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Gender differences in self-efficacy in relation to Grade 9 science achievement in South Africa

by

MASHELA KATLEGO

(10604601)

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Supervisor: Dr Celeste Combrinck

Co-supervisor: Prof Surette Van Staden

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DECLARATION

I, MASHELA KATLEGO, student number 10604601, declare that the dissertation/thesis titled *Gender differences in self-efficacy in relation to Grade 9 science achievement in South Africa*, which I hereby submit for the degree M.Ed. in Assessment and Quality Assurance in Education and Training at the University of Pretoria, is my own work. Also, I have not previously submitted it for a degree at this or any other tertiary institution.

Mashela Katlego (signed on 10 November 2022)

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ABSTRACT

The gender trends in science achievement in South Africa have raised concerns for gender equity, as male learners continue to achieve poor results compared to their female counterparts. The current study investigated whether gender differences in self-efficacy contribute to the growing gender gap in science amongst Grade 9 learners in South Africa. This study took a post-positivist stance and used self-efficacy theory as a framework that guided the selection of variables in the TIMSS 2019 data. The theory emphasised the role of self-efficacy on learner achievement: higher levels of self-efficacy are associated with higher achievement. This study followed a quantitative secondary data analysis design. The TIMSS 2019 data for South Africa was analysed with descriptive statistics and multiple linear regression. In the TIMSS 2019 cycle, 520 schools and 20 829 learners in Grade 9 were sampled in South Africa. Data was collected through questionnaires and achievement tests. The current study used teacher and learner questionnaires, including the overall science achievement for data analysis. The findings reflected significant differences in self-efficacy between the genders. Female learners reported higher self-efficacy, which was associated with their higher science achievement. Studies in other countries reported self-efficacy as an indicator of academic achievement amongst males and females. In South Africa, self-efficacy is also a contributing factor to Grade 9 science achievement. The current study suggests that to understand the effect of self-efficacy on learner achievement, researchers should also consider the language of the test as it poses a greater impact on the performance of the learners.

*Key Terms: s*elf-efficacy, gender, Grade 9, science achievement, TIMSS 2019

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Edited by:

Anneke-Jean Diesel

Bachelor of Arts Honours in Corporate and Marketing Communications (cum laude) and Bachelor of Arts in Corporate and Marketing Communications (cum laude)

Reviewed by:

Khomotso Bopape

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Address: **570 Fehrsen Street, Brooklyn Bridge Office Park, Brooklyn, Pretoria, 0181**
Tel No.: **012 433 6584,** Fax No.: **086 267 2164** and Email Address: **editor@letsedit.co.za**

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LIST OF ABBREVIATIONS AND ACRONYMS

CAPS	Curriculum and assessment policy statement
DBE	Department of Basic Education
DME	Data Management Expert
DPC	Data Processing Centre
GCC	Gulf Cooperation Council
HSRC	Human Resource Research Council
IQCM	International Quality Control Monitors
IRT	Item Response Theory
ISCED	International Standard Classification of Education
KMO	Kaiser-Meyer-Olkin
LoT	Language of the test
MAR	Missing at random
MCAR	Missing completely at random
MDG	Millennium Development Goals
MLR	Multiple linear regression
MNAR	Missing not at random
NRC	National Research Coordinators
PCA	Principal Component Analysis
PIRLS	Progress in International Reading and Literacy Study
PV	Plausible values
SACMEQ	Southern and Eastern African Consortium for Monitoring Educational Quality
SDG	Sustainable Development Goals
SE	Standard error
SMIRC	Science and Mathematics Item Review Committee
SPSS	Statistics Package for Social Sciences
STEM	Science, Technology, Engineering and Mathematics
UN	United Nations
VIF	Variance Inflation Factor

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CHAPTER 1

GENERAL ORIENTATION

1.1 Introduction

The current study comprises a secondary data analysis of the Trends in International Mathematics and Science Study (TIMSS) 2019 South African data. The study investigated gender-related differences in self-efficacy and its effects on science achievements among Grade 9 learners in South Africa.

TIMSS is an international comparative study of learners' achievements in mathematics and sciences. The establishment of TIMSS aimed to improve the teaching and learning of science and mathematics in school systems through curricula comparison and practices of different countries participating in the study (Mullis & Martin, 2012). TIMSS assessed achievements in science and mathematics in grades 4 and 8 of various countries participating in the study (Fishbein et al., 2018). The TIMSS study has been administered every four years since 1995. The TIMSS 2019 marked the seventh cycle of the international study providing trends in mathematics and science of countries participating in the study. South Africa has participated in TIMSS surveys since 1995 conducted by the Human Resource Research Council (HSRC). The Grade 8 learners in South Africa participated in the 1995, 1999 and 2003 TIMSS cycles. The 2003 TIMSS cycle in South Africa was administered on both Grad e 8 and 9 learners. The Grade 9 learners continued with the 2011, 2015 and 2019 TIMSS cycles (Reddy et al., 2020).

TIMSS collects a rich array of data about the national, school, classroom and home contexts in which learners study science and mathematics. TIMSS uses the contexts to provide international comparative perspectives on educational factors relating to science and mathematics achievements of participating countries (Fishbein et al., 2021). The findings from TIMSS 2019 survey indicated that females continue to attain better results in science compared to males in many countries taking part in the study (Mullis et al., 2020).

Different studies internationally and locally reported a positive relationship between academic performance and self-efficacy. The relationship indicates that learners with high levels of self-efficacy tend to perform better academically than those with low self-efficacy beliefs (Britner & Pajares, 2006; Jamil & Mahmud, 2019; Juan et al., 2018). The current study compared gender and self-efficacy beliefs of South African Grade 9 learners in relation to their science achievements in the TIMSS 2019 survey.

1.2 Background of the study

In 2015, South Africa was part of the 193 countries that agreed to the 2030 Agenda on Sustainable Development framework guiding global development. In the 2030 Agenda, 17 Sustainable Development Goals (SDGs) were agreed upon in the United Nations (UN) general assembly as a global call for action to eliminate poverty and ensure peace and prosperity for all people by the year 2030 (Statistics South Africa, 2019).

Amongst the 17 SDGs, SDG4 concerns inclusive and equitable quality education and promotes lifelong opportunities for learning. The aim is to ensure that by 2030 male and female learners complete free, equitable, quality primary and secondary education that leads to effective learning outcomes. SDG5 is concerned with achieving gender equity and empowering all females by eliminating discrimination and ensuring equal opportunities in decision-making, politics, economic and public life (United Nations [UN], 2015).

According to the 2015 Millennium Development Goals (MDG) country report, South Africa has reached gender parity in education regarding learner enrolment in primary and secondary schools (Statistics South Africa, 2015). However, despite the progress made in education, gender-related differences and inequalities persist. The 2018 South Africa Commission for Gender Equality report stated that more females than males in South Africa complete secondary school and enter institutions of higher learning (Afrobarometer, 2019). However, there are still more concerns about the underrepresentation of females in the fields related to Science, Technology, Engineering and Mathematics (STEM) (Reddy et al., 2016; Statistics South Africa, 2015).

