they do to the human body | ☐ | ☐ | ☐ | ☐ |
| 33. | The effect of strong electric shocks and lightning on the human body | ☐ | ☐ | ☐ | ☐ |
| 34. | How it feels to be weightless in space | ☐ | ☐ | ☐ | ☐ |
| 35. | How to find my way and navigate by the stars | ☐ | ☐ | ☐ | ☐ |
| 36. | How the eye can see light and colours | ☐ | ☐ | ☐ | ☐ |
| 37. | What to eat to keep healthy and fit | ☐ | ☐ | ☐ | ☐ |
| 38. | Eating disorders like anorexia or bulimia | ☐ | ☐ | ☐ | ☐ |
| 39. | The ability of lotions and creams to keep the skin young | ☐ | ☐ | ☐ | ☐ |
| 40. | How to exercise to keep the body fit and strong | ☐ | ☐ | ☐ | ☐ |
| 41. | Plastic surgery and cosmetic surgery | ☐ | ☐ | ☐ | ☐ |
| 42. | How radiation from solariums and the sun might affect the skin | ☐ | ☐ | ☐ | ☐ |
| 43. | How the ear can hear different sounds | ☐ | ☐ | ☐ | ☐ |
| 44. | Rockets, satellites and space travel | ☐ | ☐ | ☐ | ☐ |
| 45. | The use of satellites for communication and other purposes | ☐ | ☐ | ☐ | ☐ |
| 46. | How X-rays, ultrasound, etc. are used in medicine | ☐ | ☐ | ☐ | ☐ |
| 47. | How petrol and diesel engines work | ☐ | ☐ | ☐ | ☐ |
| 48. | How a nuclear power plant functions | ☐ | ☐ | ☐ | ☐ |

## C. What I want to learn about

**How interested are you in learning about the following?**

(Give your answer with a tick on each line. If you do not understand, leave the line blank.)

| | | *Not interes-ted* | | | *Very interes-ted* |
|---|---|---|---|---|---|
| 1. | How crude oil is converted to other materials, like plastics and textiles | ☐ | ☐ | ☐ | ☐ |
| 2. | Optical instruments and how they work (telescope, camera, microscope, etc.) | ☐ | ☐ | ☐ | ☐ |
| 3. | The use of lasers for technical purposes (CD-players, bar-code readers, etc.) | ☐ | ☐ | ☐ | ☐ |
| 4. | How cassette tapes, CDs and DVDs store and play sound and music | ☐ | ☐ | ☐ | ☐ |
| 5. | How things like radios and televisions work | ☐ | ☐ | ☐ | ☐ |
| 6. | How mobile phones can send and receive messages | ☐ | ☐ | ☐ | ☐ |
| 7. | How computers work | ☐ | ☐ | ☐ | ☐ |
| 8. | The possibility of life outside earth | ☐ | ☐ | ☐ | ☐ |
| 9. | Astrology and horoscopes, and whether the planets can influence human beings | ☐ | ☐ | ☐ | ☐ |
| 10. | Unsolved mysteries in outer space | ☐ | ☐ | ☐ | ☐ |
| 11. | Life and death and the human soul | ☐ | ☐ | ☐ | ☐ |
| 12. | Alternative therapies (acupuncture, homeopathy, yoga, healing, etc.) and how effective they are | ☐ | ☐ | ☐ | ☐ |
| 13. | Why we dream while we are sleeping, and what the dreams may mean | ☐ | ☐ | ☐ | ☐ |
| 14. | Ghosts and witches, and whether they may exist | ☐ | ☐ | ☐ | ☐ |
| 15. | Thought transference, mind-reading, sixth sense, intuition, etc. | ☐ | ☐ | ☐ | ☐ |
| 16. | Why the stars twinkle and the sky is blue | ☐ | ☐ | ☐ | ☐ |
| 17. | Why we can see the rainbow | ☐ | ☐ | ☐ | ☐ |
| 18. | Properties of gems and crystals and how these are used for beauty | ☐ | ☐ | ☐ | ☐ |

## E. What I want to learn about

**How interested are you in learning about the following?**

(Give your answer with a tick on each line. If you do not understand, leave the line blank.)

| | | *Not interes- ted* | | | *Very interes- ted* |
|---|---|---|---|---|---|
| 1. | Symmetries and patterns in leaves and flowers .......................... | ☐ | ☐ | ☐ | ☐ |
| 2. | How the sunset colours the sky ................................................. | ☐ | ☐ | ☐ | ☐ |
| 3. | The ozone layer andP how it may be affected by humans ......... | ☐ | ☐ | ☐ | ☐ |
| 4. | The greenhouse effect and how it may be changed by humans | ☐ | ☐ | ☐ | ☐ |
| 5. | What can be done to ensure clean air and safe drinking water .. | ☐ | ☐ | ☐ | ☐ |
| 6. | How technology helps us to handle waste, garbage and sewage .................................................................. | ☐ | ☐ | ☐ | ☐ |
| 7. | How to control epidemics and diseases ..................................... | ☐ | ☐ | ☐ | ☐ |
| 8. | Cancer, what we know and how we can treat it .......................... | ☐ | ☐ | ☐ | ☐ |
| 9. | Sexually transmitted diseases and how to be protected against them ............................................................... | ☐ | ☐ | ☐ | ☐ |
| 10. | How to perform first-aid and use basic medical equipment ......... | ☐ | ☐ | ☐ | ☐ |
| 11. | What we know about HIV/AIDS and how to control it ................. | ☐ | ☐ | ☐ | ☐ |
| 12. | How alcohol and tobacco might affect the body .......................... | ☐ | ☐ | ☐ | ☐ |
| 13. | How different narcotics might affect the body ............................ | ☐ | ☐ | ☐ | ☐ |
| 14. | The possible radiation dangers of mobile phones and computers | ☐ | ☐ | ☐ | ☐ |
| 15. | How loud sound and noise may damage my hearing ................ | ☐ | ☐ | ☐ | ☐ |
| 16. | How to protect endangered species of animals .......................... | ☐ | ☐ | ☐ | ☐ |
| 17. | How to improve the harvest in gardens and farms ...................... | ☐ | ☐ | ☐ | ☐ |
| 18. | Medicinal use of plants ............................................................... | ☐ | ☐ | ☐ | ☐ |
| 19. | Organic and ecological farming without use of pesticides and artificial fertilizers ........................................................................ | ☐ | ☐ | ☐ | ☐ |
| 20. | How energy can be saved or used in a more effective way ........ | ☐ | ☐ | ☐ | ☐ |
| 21. | New sources of energy from the sun, wind, tides, waves, etc. ... | ☐ | ☐ | ☐ | ☐ |
| 22. | How different sorts of food are produced, conserved and stored | ☐ | ☐ | ☐ | ☐ |
| 23. | How my body grows and matures .............................................. | ☐ | ☐ | ☐ | ☐ |