According to the Department of Basic Education (Department of Basic Education [DBE], 2017), Grade 6 learners in South Africa participated in the fourth cycle of the Southern and Eastern African Consortium for Monitoring Educational Quality (SACMEQ, currently known as SEACMEQ). SACMEQ is a cross-national initiative established by countries in the eastern and southern parts of Africa to test the numeracy and reading skills of learners in Grade 6. The administration of SACMEQ in South Africa provides the DBE with research-based data that policymakers can utilise to plan for improvements in the quality of education in South Africa. The SACMEQ IV findings reflected a significant gender difference in reading and mathematics average scores, with female learners attaining better results than males (DBE, 2017).

South African learners also participated in the Progress in International Reading and Literacy Study (PIRLS) 2016. PIRLS is a large-scale international study that assesses Grade 4 learners on reading comprehension and also monitors the trends in their reading literacy (Howie et al., 2017). In the PIRLS 2016, South Africa was the second with the largest gender gap amongst the participating countries, whereby females performed significantly better than their male counterparts (Howie et al., 2017).

TIMSS results from the 2011 and 2015 cycles revealed a statistically significant gender gap in South Africa, with female average science scores higher than those of males (Mullis et al., 2016; Martin et al., 2012). Male learners in Grade 9 continued to perform worse than females in the TIMSS 2019 survey. Science achievement by gender revealed that female learners obtained a higher average score (376; standard error [SE]=3.2) than their male counterparts (364; SE=3.6) (Mullis et al., 2020). These findings revealed a statistically significant difference between the two genders in Grade 9 (Reddy et al., 2020).

Research has been done to investigate the relationship between gender-related differences in self-efficacy and science achievement (Aurah, 2017; Gor et al., 2020; Juan et al., 2018). Reports from these studies revealed that self-efficacy is an important predictor of science achievement. Regarding South Africa, there is insufficient literature comparing the two constructs (gender and self-efficacy). Therefore, it is worthwhile to investigate self-efficacy and its relationship with science achievement amongst male and female learners in Grade 9 in South Africa to determine whether it is a contributing factor to the growing gender gap in Grade 9 science.

1.3 Definition of terms

Gender: In the current study, gender refers to the biological binary classification in which people are categorised at birth as male or female (Hyde et al., 2019).

Self-efficacy: Refers to an individual's belief in their capacities to execute behaviours to produce specific performance attainment (Carey & Forsyth, 2009).

Academic achievement: Represent performance outcomes that show the extent to which a learner has accomplished specific goals focused on school activities (Steinmayr et al., 2016).

1.4 Problem statement

Females outperforming males in secondary schools and other levels have become a growing international phenomenon (Jackman & Morrain-Webb, 2019). According to Sabarwal and Abu-Jewdeh (2017), international benchmark tests indicate that males lag behind females on test averages, with males being more likely to be low achievers compared to females of the same age. Educational statistics worldwide indicate that males perform poorly compared to females in all subjects, whether science or non-science majors (Jackman & Morrain-Webb, 2019).

From 1995 to 2019, TIMSS results on science achievements by gender in Grade 8 reflected a trend of improved performance among females, with males initially outperforming females to females now performing better than males internationally (Mullis et al., 2016; Mullis et al., 2020). International trends in science achievement by gender are mirrored in South Africa, where males lagged behind females in science achievements during the 2011, 2015, and 2019 TIMSS cycles (Mullis et al., 2020).

Although the large majority of South Africans agree that males and females have equal access to education (Afrobarometer, 2019; Statistics South Africa, 2021), the education quality in the country remains poor (Hogan, 2020). There are also concerns about the overall underperformance of males when compared to their female counterparts (Reddy et al., 2020). Special attention should be focused to the growing gender gap to achieve the global movement on sustainable development toward gender equity and equality by the year 2030.

Researchers have confirmed the existence of a positive relationship between self-efficacy and academic performance. However, there is a lack of literature in South Africa that reported the relationship between gender differences in self-efficacy beliefs and scientific achievements. The available literature reveals varying results regarding the relationship between the two constructs in other countries. In Kenya, studies found mixed results regarding self-efficacy difference between male and female learners and their science performance. According to Aurah (2017), a significant correlation exists between academic performance and self-efficacy, with females having higher self-efficacy scores and outperforming males in science achievements. Gor et al. (2020) found that males have higher science self-efficacy and outperform females academically in science. Juan et al. (2018) reported similar results to Aura (2017) in South Africa, and the same results were obtained in Spain (Schina et al., 2019). Musisi et al. (2021) found no significant correlation between gender differences in self-efficacy, biology, and chemistry in Uganda. On the other hand, male learners were found to be more confident in completing academic physics tasks than their female counterparts.

Nasir and Iqbal (2019) stated that academic self-efficacy is an important predictor of academic performance, and a learner's academic performance can be based on the learner’s academic self-efficacy. The current study utilised TIMSS data from the

2019 survey to explore the effects of gender-related differences in self-efficacy on science achievements amongst Grade 9 learners in South Africa. The study investigated whether self-efficacy significantly contributed to females' higher performance compared to males in science in the TIMSS 2019 survey.

1.5 Purpose of the study

The study aimed to investigate the extent gender-related differences in self-efficacy contribute to the growing gender gap in science achievements amongst Grade 9 learners in South Africa.

1.6 Research questions

This study aimed to answer the research question: To what extent do gender differences in self-efficacy correlate with learner achievement in Grade 9 science in South Africa?

1.6.1 Sub-question

1. What difference in self-efficacy exists between male and female learners in Grade 9?
2. To what extent do gender differences in self-efficacy contribute to science achievement when controlling for background factors such as socio-economic status?

1.7 Statement of hypotheses

Table 1.1 illustrates the null and alternative hypotheses.

Table 1.1

Sub-research questions with null and alternative hypotheses

Sub-research questions	The null and alternative hypothesis

1	What difference in self-efficacy exists between male and female learners in Grade 9?	H_0: There is no significant difference in self-efficacy between male and female learners in Grade 9. H_1: There is a significant difference in self-efficacy between the genders in Grade 9.
2	To what extent do gender differences in self-efficacy contribute to science achievement when controlling background factors such as socio-economic status?	H_0: No significant gender difference in self-efficacy and science achievement exists when SES factors are controlled. H_1: When SES factors are controlled, there is a significant gender difference in self-efficacy and science achievement.

1.8 Assumptions

The current study is based on the notion that the data in the IEA is consistent, precise, and contains minimal errors. These assumptions are based on the IEA's many years of experience conducting large-scale educational research. Furthermore, TIMSS has been conducting assessment projects in science and mathematics surveys for many years, indicating that their researchers have advanced knowledge in conducting surveys. As a result, there is evidence that their data is trustworthy and valid. This study is situated within a post-positivist paradigm where reality can be tested in relation to social constructs of self and issues of efficacy.

1.9 Delimitations

This study only explored the relationship between gender differences in self-efficacy and science achievement among Grade 9 learners in South African who participated in the TIMSS 2019 survey. Although other factors influence how male and female learners perform in science, this study only examined the self-efficacy factors measured in the TIMSS 2019.

1.10 Ethical Considerations

The sampling, data collection, and analysis techniques utilised in this study were subjected to ethical considerations. The DBE authorised the HSRC to conduct TIMSS 2019 as an independent body in South Africa. Schools agreed to take part in the study, and parents were given a consent form to sign on their child's behalf. No school or learner names were included in the data to ensure anonymity. Permission to conduct secondary data analysis was obtained from the University of Pretoria, Faculty of Education Ethics Committee for this current study.