| | *Not interes-ted* | | | *Very interes-ted* |
|---|---|---|---|---|
| 24. Animals in my area | ☐ | ☐ | ☐ | ☐ |
| 25. Plants in my area | ☐ | ☐ | ☐ | ☐ |
| 26. Detergents, soaps and how they work | ☐ | ☐ | ☐ | ☐ |
| 27. Electricity, how it is produced and used in the home | ☐ | ☐ | ☐ | ☐ |
| 28. How to use and repair everyday electrical and mechanical equipment | ☐ | ☐ | ☐ | ☐ |
| 29. The first landing on the moon and the history of space exploration | ☐ | ☐ | ☐ | ☐ |
| 30. How electricity has affected the development of our society | ☐ | ☐ | ☐ | ☐ |
| 31. Biological and human aspects of abortion | ☐ | ☐ | ☐ | ☐ |
| 32. How gene technology can prevent diseases | ☐ | ☐ | ☐ | ☐ |
| 33. Benefits and possible hazards of modern methods of farming | ☐ | ☐ | ☐ | ☐ |
| 34. Why religion and science sometimes are in conflict | ☐ | ☐ | ☐ | ☐ |
| 35. Risks and benefits of food additives | ☐ | ☐ | ☐ | ☐ |
| 36. Why scientists sometimes disagree | ☐ | ☐ | ☐ | ☐ |
| 37. Famous scientists and their lives | ☐ | ☐ | ☐ | ☐ |
| 38. Big blunders and mistakes in research and inventions | ☐ | ☐ | ☐ | ☐ |
| 39. How scientific ideas sometimes challenge religion, authority and tradition | ☐ | ☐ | ☐ | ☐ |
| 40. Inventions and discoveries that have changed the world | ☐ | ☐ | ☐ | ☐ |
| 41. Very recent inventions and discoveries in science and technology | ☐ | ☐ | ☐ | ☐ |
| 42. Phenomena that scientists still cannot explain | ☐ | ☐ | ☐ | ☐ |

## F. My science classes

**To what extent do you agree with the following statements about the science that you may have had at school?**

(Give your answer with a tick on each line. If you do not understand, leave the line blank.)

**P**

| | *Disagree* | | | *Agree* |
|---|---|---|---|---|
| 1. School science is a difficult subject | ☐ | ☐ | ☐ | ☐ |
| 2. School science is interesting | ☐ | ☐ | ☐ | ☐ |
| 3. School science is rather easy for me to learn | ☐ | ☐ | ☐ | ☐ |
| 4. School science has opened my eyes to new and exciting jobs | ☐ | ☐ | ☐ | ☐ |
| 5. I like school science better than most other subjects | ☐ | ☐ | ☐ | ☐ |
| 6. I think everybody should learn science at school | ☐ | ☐ | ☐ | ☐ |
| 7. The things that I learn in science at school will be helpful in my everyday life | ☐ | ☐ | ☐ | ☐ |
| 8. I think that the science I learn at school will improve my career chances | ☐ | ☐ | ☐ | ☐ |
| 9. School science has made me more critical and sceptical | ☐ | ☐ | ☐ | ☐ |
| 10. School science has increased my curiosity about things we cannot yet explain | ☐ | ☐ | ☐ | ☐ |
| 11. School science has increased my appreciation of nature | ☐ | ☐ | ☐ | ☐ |
| 12. School science has shown me the importance of science for our way of living | ☐ | ☐ | ☐ | ☐ |
| 13. School science has taught me how to take better care of my health | ☐ | ☐ | ☐ | ☐ |
| 14. I would like to become a scientist | ☐ | ☐ | ☐ | ☐ |
| 15. I would like to have as much science as possible at school | ☐ | ☐ | ☐ | ☐ |
| 16. I would like to get a job in technology | ☐ | ☐ | ☐ | ☐ |

## G. My opinions about science and technology

**To what extent do you agree with the following statements?**

(Give your answer with a tick on each row. If you do not understand, leave the line blank.)

| | | *Disagree* | | | *Agree* |
|---|---|---|---|---|---|
| 1. | Science and technology are important for society ..................... | ☐ | ☐ | ☐ | ☐ |
| 2. | Science and technology will find cures to diseases such as HIV/AIDS, cancer, etc. .......................................................... | ☐ | ☐ | ☐ | ☐ |
| 3. | Thanks to science and technology, there will be greater opportunities for future generations ........................................... | ☐ | ☐ | ☐ | ☐ |
| 4. | Science and technology make our lives healthier, easier and more comfortable ....................................................................... | ☐ | ☐ | ☐ | ☐ |
| 5. | New technologies will make work more interesting .................... | ☐ | ☐ | ☐ | ☐ |
| 6. | The benefits of science are greater than the harmful effects it could have ................................................................... | ☐ | ☐ | ☐ | ☐ |
| 7. | Science and technology will help to eradicate poverty and famine in the world ..................................................................... | ☐ | ☐ | ☐ | ☐ |
| 8. | Science and technology can solve nearly all problems ............... | ☐ | ☐ | ☐ | ☐ |
| 9. | Science and technology are helping the poor ............................ | ☐ | ☐ | ☐ | ☐ |
| 10. | Science and technology are the cause of the environmental problems ............................................................. | ☐ | ☐ | ☐ | ☐ |
| 11. | A country needs science and technology to become developed | ☐ | ☐ | ☐ | ☐ |
| 12. | Science and technology benefit mainly the developed countries ............................................................. | ☐ | ☐ | ☐ | ☐ |
| 13. | Scientists follow the scientific method that always leads them to correct answers .......................................................................... | ☐ | ☐ | ☐ | ☐ |
| 14. | We should always trust what scientists have to say ................... | ☐ | ☐ | ☐ | ☐ |
| 15. | Scientists are neutral and objective ........................................... | ☐ | ☐ | ☐ | ☐ |
| 16. | Scientific theories develop and change all the time .................... | ☐ | ☐ | ☐ | ☐ |

## H. My out-of-school experiences

**How often have you done this outside school?**
(Give your answer with a tick on each line. If you do not understand, leave the line blank.)
**I have ...**

| | | *Never* | | | *Often* |
|---|---|---|---|---|---|
| 1. | tried to find the star constellations in the sky | ☐ | ☐ | ☐ | ☐ |
| 2. | read my horoscope (telling future from the stars) | ☐ | ☐ | ☐ | ☐ |
| 3. | read a map to find my way | ☐ | ☐ | ☐ | ☐ |
| 4. | used a compass to find direction | ☐ | ☐ | ☐ | ☐ |
| 5. | collected different stones or shells | ☐ | ☐ | ☐ | ☐ |
| 6. | watched (not on TV) an animal being born | ☐ | ☐ | ☐ | ☐ |
| 7. | cared for animals on a farm | ☐ | ☐ | ☐ | ☐ |
| 8. | visited a zoo | ☐ | ☐ | ☐ | ☐ |
| 9. | visited a science centre or science museum | ☐ | ☐ | ☐ | ☐ |
| 10. | milked animals like cows, sheep or goats | ☐ | ☐ | ☐ | ☐ |
| 11. | made dairy products like yoghurt, butter, cheese or ghee | ☐ | ☐ | ☐ | ☐ |
| 12. | read about nature or science in books or magazines | ☐ | ☐ | ☐ | ☐ |
| 13. | watched nature programmes on TV or in a cinema | ☐ | ☐ | ☐ | ☐ |
| 14. | collected edible berries, fruits, mushrooms or plants | ☐ | ☐ | ☐ | ☐ |
| 15. | participated in hunting | ☐ | ☐ | ☐ | ☐ |
| 16. | participated in fishing | ☐ | ☐ | ☐ | ☐ |
| 17. | planted seeds and watched them grow | ☐ | ☐ | ☐ | ☐ |
| 18. | made compost of grass, leaves or garbage | ☐ | ☐ | ☐ | ☐ |
| 19. | made an instrument (like a flute or drum) from natural materials | ☐ | ☐ | ☐ | ☐ |
| 20. | knitted, weaved, etc | ☐ | ☐ | ☐ | ☐ |
| 21. | put up a tent or shelter | ☐ | ☐ | ☐ | ☐ |
| 22. | made a fire from charcoal or wood | ☐ | ☐ | ☐ | ☐ |
| 23. | prepared food over a campfire, open fire or stove burner | ☐ | ☐ | ☐ | ☐ |
| 24. | sorted garbage for recycling or for appropriate disposal | ☐ | ☐ | ☐ | ☐ |
| 25. | cleaned and bandaged a wound | ☐ | ☐ | ☐ | ☐ |
| 26. | seen an X-ray of a part of my body | ☐ | ☐ | ☐ | ☐ |

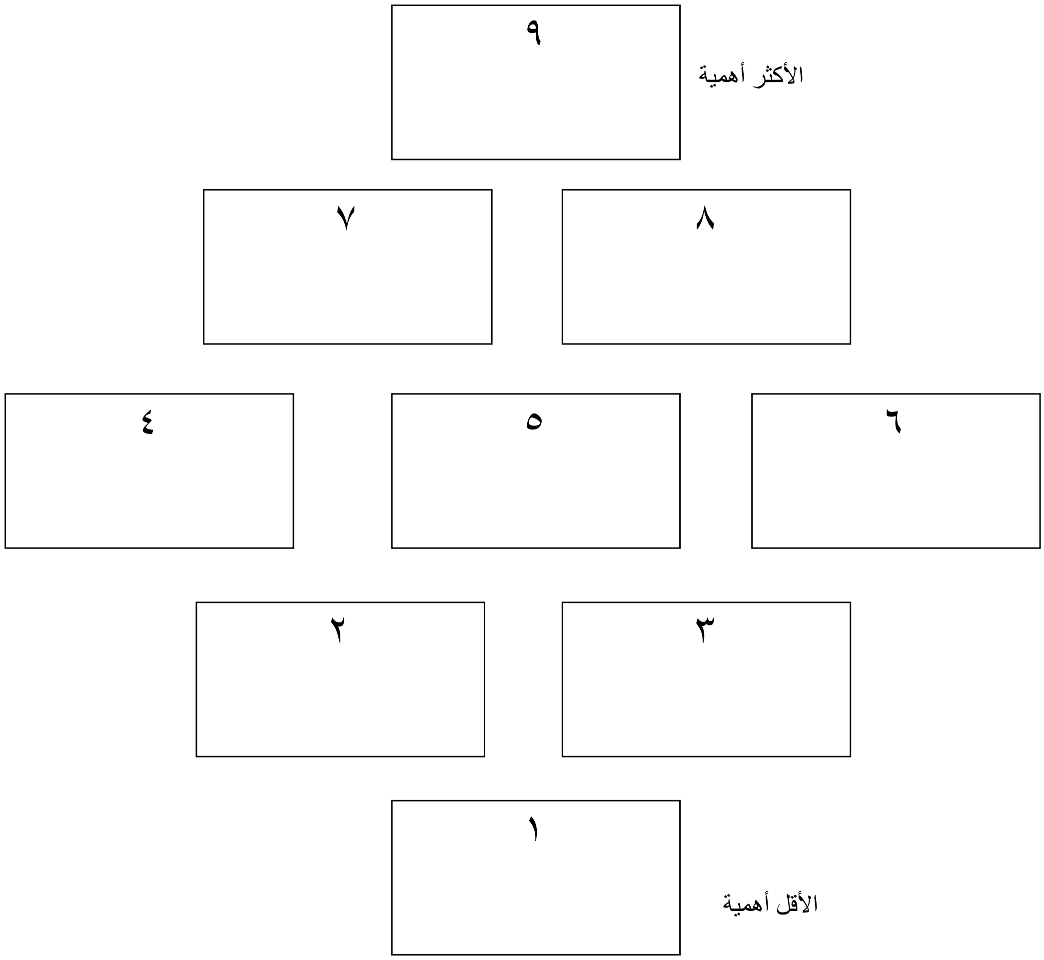
| | | *Never* | | | *Often* |
|---|---|---|---|---|---|
| 27. | taken medicines to prevent or cure illness or infection .............. | ☐ | ☐ | ☐ | ☐ |
| 28. | taken herbal medicines or had alternative treatments (acupuncture, homeopathy, yoga, healing, etc.) ......................... | ☐ | ☐ | ☐ | ☐ |
| 29. | been to a hospital as a patient ................................................... | ☐ | ☐ | ☐ | ☐ |
| 30. | used binoculars .......................................................................... | ☐ | ☐ | ☐ | ☐ |
| 31. | used a camera ........................................................................... | ☐ | ☐ | ☐ | ☐ |
| 32. | made a bow and arrow, slingshot, catapult or boomerang ......... | ☐ | ☐ | ☐ | ☐ |
| 33. | used an air gun or rifle ............................................................... | ☐ | ☐ | ☐ | ☐ |
| 34. | used a water pump or siphon ..................................................... | ☐ | ☐ | ☐ | ☐ |
| 35. | made a model such as toy plane or boat etc ............................. | ☐ | ☐ | ☐ | ☐ |
| 36. | used a science kit (like for chemistry, optics or electricity) .......... | ☐ | ☐ | ☐ | ☐ |
| 37. | used a windmill, watermill, waterwheel, etc ............................... | ☐ | ☐ | ☐ | ☐ |
| 38. | recorded on video, DVD or tape recorder .................................. | ☐ | ☐ | ☐ | ☐ |
| 39. | changed or fixed electric bulbs or fuses ..................................... | ☐ | ☐ | ☐ | ☐ |
| 40. | connected an electric lead to a plug etc. .................................... | ☐ | ☐ | ☐ | ☐ |
| 41. | used a stopwatch ....................................................................... | ☐ | ☐ | ☐ | ☐ |
| 42. | measured the temperature with a thermometer .......................... | ☐ | ☐ | ☐ | ☐ |
| 43. | used a measuring ruler, tape or stick ......................................... | ☐ | ☐ | ☐ | ☐ |
| 44. | used a mobile phone.................................................................... | ☐ | ☐ | ☐ | ☐ |
| 45. | sent or received an SMS (text message on mobile phone) ........ | ☐ | ☐ | ☐ | ☐ |
| 46. | searched the internet for information ......................................... | ☐ | ☐ | ☐ | ☐ |
| 47. | played computer games ............................................................. | ☐ | ☐ | ☐ | ☐ |
| 48. | used a dictionary, encyclopaedia, etc. on a computer ................ | ☐ | ☐ | ☐ | ☐ |
| 49. | downloaded music from the internet .......................................... | ☐ | ☐ | ☐ | ☐ |
| 50. | sent or received e-mail ............................................................... | ☐ | ☐ | ☐ | ☐ |
| 51. | used a word processor on the computer .................................... | ☐ | ☐ | ☐ | ☐ |
| 52. | opened a device (radio, watch, computer, telephone, etc.) to find out how it works ................................................................... | ☐ | ☐ | ☐ | ☐ |