1.11 Research structure

This study comprises six chapters. The current chapter provided a general overview of the research. The second chapter gives the reader an overview of the TIMSS 2019 survey conducted internationally and in South Africa, including methods and procedures. The third chapter contains a literature review as well as a theoretical framework. The methodology, which includes the study design and data analysis procedures, is outlined in Chapter 4. Chapter 5 focuses on detailed data analysis and discusses the results, while Chapter 6 provides conclusions and recommendations.

1.12 Summary

This chapter provided an overview of the background of this study, problem statement, research questions, and the outline of the study. Science is a broad aspect of school teaching, leading to increased scientific and technological expertise and advancement in higher education and other related sectors. It has been reported that although South Africa has achieved gender equity and equality in education, gender imbalance in relation to academic achievement continues to be an issue in mathematics and science classrooms. Findings from TIMSS 2019, PIRLS 2016, and SACMEQ IV have indicated that male learners in South Africa tend to achieve poor results compared to their female counterparts. The poor academic performance of male learners in science and mathematics has become a concern.

According to research, there is a significant correlation between self-efficacy and academic achievement. Self-efficacy has been reported as a strong predictor of learner performance in school. Studies have found that learners with higher levels of self-efficacy tend to achieve better results academically than learners with low self-efficacy levels. Studies referred to in this thesis found that males have lower science self-efficacy than females and, as a result, often achieve lower grades in this academic subject.

The current study is a secondary data analysis of the TIMSS 2019 data for South Africa. The study investigated whether gender-related differences in self-efficacy contribute to the current gender gap in the science performance of Grade 9 learners in South Africa. The next chapter of the research study provides a background on the TIMSS 2019 survey, including its methods and procedures.

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CHAPTER 2

TIMSS 2019 BACKGROUND

2.1 Introduction

TIMSS is a valuable resource used to monitor the effectiveness of education in countries that participate in the study. STEM subjects are key to any country's curriculum, and they play an important role in solving world problems by finding solutions to problems such as hunger, habitat destruction, sustainable growth, and stability in global growth (Mullis & Martin, 2017).

This chapter provides background on TIMSS 2019. The chapter outlines the TIMSS 2019 conceptual framework and science assessment framework, which includes the methods and procedures. The South African design of the TIMSS 2019 survey will also be discussed.

2.2 TIMSS 2019 assessment

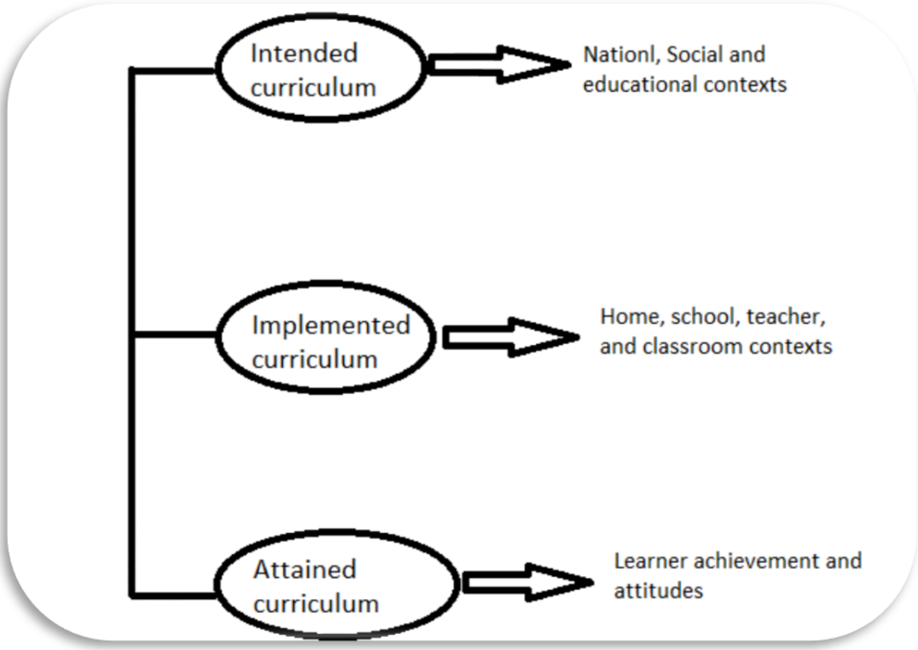
TIMSS assessments are primarily developed to provide information regarding learners' achievement in science and mathematics to participating countries. The information obtained from TIMSS can be used to improve educational policies and practices. TIMSS' mission is to measure science and mathematics achievements of learners in a way that is fair to the richness and breadth of these subjects as they are taught in various countries. The results from TIMSS assessments can be used to track the declines or improvements in the education of the participating countries by tracking trends in learner performance. Furthermore, administering TIMSS in both grades every four years allows for grade cohort progress tracking (Mullis & Martin, 2017).

2.3 TIMSS 2019 assessment framework

TIMSS uses curriculum as an organising concept to consider how educational opportunities are provided to learners and factors that influence the way learners utilise these opportunities. According to Mullis and Martin (2017), TIMSS uses existing curriculums (intended, implemented, and attained curriculums) as a conceptual framework to organise concepts. Figure 2.1 depicts the curriculum model used by TIMSS.

Figure 2.1

TIMSS curriculum model



The intended curriculum is a set of formal documents that specifies what learners will learn in school. It stipulates the knowledge, values, attitudes, and skills to be acquired, as well as the assessment of the teaching and learning outcomes. The implemented curriculum involves the actual teaching and learning activities in schools and the interaction between teachers and learners. The attained curriculum includes the knowledge, attitudes, understanding, and skills learners gain through teaching and learning (UNESCO, 2013).

2.4 TIMSS 2019 Science Framework

The science framework was developed around two domains (content and cognitive)

2.4.1 Content domain

The Grade 9 science content in South Africa is organised around four topics (life and living, energy and change, matter and material, and planet earth and beyond). Table 2.1 shows the Grade 9 science content in South Africa and how it relates to the TIMSS 2019 survey.

Table 2.1

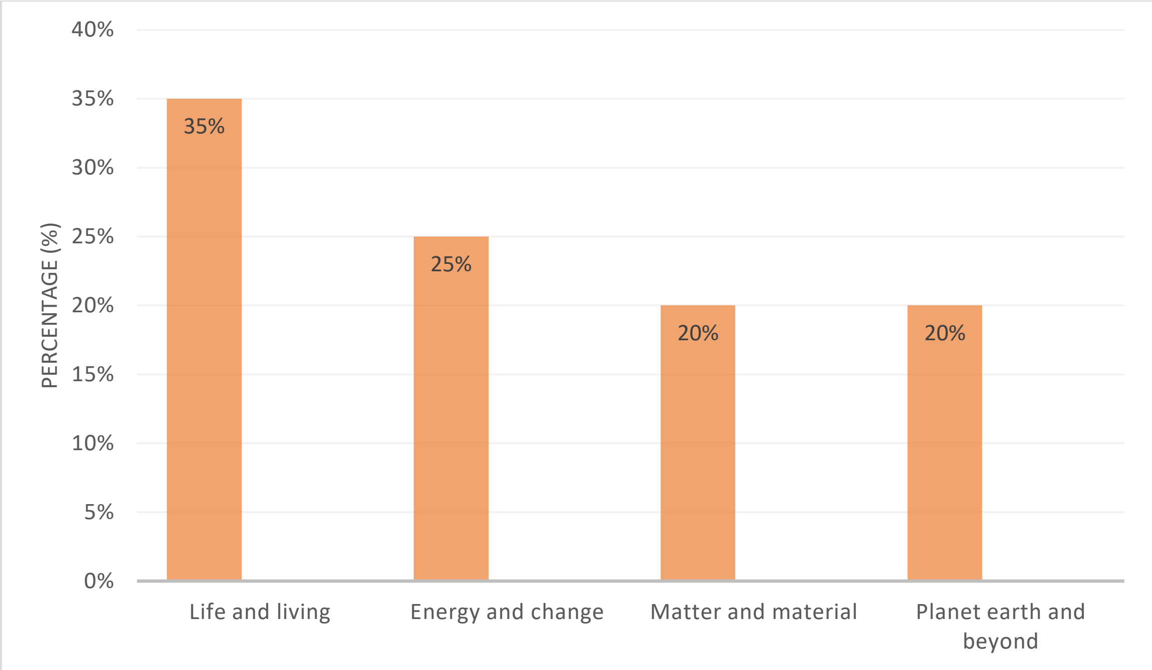
The relatedness of Grade 9 science content in South Africa and that of the TIMSS 2019

Grade 9 science content	TIMSS 2019 science content
Life and living	Biology
Matter and material	Physics
Energy and change	Chemistry
Planet earth and beyond	Earth science

The science content for Grade 9 in South Africa relates to that assessed by TIMSS. Life and living relate to biology, matter and material to physics, energy and change to chemistry, and planet earth and beyond to earth science. Figure 2.2 shows the total percentages devoted to each topic in the TIMSS 2019.

Figure 2.2

Target percentage devoted to topics in science for the TIMSS 2019 survey



In the science content, 35% was devoted to life and living, and 25% to energy and change. Matter and material, and planet earth and beyond were allocated 20% each of the total content to be assessed. Each of the four topics included several major topic areas, and each area was divided into sub-topics. ANNEXURE A presents the Grade 9 science curriculum in South Africa and the topics assessed in the TIMSS 2019 survey.

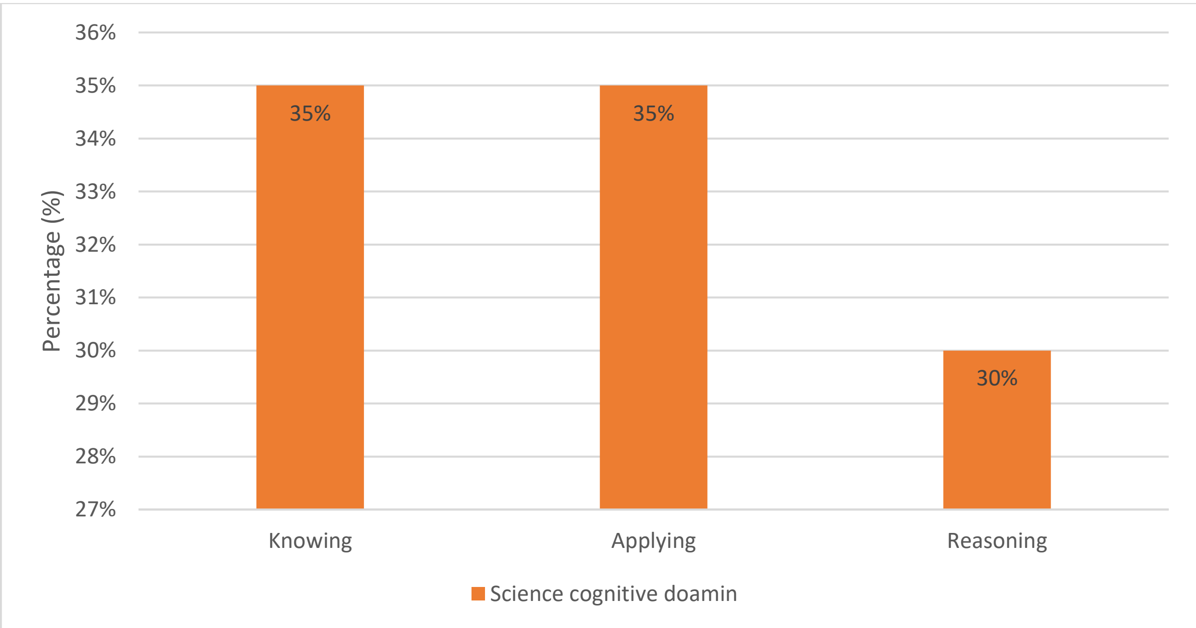
2.4.2 Cognitive domain

The cognitive domain was divided to form three sub-domains (knowing, applying, and reasoning). Knowing sub-domain addresses the learner's ability to recognise, describe, recall, and provide examples of concepts, facts and procedures required for a solid scientific foundation. The applying sub-domain is concerned with using knowledge of science to contrast, classify and compare groups of materials or objects, generating explanations, relating science concepts to specific contexts, and solve practical problems. The reasoning sub-domain involves the use of evidence and understanding of science to analyse, synthesise, and make generalisations mostly in unfamiliar contexts (Mullis & Martin, 2017).

The total number of items in the cognitive domain was distributed to each sub-domain based on the percentage allocated to each one. The percentages of items per sub-domain were applied across the achievement booklets. Figure 2.3 shows the percentages of items devoted to each of the three sub-domains.

Figure 2.3

Percentages of items per sub-domain across the achievement booklets



Items related to the knowing sub-domain assessed learners' knowledge of facts, processes, concepts, and equipment used in science. The sub-domain accounted for 35% of the cognitive domains devoted to science in Grade 9. This sub-domain included the following: recalling, identifying or stating facts, relationships, and concepts; identifying properties or characteristics of specific organisms, materials, and processes; identifying scientific procedures; recognising and use of scientific symbols, vocabulary, abbreviation, scales, and units. Learners were also required to describe the structures, properties and functions of materials and organisms (Mullis & Martin, 2017).

The applying sub-domain also accounted for 35% of the cognitive domain, similar to knowing. In this sub-domain, learners were required to engage in the application of scientific knowledge to familiar situations. It included identifying similarities and differences between organisms and materials and classifying, distinguishing, or sorting organisms, objects, and processes based on their characteristics. The learners were also required to apply scientific knowledge to an inferred or observed behaviour, property, or organism. It included using models to show knowledge of science concepts, cycles, relationships, or systems to solve science problems. Furthermore, learners had to interpret graphical, tabular, pictorial, and textual information (Mullis & Martin, 2017).

Reasoning was allocated 30% of items in the cognitive domain. Items in the reasoning sub-domain require learners to analyse data, draw conclusions, and use their understanding of science in unfamiliar contexts. The items required learners to use more than one strategy or approach to solve problems. This included using scientific reasoning that encompassed the development of hypotheses and designing scientific experiments or investigations (Mullis & Martin, 2017).

2.5 TIMSS 2019 instruments for science

TIMSS and PIRLS International Study Centre at Boston College collaborated with participating countries to adapt instruments for the 2019 TIMSS. The instruments included achievement tests and questionnaires covering home, school, teachers, learners, and curriculum (Martin et al., 2020).

2.5.1 The achievement test

Since the start of TIMSS in 1995, assessments have been developed into two general item formats: selected and constructed responses. From the selected responses (multiple choice questions), a set of options were provided from which learners had to choose their answers. Constructed response items required learners to use their knowledge of science to respond to questions. Most of the items in the TIMSS 2019 were carried forward from the previous TIMSS cycle. In the TIMSS 2019, 325 new science achievement items (or questions) were developed, and field tested (Martin et al., 2020).