| | | Never | | | Often |
|---|---|---|---|---|---|
| 53. | baked bread, pastry, cake, etc ................................................... | ☐ | ☐ | ☐ | ☐ |
| 54. | cooked a meal ............................................................................ | ☐ | ☐ | ☐ | ☐ |
| 55. | walked while balancing an object on my head ........................... | ☐ | ☐ | ☐ | ☐ |
| 56. | used a wheelbarrow ................................................................... | ☐ | ☐ | ☐ | ☐ |
| 57. | used a crowbar (jemmy) ............................................................. | ☐ | ☐ | ☐ | ☐ |
| 58. | used a rope and pulley for lifting heavy things ........................... | ☐ | ☐ | ☐ | ☐ |
| 59. | mended a bicycle tube ............................................................... | ☐ | ☐ | ☐ | ☐ |
| 60. | used tools like a saw, screwdriver or hammer ........................... | ☐ | ☐ | ☐ | ☐ |
| 61. | charged a car battery ................................................................. | ☐ | ☐ | ☐ | ☐ |

# Appendix 2: Damion ranking -Arabic Version

لماذا تعتقد ان تدريس العلوم الطبيعية (الفيزياء والكيمياء والأحياء) يعتبر مهم؟

ملاحظة لا توجد إجابة صحيحة او خاطئة.



يمكنك ترتيب الكروت التالية في الخانات الفارغة وفقاً لأهميتها، لبيان أهمية تدريس المواد العلمية الطبيعية (الفيزياء والكيمياء والأحياء) في المدرسة.

على سبيل المثال إذا كنت تعتقد ان تدريس العلوم (الفيزياء والكيمياء والأحياء) مهم "**لمساعدة الشباب (بنين وبنات) على معرفة الوظائف التي يقوم بها العلماء**" ضع الكرت في الخانة رقم ٩ الأكثر أهمية. ومن ثم رتب بقية الكروت وفق الاهمية التي تعتقد.

| | | |
|---|---|---|
| لتقديم مساهمة فريدة من نوعها لتعليم متوازن، مما يعكس حقيقة أن العلم هو انجاز ثقافي مهم. | لتبصير الشباب بالأشياء المثيرة في العلوم ( الفيزياء والكيمياء والأحياء). | لمساعدة الدولة في تلبية احتياجاتها من العلماء المؤهلين بشكل جيد |
| لتطوير المهارات العملي. | للمساعدة في اعداد الشباب (بنين و بنات) للعيش في مجتمع تكنولوجيا متقدم | لتوعية الشباب (بنين وبنات) إلى الحقائق العلمية و نظرياته المهامة. |
| لمساعدة الشباب (بنين وبنات) على معرفة الوظائف التي يقوم بها العلماء. | تساعد الشباب (بنين و بنات) على الاحساس بالظواهر او الاحداث العلمية و الطبيعية التي تدور حولهم و التي تعرض في وسائل الإعلام. | للمساعدة في فهم مواقف الحياة اليومية و اتخاذ القرار المناسب. |

# Appendix 3: Cronbach's Alpha

| N | Topics | Cronbach's Alpha | N of items |
|---|---|---|---|
| 1. | Human Biology (H-B) | 0.891 | 25 |
| 2. | Universal (U) | 0.873 | 11 |
| 3. | Light (L) | 0.776 | 10 |
| 4. | Animal (A) | 0.740 | 5 |
| 5. | Plant (P) | 0.774 | 6 |
| 6. | Geology (G) | 0.755 | 8 |
| 7. | Electric (E) | 0.647 | 4 |
| 8. | Technology (T) | 0.788 | 5 |
| 9. | Chemistry (C) | 0.781 | 12 |

# Appendix 4: Supervisor approval for data collection

UNIVERSITY *of York*

*Professor Judith Bennett*
*Salters' Professor of Science Education*

**DEPARTMENT OF EDUCATION**
The University of York
YORK YO10 5DD
England

Telephone: 01904 323471
International: +44 1904 323471
e-mail: judith.bennett@york.ac.uk

13 November 2016

The Saudi Cultural Bureau Attaché
Royal Embassy of Saudi Araba
Cultural Bureau in London
630 Chiswick High Road
London
W4 5RY

To whom it may concern

**Application by Wafa Alrasheed for approval for data collection for her doctoral research**

I am writing to you in the capacity of Wafa Alrasheed's PhD supervisor at the University of York in the UK. The title of her thesis is *The Student Voice in Science Education*. Wafa Alrasheed is currently in her second year of study and will be undertaking the main data collection for her research. In order to collect her data, Wafa Alrasheed requires your assistance and support to obtain enable her to gather her data from schools in Saudi Arabia.

Wafa Alrasheed's and plans to collect her data in Saudi Arabia. The data she plans to collect prove beneficial to both to the schools involved and to those involved in curriculum planning in Saudi Arabia.