The TIMSS and PIRLS International Study Centre at Boston College collaborated with each participating country's experts and National Research Coordinators (NRCs) to update the TIMSS assessment framework. This process involved developing new achievement items and scoring guidelines. Once the process was done, the TIMSS and PIRLS International Study Centre prepared an international version in English that included all achievement items. Some NRCs from various countries were then tasked with translating the items into different languages according to each participating country’s language policy for teaching in Grade 8. A group of experts, known as the Science and Mathematics Item Review Committee (SMIRC), guided the development process. The SMIRC comprised 13 members (six experts in science and science education and seven in mathematics and mathematics education). The primary purpose of the SMIRC was to review proposed science and mathematics frameworks, field test and scoring guidelines, and proposed item blocks (Martin et al., 2020).

2.5.2 Learner booklet design for TIMSS 2019

TIMSS encountered difficulty because the assessment required more questions than a single learner could answer in the time allotted for testing. Thus, TIMSS made use of matrix sampling approach that involved packaging all the science items in the assessment pool into 14 learner achievement booklets, with each learner required to complete only one booklet. Once the assessment was administered, data collected, and processed, TIMSS then made use of Item Response Theory (IRT) scaling method to create a comprehensive picture of learner achievement. The picture covered the entire population of each country based on individual learners' combined responses to the assigned booklets (Mullis & Martin, 2017).

While creating learner achievement booklets for the 2019 survey, items were grouped into series of blocks. Each block had about 12 to 18 items for Grade 8. A total of 28 blocks (14 blocks for science and 14 for mathematics) were created. Of the 28 blocks, 16 blocks (eight blocks for science and eight for mathematics) were trend items carried forward from TIMSS 2015, and the remaining 12 blocks comprised new items. The 28 blocks were then distributed into 14 booklets, with each learner's booklet comprising two blocks for science and two for mathematics (Mullis & Martin, 2017).

During the testing period, the Grade 8 learners were allocated an average of 22.5 minutes to complete each item block. Consequently, 10.5 hours were estimated to complete all 28 blocks of Grade 8 assessment items. Since each learner was required to answer only one booklet, the Grade 8 learners were given 90 minutes to complete the entire booklet (Mullis & Martin, 2017).

2.6 Questionnaires

2.6.1 School questionnaire

The principals of the school completed the school questionnaire. The questions included the following: the level of learners' numeracy and literacy skills when they first entered the school; the socioeconomic status of the learners; teaching resources available at the school; discipline at the school; emphasis on academic excellence; and the principal's level of education (Martin et al., 2020).

2.6.2 Teacher questionnaire

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The teacher questionnaire was administered in two separate versions (mathematics and science) to cater for teachers who teach science and mathematics, respectively. In the questionnaire, the teachers were asked about their level of education, professional development, and career satisfaction. The questionnaire also included questions on learners' readiness for interaction, frequency of doing various instructional activities, challenges related to teaching, topics covered in the curriculum, assessment practices, and availability of instructional resources in the school (Martin et al., 2020).

2.6.3 Learner questionnaire

Learners in either grades 8 or 9 received two separate questionnaires. One questionnaire was designed for countries that taught science as distinct subjects (biology, earth science, physics, and chemistry), with questions based on each content area separately. The other questionnaire was distributed to countries such as South Africa where science is taught as an integrated subject. The learner questionnaire asked the Grade 9 learners about their educational experiences regarding science and mathematics at home and school and their attitudes toward these subjects (Mullis & Martin, 2017).

2.7 Learner population assessed

In the TIMSS 2019, participating countries were allowed to assess one or both population groups based on the availability of resources and policy priorities. TIMSS uses years of formal schooling as the basis for comparison amongst participating countries. Thus, TIMSS 2019 assessments in Grade 8 targeted grade levels that corresponded with eight years of formal schooling (Mullis & Martin, 2017). The populations targeted by TIMSS are defined as follows:

- In Grade 4, the target grade for TIMSS was the grade that represent four years of schooling based on the International Standard Classification of Education (ISCED).
- In Grade 8, the target for TIMSS was the grade that represent eight years of schooling according to the ISCED.

According to the Institute for Statistics of the United Nations Educational, Scientific, and Cultural Organization (UNESCO, 2012), ISCED provides a comprehensive framework for organising educational programmes and qualifications by using uniform international definitions to facilitate educational systems around the world from pre-primary to doctoral study. Level 1 corresponds with the first stage of basic education or primary education. Eight years after starting with level 1 represents the eight years of formal schooling, which is the target grade for TIMSS assessments. TIMSS, however, recommended participating countries to assess the next grade (i.e., Grade 9) if the average age of the learners in Grade 8 is 13.5 or younger during the time of testing (Mullis & Martin, 2017).

During the sample selection process for the TIMSS 2019 survey, the NRCs in each country provided Statistics Canada with a list of schools that offered Grade 8 classes, and South Africa submitted the lists of Grade 9s. The lists were used to select a nationally representative sample of schools and learners for Grade 8 (internationally) and Grade 9 for the South African sample. The basic TIMSS sample design required at least 4000 learners and 150 schools for Grade 8 in each participating country (Mullis & Martin, 2017).

2.8 Sampling of schools and learners(N)

The TIMSS 2019 used a two-stage stratified cluster sampling design to select schools and classes. The first stage involved sampling of schools at random, and the second involved sampling of one or more intact classes within the sampled schools (Martin et al., 2020).

2.8.1 First sampling stage

Schools were sampled using probability proportion to school size. The sampled schools were from the list of schools with eligible learners. The sampling was based on demographic variables. During the sampling process, two replacement schools were also sampled in case any schools decided to withdraw from the project or were unavailable (Martin et al., 2020).

2.8.2 Second sampling stage

Each sampled school selected one or more intact classes from the targeted grade using Windows Within-School Sampling software (WinW3S) developed by Statistics Canada and IEA Hamburg. Smaller classes below the minimum recommended class size were combined into pseudo-classes before the sampling process took place (Martin et al., 2020).

2.9 Data collection

Standardised operational procedures were followed during data collection for TIMSS to provide participating countries with reliable data for learners' achievement profiles and learning contexts. A collaborative team developed these procedures from the TIMSS and PIRLS International Study Centre, IEA Hamburg, Statistics Canada, IEA Amsterdam, and NRCs from participating countries. For each TIMSS cycle, the standardised operations procedures were updated to ensure efficient data collection (Martin et al., 2020).

In each participating country, the NRCs were responsible for implementing TIMSS 2019. From March to May 2018, full-scale field testing was conducted by countries to test all TIMSS instruments in preparation for the main survey, which took place from October to December 2019 in South Africa (Martin et al., 2020).

TIMSS 2019 data included the collection of achievement booklets and background questionnaires. The NRCs' careful planning and organisation were required to prepare and distribute assessment materials to participating schools (Martin et al., 2020). In South Africa, the provincial education departments assisted with arranging access to schools. Data collecting companies appointed by the DBE had to collect data for TIMSS. They were also responsible for making appointments with schools and verifying the correctness of the materials received from the HSRC.

2.10 Quality assurance

The IEA deployed International Quality Control Monitors (IQCMs) that visited schools in participating countries to implement an international quality assurance programme. The IQCMs sampled 15 schools out of the total number of participating schools in each country. The sampled schools were visited to investigate the level of adherence to the standard procedures set by TIMSS (Martin et al., 2017).

2.11 Scoring procedures

There were 220 assessment items for science in the TIMSS 2019. These items were divided into selected response and constructed response items (Martin et al., 2020).

2.11.1 Selected response items

The items in the multiple-choice questions accounted for half the score points of the total number of scores in the assessment. Each question in this category had four options from which learners could choose. Of the four possible answers, learners had to select only one correct answer. The majority of the selected response questions were worth one score point, although some were compound and worth two (Martin et al., 2020).

2.11.2 Constructed response items

Items in this category also accounted for half the score points in the assessment for TIMSS 2019. The challenge with these items was that they require human scoring. To overcome this challenge and ensure the reliability of scoring the items, the TIMSS and PIRLS International Study Centre provided a scoring guide for each response. The guideline had descriptions and examples of suitable responses for each score point value. In addition, extensive training was also provided to individuals using the scoring guides (Martin et al., 2020).

2.12 TIMSS 2019 science achievement scores

TIMSS used IRT scaling to obtain plausible values (PVs). Following this method, TIMSS estimated five imputed proficiency scores for each learner based on their conditioned and ability distribution upon learner and class characteristics. These imputed scores were then used to compare achievement between different iterations of TIMSS (Martin et al., 2020).

2.13 Data capturing

After data was collected, national centres were responsible for capturing all data using Data Management Expert (DME) from IEA. The NRCs were requested to verify the captured data with the originally collected data to minimise errors. Once data were verified, it was submitted for final cleaning and checking of inconsistencies by the IEA Data Processing Centre (DPC) (Martin et al., 2020).

2.14 Validity and reliability of instruments

2.14.1 Validity of instruments

TIMSS made use of an evidence-centred design framework to ensure validity. This framework involved observing best practices in the assessment design during the development process of items. The process required establishing standards for items and test forms, specifying the items to measure, defining the target construct, and ensuring that the assessment met the test specifications (Martin et al., 2020).

2.14.2 Reliability

Reliability is concerned with how much a measurement procedure yields similar findings on consistent assessment conditions (Schult & Spartfeldt, 2018). To ensure reliability, TIMSS deployed three ways for human scoring reliability: Within-country, trend, and cross-country.

2.14.2.1 Within-country reliability

Two independent scorers were deployed for scoring a sample of 200 constructed items selected at random. An international average agreement of 94% for science in Grade 8 was recorded, indicating high reliability (Martin et al., 2020).

2.14.2.2 Trend-item scoring reliability

Countries that participated in the 2015 TIMSS were requested to send samples of scored learner booklets from the 2015 cycle to IEA Hamburg, where they were scanned and digitally saved for future use. Scorers of TIMSS 2019 in each country were requested to score the learner responses collected in 2015 using the Coding Expert Software. This procedure allows TIMSS to measure scoring consistency from one TIMSS cycle to the next. Each country scored 200 responses for each of the 13 science items in Grade 8. The results revealed a high degree of scoring consistency in science internationally between the 2015 and 2019 TIMSS cycles (Martin et al., 2020).

2.14.2.3 Cross-country scoring reliability

Because of the differences in the languages used participating countries, it became a challenge for TIMSS to establish the reliability of constructed response scoring across countries. Therefore, to overcome this challenge, the TIMSS and PIRLS International Study Centre conducted a cross-country scoring reliability amongst countries in the Northern Hemisphere that had scored the constructed response items in English. In addition, a sample of learners' responses from countries that use English as a medium of instruction in the Southern Hemisphere was also collected. The cross-country scoring comprised 200 learner responses for each of the 13 science items in Grade 8. These items from each country taking part in TIMSS were then scored independently in other participating countries. The degree to which the scores agreed once scoring was completed was used as a measure of reliability across countries. The results from the cross-country reliability scoring for science in Grade 8 indicated a high similarity agreement across the scorers in different countries (Martin et al., 2020).

2.15 South African design of TIMSS study

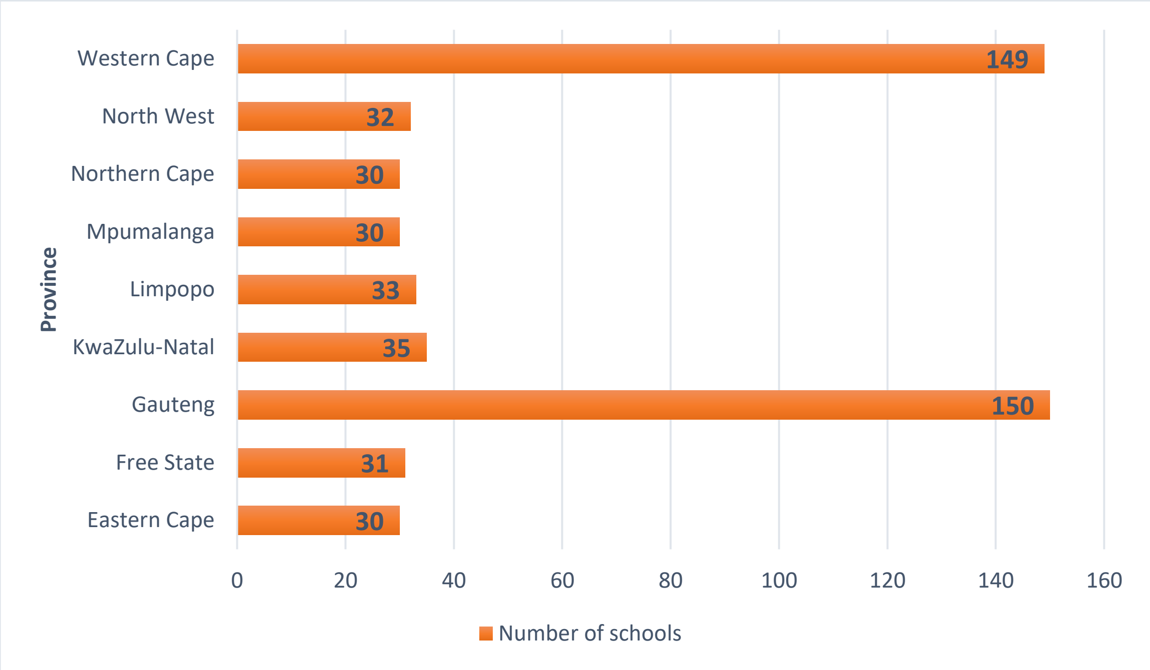
In South Africa, the DBE and the HSRC collaborated to conduct the TIMSS 2019. Internationally the study was tested on Grade 4 and Grade 8 learners. However, in South Africa, the study was conducted in Grade 5 and Grade 9, a one-year older cohort than in the other countries (Reddy et al., 2022).

2.15.1 Sample selection for South Africa

In the TIMSS 2019, there were 524 schools sampled. However, four schools withdrew from the study, with 520 schools evidently participating in the TIMSS 2019 cycle (Reddy et al., 2022). Figure 2.4 shows the number of schools per province that participated in the study.

Figure 2.4

Number of schools per province in TIMSS 2019 for South Africa



Based on the TIMSS 2015 results for Grade 9, Gauteng and Western Cape had a higher achievement percentage than the other provinces. The sample size for the two provinces was increased to 150 schools each while keeping the other provinces at 30 schools each. The increase in Gauteng and Western Cape's sample size comes from the two provinces serving as self-standing entities called benchmarking participants in the TIMSS 2019. A benchmarking participant can be a city, province, country, or state (Reddy et al., 2022b).