The empirical data Wafa Alrasheed wishes to collect will be gathered through a questionnaire and focus groups. Wafa and I estimate that she will need three-to-four months to complete her data collection.

Wafa Alrasheed's project has been through a rigorous process of ethical approval at the University of York. The data she plans to collect is for use only as part of her academic research. Her project will be reported in a way that ensures that no individual pupils would be named and no school would be identified without the express written permission of that school. I am therefore confident that Wafa Alrasheed will use the data responsibly and respectfully, will not identify the source or identity of schools or individuals and will be happy to share her findings with any legitimate organisation that is interested in academic research. I would therefore be very grateful for your support in helping her gain the necessary approval for access to the data that she is requesting.

If you would like any further clarification, please feel free to contact me directly at the university.

Yours faithfully,

Judith Bennett

Professor J M Bennett

# Appendix 5: Approval to apply the study in Qassim schools

بسم الله الرحمن الرحيم

ROYAL EMBASSY OF SAUDI ARABIA
CULTURAL BUREAU
LONDON

سفارة المملكة العربية السعودية
الملحقية الثقافية
لندن

1438/05/30

رقم السجل المدني [redacted]

إفـــــــــادة

تفيد الملحقية الثقافية بسفارة المملكة العربية السعودية في لندن بأن الطالبة / وفاء علي بن ابراهيم الرشيد مبتعثة من قبل وزارة التعليم العالي لدراسة الدكتوراه في تخصص التربية في جامعة York اعتباراً من 1437/03/05 إلى تاريخ 1440/01/20.

وبناءً على توصية المشرف الدراسي على بحث الدكتوراه ستتقدم المبتعثة بطلب القيام برحلة علمية إلى المملكة العربية السعودية لإكمال إجراءات بحثها:

"Student Voice in Science Education"

ونظرًا لضرورة إرفاق موافقة من الجهة المستضيفة في المملكة لاستكمال طلب الموافقة على الرحلة العلمية تم منحها هذا الخطاب بناء على طلبها وذلك لتقديمه إلى المدير العام للتربية و التعليم بمنطقة القصيم، ونأمل تسهيل مهمة الطالبة في جمع البيانات المطلوبة.

وتقبلوا خالص التحية والتقدير ،،،

**القائم بأعمال الملحقية الثقافية**

**بسفارة المملكة العربية السعودية في لندن**

**د. فهد بن عبدالله النعيم**

ROYAL EMBASSY OF SAUDI ARABIA-LONDON · CULTURAL BUREAU

الرقم: ........ التاريخ: ........ الموافق: ........ المرفقات: ........

630 Chiswick High Road, London W4 5RY Tel: +44 (0) 20 3249 7000 Fax: +44 (0) 20 3249 7001 E-mail: sacbuk@uksacb.org
www.uksacb.org

# Appendix 6: Letter to school principal

المملكة العربية السعودية
وزارة التعـليم
(٢٨٠)
الإدارة العامة للتعليم بمنطقة القصيم

وزارة التعـليم
Ministry of Education

سعــادة قائد المدرسة    حفظه الله

السلام عليكم و رحمة الله وبركاته
نفيدكم أن الباحثة: وفاء بنت علي الرشيد طالبة دكتوراه في جامعة يورك البريطانية. و حيث ان بحثها في الدكتوراه يبحث في صوت الطالب السعودي كما افاد خطاب سعادة الملحق السعودي. فقد أعطيت الموافقة على اجراء البحث في المدارس التابعة للإدارة العامة للتعليم بمنطقة القصيم، وفق الاجراءات المتبعة لذلك. لذا نأمل منكم التكرم بتمكين الطالبة أثناء زيارتها لمدرستكم بجمع البيانات من الطلاب حتى تستوفي شروط بحثها.

و نقدر لكم سلفاً تفهمكم ولكم منا وافر التحيات

مدير إدارة التخطيط والتطوير
محمد بن ناصر المجحدي

qassimedu.gov.sa

# Appendix 7: Explanatory sheet by researcher

UNIVERSITY of York
Department of Education

وزارة التعليم
Ministry of Education

**طلب الموافقة على المشاركة في البحث**

---

***عزيزتي الأستاذة:***

السلام عليكم ورحمة الله وبركاته وبعد

أنا طالبة في كلية التربية بجامعة يورك البريطانية أقوم حالياً بإجراء بحث علمي للحصول على درجة الدكتوراه. نظراً لأن دراستي متركزة على الطلاب السعوديين فقد تم ترشيح مدرستكم للمساهمة في هذه الدراسة. لذا يسرني ان أدعو طلاب مدرستكم للمشاركة في هذه الاستبيان التي أحاول من خلاله دراسة صوت الطالب السعودي لمعرفة وجهة نظره تجاه المواد العلمية الطبيعية والتكنولوجيا (الفيزياء، الأحياء، الكيمياء والحاسب الآلي). والتي سيكون لنتائجها بإذن الله فائدة غير مباشرة على مدرستكم وعلى المشاركين وذلك من خلال اسهام نتائجها في تطوير العملية التعليمية وتقديم التوصيات للعاملين في المجال التعليمي بما يعود بالنفع على الطالب والمعلم والمدرسة بإذن الله.

***أولاً: عنوان الدراسة*** :

وجهات نظر الطلاب تجاه المواد العلمية: دراسة تطبيقية على طلاب المدراس الثانوية السعودية.

***ثانياً: الإجراءات***

عند الموافقة على المشاركة في هذا البحث

1- وسوف أجمع المعلومات ذات الصلة بتلك الدراسة من خلال عينة التلاميذ المرشحة للمشاركة في مدرستك عن طريق توزيع الاستبيان التي يستطيع المشارك ابداء أرائه من خلال تلك الاستبيان.
2- أود التأكيد على أن كل الاستبيانات سيتم ترميزها من قبل الباحث بشكل يحفظ خصوصية المشارك بحيث لا أحد يستطيع التعرف معلومات المشاركين.
3- في حال شعرت او شعر أحد المشاركين بعدم الارتياح لأي سبب، يستطيع الانسحاب.
4- سيتم ترشيح عدد من الطلاب من قبلك للمشاركة في مجموعة التركيز وذلك بترتيب كروت لعبة الالماسة.

***ثالثاً: السرية***

سيتم التعامل مع البيانات الخاصة بكل المشاركين بالسرية قدر الامكان. ولن يتم استخدام الأسماء الفردية أو غيرها من المعلومات الشخصية في نتائج هذه الدراسة لان الاستمارات سيتم ترميزها.

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Department of Education

وزارة التعليم
Ministry of Education

## طلب الموافقة على المشاركة في البحث

---

وحيث ان الرموز ستتم من الباحث لذلك فكافة المعلومات الشخصية الخاصة بالمشاركين ستكون أمنة إن شاء الله.

عند اكتمال البحث، وأنا قد حفظ إجابتك في البحوث المستقبلية به نفسي. وسوف تحتفظ هذه السجلات لمدة تصل إلى 6 أشهر بعد الدراسة قد انتهت. سيتم اتخاذ الإجراءات نفسها المذكورة أعلاه لحماية سرية هذه البيانات الدراسة.

كما اود الإشارة ان البيانات فقط ربما يتم الاحتفاظ بها بعد اكتمال البحث وذلك لاستخدامها في بحوث لي مستقبلية وذلك في غضون ستة أشهر من انتهاء هذه الدراسة مع ملاحظة ان هذه البيانات سيتم التعامل معها بنفس السرية أنفة الذكر.

***<u>ربعاً: حقوق المشاركين</u>***

المشاركة في هذا البحوث تطوعية تماما. فالمشارك له الحرية في رفض المشاركة في هذه الدراسة. كما يمكنه رفض الإجابة عن أي أسئلة ويمكنه الانسحاب من المشاركة في أي وقت يحب. سواء رغب المشارك المشاركة في البحث والإجابة على الأسئلة أم لم يرغب، فلن يترتب على ذلك أي عقوبة او اجراء يُضر به.

***<u>خامساً: للاستفسار</u>***

إذا كان لديك أي أسئلة او استفسار حول هذا البحث، يسعدني ان تتواصلي معي عبر الوسائل التالية

الجوال [redacted]

البريد الإلكتروني: [redacted]@york.ac.uk

***<u>سادساً: الموافقة</u>***

إذا كنت قد وافقتي على مشاركة الطالبات في هذه الدراسة، آمل منك التكرم التوقيع على هذه الورقة ولاحتفاظ بنسخة منها في سجلاتك مع خالص شكري وتقديري.

| الاسم | التوقيع | التاريخ |
|---|---|---|
| ………………. | …………………. | ………………… |

# Appendix 8: Mean value and Chi squire of ROSE items

| item | Mean B | Mean G | chi | p |
|---|---|---|---|---|
| A1. Stars, planets and the universe | 2.42 | 2.86 | 40.369 | .000 |
| A2. Chemicals, their properties and how they react | 2.50 | 2.69 | 9.731 | .021 |
| A3. The inside of the earth | 2.28 | 2.65 | 30.326 | .000 |
| A4. How mountains, rivers and oceans develop and change | 2.50 | 2.66 | 8.421 | .038 |
| A5. Clouds, rain and the weather | 2.69 | 2.93 | 11.467 | .009 |
| A6. The origin and evolution of life on earth | 2.72 | 2.95 | 11.162 | .011 |
| A7. How the human body is built and functions | 2.88 | 3.20 | 21.242 | .000 |
| A8. Heredity, and how genes influence how we develop | 2.56 | 2.92 | 34.042 | .000 |
| A9. Sex and reproduction | 2.79 | 2.58 | 9.003 | .029 |
| A10. Birth control and contraception | 2.46 | 2.57 | 4.698 | .195 |
| A11. How babies grow and mature | 2.66 | 2.86 | 8.158 | .043 |
| A12. Cloning of animals | 2.28 | 2.43 | 4.420 | .219 |
| A13. Animals in other parts of the world | 2.59 | 2.50 | 1.371 | .712 |
| A14. Dinosaurs, how they lived and why they died out | 2.43 | 2.76 | 20.951 | .000 |
| A15. How plants grow and reproduce | 2.24 | 2.29 | 1.205 | .752 |
| A16. How people, animals, plants and the environment depend | 2.51 | 2.59 | 2.210 | .530 |
| A17. Atoms and molecules | 2.05 | 2.21 | 7.589 | .055 |
| A18. How radioactivity affects the human body | 2.27 | 2.74 | 40.025 | .000 |
| A19. Light around us that we cannot see (infrared, ultraviol.) | 2.40 | 2.57 | 11.019 | .012 |
| A20. How animals use colours to hide, attract or scare | 2.56 | 2.87 | 17.378 | .001 |
| A22. Black holes, supernovas and other spectacular objects | 2.62 | 2.97 | 17.441 | .001 |
| A23. How meteors, comets or asteroids may cause disasters on | 2.49 | 2.90 | 24.285 | .000 |
| A24. Earthquakes and volcanoes | 2.47 | 2.76 | 19.745 | .000 |
| A25. Tornados, hurricanes and cyclones | 2.33 | 2.48 | 7.785 | .051 |
| A26. Epidemics and diseases causing large losses of life | 2.76 | 3.20 | 38.965 | .000 |
| A27. Brutal, dangerous and threatening animals | 2.81 | 2.64 | 7.994 | .046 |
| A28. Poisonous plants in my area | 2.68 | 2.66 | 1.831 | .608 |
| A29. Deadly poisons and what they do to the human body | 2.86 | 3.06 | 7.859 | .049 |
| A30. How the atom bomb functions | 2.65 | 2.76 | 2.864 | .413 |
| A31. Explosive chemicals | 2.63 | 2.72 | 1.982 | .576 |
| A32. Biological and chemical weapons and what they do to the | 2.55 | 2.81 | 12.309 | .006 |
| A33. The effect of strong electric shocks and lightning on | 2.73 | 3.06 | 23.123 | .000 |
| A34. How it feels to be weightless in space | 2.96 | 3.40 | 32.334 | .000 |
| A35. How to find my way and navigate by the stars | 2.84 | 3.03 | 9.625 | .022 |
| A36. How the eye can see light and colours | 2.70 | 2.87 | 8.514 | .037 |
| A37. What to eat to keep healthy and fit | 3.21 | 3.30 | 4.489 | .213 |

| item | Mean B | Mean G | chi | p |
|---|---|---|---|---|
| A38. Eating disorders like anorexia or bulimia | 2.87 | 3.14 | 23.474 | .000 |
| A39. The ability of lotions and creams to keep the skin young | 2.42 | 3.45 | 152.73 | .000 |
| A40. How to exercise to keep the body fit and strong | 3.29 | 3.44 | 11.678 | .009 |
| A41. Plastic surgery and cosmetic surgery | 2.32 | 2.88 | 48.922 | .000 |
| A42. How radiation from solariums and the sun might affect the skin | 2.39 | 2.96 | 54.996 | .000 |
| A43.How the ear can hear different sounds | 2.79 | 3.03 | 11.689 | .009 |
| A44. Rockets, satellites and space travel | 2.60 | 2.73 | 3.280 | .350 |
| A45. The use of satellites for communication and other purposes | 2.60 | 2.53 | 6.513 | .089 |
| A46. How X-rays, ultrasound, etc. are used in medicine | 2.39 | 2.68 | 20.794 | .000 |
| A47. How petrol and diesel engines work | 2.81 | 2.10 | 86.298 | .000 |
| A48. How a nuclear power plant functions | 2.47 | 2.30 | 4.745 | .191 |