2.15.2 Stratification of schools

Explicit and implicit stratification were used during the sampling of schools. In the explicit stratification, sampling of schools was based on the province, type of school, and language used as medium of instruction (English and Afrikaans). In the implicit stratification, schools were grouped based on their level of performance per province.

2.15.3 The stages of sampling selection

In the first stage, Statistics Canada was provided with the DBE's 2018 master list of schools. The sample was explicitly stratified by school type and province and implicitly by school quintile. The schools found in the sampling frame had no missing information on the stratification variable and offered Grade 9 classes. Two replacement schools were also selected to close the gap if a school withdrew (Reddy et al., 2022a).

For the second stage, schools sampled in the first stage were then requested to submit lists of their Grade 9 classes. WinW3s software was used to randomly sample intact classes from the lists provided. In each school, one Grade 9 class was sampled. However, when a school had classes smaller than the recommended size, more than one class was selected (Reddy et al., 2022a).

2.15.4 Translation and preparing assessment instruments

In preparation for administering TIMSS 2019, the HSRC was responsible for translating (from English to Afrikaans) and adapting the assessment instrument in South Africa. After completing the translations and adaptations, they were documented using National Adaptation Forms and sent to IEA for verification before they could be assembled into the contextual questionnaires and achievement booklets (Reddy et al., 2020).

2.15.5 Field testing of instruments

The field test was piloted in four schools (two in Gauteng and KwaZulu-Natal). The test was used as a rehearsal for the TIMSS 2019 survey, and 500 learners participated. The test aimed to investigate how the items work, measure the reliability and validity of the questionnaire, and develop mitigation plans for any problem that may arise (Reddy et al., 2020).

2.16 Summary

This chapter outlined the methods and procedures used in the TIMSS 2019 survey. The chapter discussed the conceptual and assessment frameworks used by TIMSS as well as the achievement test and contextual questionnaire. The South African design of TIMSS in terms of sampling procedures and logistical and administrative aspects of the study was also presented.
The IEA developed TIMSS, and it is managed at Boston College in the United States by TIMSS and PIRLS International Study Centre. The main goal of the international study is to assist countries in evaluating and monitoring their science and mathematics teaching and learning, as well as learner achievement across different grades.

The TIMSS 2019 survey marked the seventh cycle of the international study. TIMSS assessment have been implemented every four years since the first cycle in 1995. The 2019 TIMSS survey was administered in 39 countries for Grade 8. South Africa was one of the few countries that administered the survey on Grade 9 learners. TIMSS collected extensive background information on school and home contexts in which teaching and learning occur. Participating countries use this information to improve educational policies.

The sampling unit at IEA Hamburg and Statistics Canada was responsible for handling the sampling procedures for the TIMSS 2019. IEA Hamburg was also responsible for overseeing data collection, processing, and analysis. The TIMSS and PIRLS International Study Centre and IEA Secretariat were responsible for overseeing the quality assurance programme and instrument translation and verification processes.

TIMSS used existing curriculums as a conceptual framework to organise concepts. The conceptual framework comprised three curricula: intended, implemented, and attained curriculum. The science assessment framework was developed around two dimensions (content and cognitive domain). The content domain specified the science content to be assessed, while the cognitive domain specified the thinking processing skills to be assessed.

Instruments used for data collection in the TIMSS 2019 were achievement tests and questionnaires that covered school, teachers, learners, curriculum, and home. The achievement test was the main instrument for data collection. Learners completed it under the supervision of the test administrators. The test was made up of multiple-choice questions and constructed response questions. Parents or guardians completed the home questionnaire, the principals completed the school questionnaire, and the NRC completed the curriculum questionnaire.

This chapter also discussed how quality data was collected, including procedures taken to ensure consistency in scoring constructed response items across countries to ensure the reliability of the results. The current chapter provided an overview of the TIMSS 2019 survey. The next chapter entails a literature review of studies conducted around academic performance by gender and self-efficacy.

CHAPTER 3

LITERATURE REVIEW AND THEORETICAL FRAMEWORK

3.1 Introduction

Gender differences in academic achievement are an international issue that many researchers worldwide have been investigating for years. Research showed that South Africa has generally achieved gender equity and equality in education regarding the enrolment of learners in school (Afrobarometer, 2019). However, the poor academic achievement of male learners when compared to their female counterparts in international studies remains a concern (Reddy et al., 2020).

International evidence shows that the relationship between gender and academic achievement is inconclusive, not only within countries but also across countries (Ruhle, 2022). In South Africa, educational achievements in relation to gender are complex and multidimensional and intersect with socioeconomic status and race (Reddy et al., 2020). Ruhle (2022) emphasised that most studies in South Africa are mostly focused on documenting achievement gaps by gender rather than identifying the root of the gender gaps in education.

A significant amount of research has been focused on the cognitive determinants of science achievement to improve the quality and increase enrolments. However, the role of non-cognitive psychosocial factors such as self-efficacy remains unexplored (Juan et al., 2018; Oosthuizen, 2021). Learners' self-efficacy strongly impacts their behaviour to succeed in a particular situation. According to Oosthuizen (2021), understanding learners' self-efficacy is a key component that needs to be considered when interpreting achievement results. In addition, enhancing the learners' self-efficacy is vital to their achievement puzzle.

This chapter explores the current gender gaps that affect equity and equality in education. The chapter also discusses the role of self-efficacy as a psychological factor that affects the academic performance of both males and females. The chapter concludes with a theoretical framework that serves as a guideline for data collection and data analysis processes.

3.2 Gender gaps in education

According to Delaney and Devereux (2021), two well-established gender gaps (achievement and career choice) affect equity and equality in education.

3.2.1 The first gender gap: Achievement

The first gender gap indicates a wide distribution of educational outcomes between males and females. On average, females tend to obtain higher educational attainments when compared to their male counterparts. The differences are mostly pronounced among learners who emerge from poor backgrounds (Delaney & Devereux, 2021; Van Broekhuizen & Spaull, 2017). Although evidence for mathematics and science achievement is not clear in relation to gender, reading results in most developed countries indicate that females do significantly better than males. According to the OECD (2019), females outperformed males in reading by 30 points on average across all 79 countries that participated in the PISA 2018.

In South Africa, considerable attention is focused on gender and education. The Grade 6 learners in South Africa participated in the SACMEQ IV survey project in 2013; this cross-national assessment revealed that male learners performed poorly compared to females (DBE, 2017). Reading results from the PIRLS 2016 survey in which Grade 4 learners in South Africa participated also showed that female performance was significantly higher by 50 score points (Mullis et al., 2017), equating to a year of schooling.

According to Spaull and Makaluza (2019), research has indicated that male learners are more likely to repeat grades, which may result in many males dropping out of school. Data from 2008–2018 shows that there have been fewer males reaching Grade 12. In addition, Spaull and Makaluza (2019) highlighted that the underrepresentation of males in Grade 12 has had serious implications when analysing the matric results by gender. Despite the low number of males reaching

Grade 12, matric results from 2008–2018 indicated that males had performed poorly in all subjects. Lindeque (2022) has also indicated that the recent Grade 12 results of 2021 reflected a higher female achievement than males.