| item | Mean B | Mean G | chi | p |
|---|---|---|---|---|
| C1. How crude oil is converted to other materials, like plastics and textiles | 2.60 | 2.47 | 4.192 | .241 |
| C2. Optical instruments and how they work (telescope, camera, microscope, etc.) | 2.67 | 2.69 | 3.976 | .264 |
| C3. The use of lasers for technical purposes (CD-players, bar-code reader, etc.) | 2.50 | 2.26 | 10.262 | .016 |
| C4. How cassette tapes, CDs and DVDs store and play sound and music | 2.47 | 2.19 | 14.331 | .002 |
| C5. How things like radios and televisions work | 2.62 | 2.36 | 11.383 | .010 |
| C6. How mobile phones can send and receive messages | 2.87 | 2.62 | 11.392 | .010 |
| C7. How computers work | 2.82 | 2.50 | 18.798 | .000 |
| C8. The possibility of life outside earth | 2.60 | 3.20 | 48.190 | .000 |
| C9. Astrology and horoscopes, and whether the planets can influence human beings | 2.20 | 2.25 | 9.679 | .021 |
| C10. Unsolved mysteries in outer space | 2.54 | 2.99 | 26.935 | .000 |
| C11. Life and death and the human soul | 2.79 | 3.20 | 29.845 | .000 |
| C12. Alternative therapies (acupuncture, homeopathy, yoga, healing, etc.) and how effective they are | 2.37 | 2.73 | 19.410 | .000 |
| C13. Why we dream while we are sleeping, and what the dreams may mean | 3.07 | 3.35 | 26.134 | .000 |
| C14. Ghosts and witches, and whether they may exist | 2.48 | 2.46 | 5.657 | .130 |
| C15. Thought transference, mind-reading, sixth sense, intuition, etc. | 2.78 | 3.15 | 24.370 | .000 |
| C16. Why the stars twinkle and the sky is blue | 2.61 | 3.02 | 26.637 | .000 |
| C17. Why we can see the rainbow | 2.51 | 2.84 | 20.984 | .000 |
| C18. Properties of gems and crystals and how these are used for beauty | 2.33 | 2.83 | 38.798 | .000 |

| Item | Mean B | Mean G | chi | p |
|---|---|---|---|---|
| E1. Symmetries and patterns in leaves and flowers | 2.19 | 2.50 | 22.952 | .000 |
| E2. How the sunset colours the sky | 2.44 | 2.82 | 28.109 | .000 |
| E3. The ozone layer and how it may be affected by humans | 2.41 | 2.60 | 7.263 | .064 |
| E4. The greenhouse effect and how it may be changed by humans | 2.29 | 2.38 | 4.417 | .220 |
| E5. What can be done to ensure clean air and safe drinking water | 2.83 | 2.92 | 7.850 | .049 |
| E6. How technology helps us to handle waste, garbage and sewage | 2.72 | 2.82 | 6.248 | .100 |
| E7. How to control epidemics and diseases | 2.74 | 3.08 | 26.331 | .000 |
| E8. Cancer, what we know and how we can treat it | 2.79 | 3.30 | 44.815 | .000 |
| E9. Sexually transmitted diseases and how to be protected against them | 2.89 | 2.70 | 7.069 | .070 |
| E10. How to perform first-aid and use basic medical equipment | 3.09 | 3.35 | 17.108 | .001 |
| E11. What we know about HIV/AIDS and how to control it | 2.74 | 3.08 | 19.883 | .000 |
| E12. How alcohol and tobacco might affect the body | 2.69 | 2.98 | 16.377 | .001 |
| E13. How different narcotics might affect the body | 2.74 | 2.89 | 3.888 | .274 |
| E14. The possible radiation dangers of mobile phones and computers | 2.64 | 2.81 | 9.267 | .026 |
| E15. How loud sound and noise may damage my hearing | 2.70 | 2.94 | 12.418 | .006 |
| E16. How to protect endangered species of animals | 2.65 | 2.58 | 1.801 | .615 |
| E17. How to improve the harvest in gardens and farms | 2.50 | 2.28 | 9.067 | .028 |
| E18. Medicinal use of plants | 2.36 | 2.55 | 5.651 | .130 |
| E19. Organic and ecological farming without use of pesticides and artificial fertilizer | 2.37 | 2.29 | 4.806 | .187 |
| E20. How energy can be saved or used in a more effective way | 2.79 | 2.55 | 12.283 | .006 |
| E21. New sources of energy from the sun, wind, tides, waves, | 2.74 | 2.63 | 4.677 | .197 |
| E22. How different sorts of food are produced, conserved and stored | 2.84 | 2.91 | 2.608 | .456 |
| E23. How my body grows and matures | 2.94 | 3.12 | 7.219 | .065 |
| E24. Animals in my area | 2.50 | 2.26 | 11.917 | .008 |
| E25. Plants in my area | 2.40 | 2.26 | 5.250 | .154 |
| E26. Detergents, soaps and how they work | 2.33 | 2.51 | 7.662 | .054 |
| E27. Electricity, how it is produced and used in the home | 2.76 | 2.47 | 16.776 | .001 |

| Item | Mean B | Mean G | chi | p |
|---|---|---|---|---|
| E28. How to use and repair everyday electrical and mechanical equipment | 2.91 | 2.61 | 17.474 | .001 |
| E29. The first landing on the moon and the history of space exploration | 2.37 | 2.69 | 16.195 | .001 |
| E30. How electricity has affected the development of our society | 2.50 | 2.41 | 2.182 | .535 |
| E31. Biological and human aspects of abortion | 2.14 | 2.52 | 23.316 | .000 |
| E32. How gene technology can prevent diseases | 2.31 | 2.65 | 24.903 | .000 |
| E33. Benefits and possible hazards of modern methods of farming | 2.22 | 2.20 | 2.242 | .524 |
| E34. Why religion and science sometimes are in conflict | 2.61 | 2.88 | 10.547 | .014 |
| E35. Risks and benefits of food additives | 2.63 | 2.81 | 6.014 | .111 |
| E36. Why scientists sometimes disagree | 2.31 | 2.51 | 7.398 | .060 |
| E37. Famous scientists and their lives | 2.35 | 2.40 | 1.488 | .685 |
| E38. Big blunders and mistakes in research and inventions | 2.42 | 2.41 | 1.825 | .610 |
| E39. How scientific ideas sometimes challenge religion, authority | 2.56 | 2.72 | 5.99 | .112 |
| E40. Inventions and discoveries that have changed the world | 2.94 | 3.03 | 2.022 | .568 |
| E41. Very recent inventions and discoveries in science and technology | 2.78 | 2.79 | 2.656 | .448 |
| E42. Phenomena that scientists still cannot explain | 2.78 | 2.93 | 8.277 | .041 |

| Items | Mean B | Mean G | chi | p |
|---|---|---|---|---|
| H1. tried to find the star constellations in the sky | 2.24 | 2.70 | 30.356 | .000 |
| H2. read my horoscope (telling future from the stars) | 1.71 | 1.45 | 14.552 | .002 |
| H3. read a map to find my way | 2.53 | 2.37 | 9.970 | .019 |
| H4. used a compass to find direction | 2.08 | 2.01 | 2.424 | .489 |
| H5. collected different stones or shells | 1.89 | 2.39 | 32.946 | .000 |
| H6. watched (not on TV) an animal being born | 2.19 | 1.72 | 33.941 | .000 |
| H7. cared for animals on a farm | 2.26 | 2.02 | 10.330 | .016 |
| H8. visited a zoo | 2.62 | 2.74 | 7.162 | .067 |
| H9. visited a science centre or science museum | 2.40 | 2.45 | 4.333 | .228 |
| H10. milked animals like cows, sheep or goats | 1.99 | 1.39 | 63.799 | .000 |
| H11. made dairy products like yoghurt, butter, cheese or ghee | 1.61 | 1.50 | 7.780 | .051 |
| H12. read about nature or science in books or magazines | 2.22 | 2.29 | 1.409 | .703 |
| H13. watched nature programmes on TV or in a cinema | 2.71 | 2.76 | 2.897 | .408 |
| H14. collected edible berries, fruits, mushrooms or plants | 2.53 | 2.58 | 2.723 | .436 |
| H15. participated in hunting | 2.45 | 1.75 | 62.148 | .000 |
| H16. participated in fishing | 1.87 | 1.62 | 11.896 | .008 |
| H17. planted seeds and watched them grow | 2.30 | 2.36 | 1.910 | .591 |
| H18. made compost of grass, leaves or garbage | 1.82 | 1.45 | 22.665 | .000 |
| H19. made an instrument (like a flute or drum) from natural materials | 1.89 | 1.46 | 29.558 | .000 |
| H20. knitted, weaved, etc | 1.63 | 1.63 | 4.709 | .194 |
| H21. put up a tent or shelter | 2.26 | 1.74 | 40.616 | .000 |
| H22. made a fire from charcoal or wood | 3.07 | 2.90 | 6.065 | .108 |

| Items | Mean B | Mean G | chi | p |
|---|---|---|---|---|
| H23. prepared food over a campfire, open fire or stove burne | 2.80 | 2.64 | 9.980 | .019 |
| H24. sorted garbage for recycling or for appropriate disposal | 2.18 | 2.16 | 4.541 | .209 |
| H25. cleaned and bandaged a wound | 2.82 | 3.12 | 16.614 | .001 |
| H26. seen an X-ray of a part of my body | 2.05 | 1.93 | 8.184 | .042 |
| H27. taken medicines to prevent or cure illness or infection | 2.70 | 2.71 | 6.790 | .079 |
| H28. taken herbal medicines or had alternative treatments (acupuncture, homeopathy, yoga, healing, etc.) | 2.05 | 2.21 | 5.715 | .126 |
| H29. been to a hospital as a patient | 2.74 | 2.81 | 3.601 | .308 |
| H30. used binoculars | 1.90 | 1.61 | 20.634 | .000 |
| H31. used a camera | 3.39 | 3.61 | 18.437 | .000 |
| H32. made a bow and arrow, slingshot, catapult or boomerang | 1.93 | 1.51 | 31.575 | .000 |
| H33. used an air gun or rifle | 2.38 | 1.55 | 88.603 | .000 |
| H34. used a water pump or siphon | 2.56 | 2.61 | 20.761 | .000 |
| H35. made a model such as toy plane or boat etc | 2.12 | 2.34 | 7.048 | .070 |
| H36. used a science kit (like for chemistry, optics and electricity) | 2.02 | 2.03 | .876 | .831 |
| H37. used a windmill, watermill, waterwheel, etc | 1.79 | 1.69 | 1.964 | .580 |
| H38. recorded on video, DVD or tape recorder | 2.45 | 2.63 | 7.717 | .052 |
| H39. changed or fixed electric bulbs or fuses | 2.59 | 2.23 | 22.665 | .000 |
| H40. connected an electric lead to a plug, etc. | 3.10 | 3.24 | 17.142 | .001 |
| H41. used a stopwatch | 2.44 | 2.44 | 6.342 | .096 |
| H42. measured the temperature with a thermometer | 2.07 | 2.36 | 12.643 | .005 |
| H43. used a measuring ruler, tape or stick | 2.52 | 2.86 | 24.120 | .000 |
| H44. used a mobile phone | 3.56 | 3.70 | 15.203 | .002 |

| Items | Mean B | Mean G | chi | p |
|---|---|---|---|---|
| H45. sent or received an SMS (text message on mobile phone) | 2.98 | 3.14 | 11.234 | .011 |
| H46. searched the internet for information | 3.60 | 3.73 | 11.715 | .008 |
| H47. played computer games | 3.02 | 2.94 | 2.110 | .550 |
| H48. used a dictionary, encyclopaedia, etc. on a computer | 2.64 | 2.80 | 6.781 | .079 |
| H49. downloaded music from the internet | 3.04 | 3.35 | 17.272 | .001 |
| H50. sent or received e-mail | 2.76 | 3.01 | 16.886 | .001 |
| H51. used a word processor on the computer | 2.78 | 3.13 | 26.963 | .000 |
| H52. opened a device (radio, watch, computer, telephone, etc) to find out how it works | 2.75 | 2.31 | 32.394 | .000 |
| H53. baked bread, pastry, cake, etc | 2.70 | 3.52 | 95.429 | .000 |
| H54. cooked a meal | 3.00 | 3.51 | 54.613 | .000 |
| H55. walked while balancing an object on my head | 2.79 | 3.23 | 28.847 | .000 |
| H56. used a wheelbarrow | 2.80 | 2.69 | 2.478 | .479 |
| H57. used a crowbar (jemmy) | 2.26 | 1.64 | 46.642 | .000 |
| H58. used a rope and pulley for lifting heavy thing | 2.54 | 1.86 | 59.061 | .000 |
| H59. mended a bicycle tube | 2.87 | 2.18 | 56.156 | .000 |
| H60. used tools like a saw, screwdriver or hammer | 3.25 | 2.67 | 47.459 | .000 |
| H61. charged a car battery | 2.73 | 1.32 | 218.066 | .000 |