3.2.2 Second gender gap: Career choice

There is growing international literature regarding female advantages in higher education (Van Broekhuizen & Spaull, 2017). However, the field of specialisation remains a concern (Juan et al., 2016). There are considerable differences in the fields of specialisation chosen by females and males. These differences are evident from secondary schooling and well-established at tertiary level. Males tend to be overrepresented in STEM-related courses, economics, and many other technical fields, while females are predominantly found in fields such as teaching, nursing, and many less technical areas (Delaney & Devereux, 2021).

Reports worldwide indicate that female graduates in higher education have increased in the past years (Sylvester, 2020). However, the low representation of females in STEM fields remains a concern as graduates are not necessarily enrolled in STEM programmes (Reddy et al., 2016). According to the UNESCO 2021 science report, female researchers account for 33.3% of STEM globally (UNESCO, 2021). This low representation of females in mathematics and science suggests that urgent attention should be paid to encouraging females to pursue STEM-related studies. In South Africa, females' representation in STEM fields is currently increasing. However, positions of leadership, power, and authority are still predominantly filled by males (Sylvester, 2020).

3.2.2.1 Factors perpetuating gender gaps in STEM

Gender-science stereotypes and career aspirations in STEM are the major contributing factors to females' interest in STEM (Makarova, 2019). Gender stereotypes regarding females' ability in STEM can limit females' future in STEM careers. According to Law et al. (2021), females are underrepresented in areas where success is associated with intellectual abilities, as these abilities are mostly associated with males. From the early ages of development, gender stereotype beliefs indicate that males are regarded as more intelligent than females in some STEM subjects (Mulvey & Irvin, 2018). Within the same age group, in the early stages of development, females may also consider males to be smarter than them (Law et al., 2021). Considering that female disengagement in STEM might arise from early ages, the focus should be on males and females from a young age to overcome the challenge of gender stereotypical beliefs.

In 2017, only 30% of STEM graduates were females across the OECD countries. Of the 30% of the graduates, 77% were based in health and welfare. It has also been reported that among the students enrolled in careers associated with STEM, females are more likely to switch and study something not related to science and mathematics (Delaney & Devereux, 2021).

3.3 Self-efficacy

Self-efficacy refers to individual's belief in their ability to achieve certain levels of performance or their belief in their ability to succeed in completing a specific task (Jamil & Mahmud, 2019). The level of self-efficacy of learners reflects the degree to which they believe they can achieve their academic goals (Baanu et al., 2016). According to Agustiani et al. (2016), self-efficacy influences learners' feelings, motivation, thinking, and behaviour. Not only does it play a role in how people feel about themselves, but it also plays a role in whether individuals can successfully achieve their goals. Meera and Jumana (2015) stated that a strong sense of self-efficacy improves the personal well-being and human accomplishments in different ways. Self-efficacy is considered an accurate predictor of academic achievement and an important non-cognitive skill that could enhance success in life (Meera & Jumana, 2015). Self-efficacy is an important supporting factor in learning because it could influence learning outcomes. Learners with high self-efficacy may believe they can complete all existing tasks, even if they are difficult. In contrast, learners with low self-efficacy may believe they cannot complete all the tasks involved in the learning process (Pratiwi & Hayati, 2020).

3.3.1 *Self-efficacy and academic achievement*

Albert Bandura introduced the concept of self-efficacy in the psychology field in 1977 (Sharma & Nasa, 2014). However, in this study, this concept will be used in the field of education. In education, self-efficacy is a major contributing factor to a learner's academic success. Academic self-efficacy strongly impacts the choices made by learners and the courses of action they pursue (Sharma & Nasa, 2014). Academic self-efficacy includes beliefs regarding the learner's ability to successfully complete academic tasks and learn the materials (Hayat et al., 2020). Learners' levels of effort and performance are impacted by their perceptions of their own academic self-efficacy (Agustiani et al., 2016). Self-efficacy is an important predictor of academic achievement and leads to an individual's excellence in performance through increasing commitment, perseverance, and endeavour (Hayat et al., 2020; Meera & Jumana, 2015). Learners with low self-efficacy levels tend to attribute their failures to low abilities, while those with higher self-efficacy levels attribute their failures to low attempts rather than lower abilities (Hayat et al., 2020).

Previous research on the impact of academic self-efficacy on learner academic performance has piqued the interest of many researchers. Many studies reported that academic self-efficacy is strongly related to learner academic performance. For example, Kolo et al. (2017) conducted a study on the relationship between academic self-efficacy held by college students and academic performance. A Pearson correlation analysis revealed a significant and positive relationship between students' self-efficacy beliefs and their academic performance. Juan et al. (2018) conducted a study that compared the self-efficacy of Grade 9 learners and their academic achievement in South Africa using TIMSS 2015 survey data. They found a positive relationship between the two constructs. Oyuga et al. (2019) also conducted a study that investigated the relationship between the academic achievement of orphaned secondary school learners in Kenya and self-efficacy. In their study, 300 learners were sampled following a saturated, simple random sampling design, and data was collected through learner questionnaires, interviews, and achievement tests. Their findings revealed a strong relationship between the two constructs. Similar findings were reflected in later studies, such as Jamil and Mahmud (2019) and Agholor (2019). They also reported that academic self-efficacy was strongly related to learner academic performance. Oosthuizen (2021) conducted secondary data analysis on TIMSS 2019 survey data for South Africa. In the analyses, self-efficacy data from the learner questionnaire was reused to investigate the effects of self-efficacy on learner achievement. Learners' responses to the self-efficacy items were merged to create a single self-efficacy scale with three levels. The results from the secondary analysis indicated that almost one out of every five learners had high levels of self-efficacy, while one out of every three had low levels. Regarding average science achievement, learners with higher self-efficacy academically performed better than those with lower self-efficacy. Learners in Grade 9 who had the highest levels of self-efficacy outperformed those with the lowest levels by 76 points, indicating a positive and statistically significant difference. This implies that, on average, learners were able to honestly assess their own abilities, which may be the first step toward determining what is necessary to improve their performance.

3.3.2 Gender differences in self-efficacy and academic achievement

Although studies had reported that self-efficacy is a strong predictor of performance outcomes (Agholor, 2019; Meera & Jumana, 2015), there have been conflicting reports about the relationship between gender, self-efficacy, and academic achievement. In a study of gender-related differences in self-efficacy and science performance, Gor et al. (2020) discovered that males had higher self-efficacy levels and outperformed females in science achievement. Lin and Tsai (2018) previously reported similar findings on Taiwanese high school learners regarding their self-efficacy and performance by gender. Jamil and Mahmud (2019) investigated the relationship between science achievement and self-efficacy among Malaysian national secondary school learners. A total of 85 male and 102 female learners participated in the study. Data was collected through a questionnaire and a test. A descriptive statistic based on gender revealed that the self-efficacy of female learners was higher and academically attained better results than male learners. Louis and Mistele (2012) conducted a secondary analysis of TIMSS 2007 results in mathematics and sciences in grade 8. Their findings revealed that male learners had low self-efficacy for science although their performance in the subject was higher when compared to females. Another study conducted in Greece by Schina et al. (2019) that focused on the role of gender in learners' achievement and self-efficacy as a conceptual framework to investigate learners' achievement in Scratch programming lessons. The study participants were 27 primary learners (15 males and 12 females) aged between 9 and 12. Data collected through an evaluation report and a learner questionnaire were analysed statistically. Their findings revealed that females had lower self-efficacy but outperformed their male counterparts in terms of achievement. These findings could not be generalised due to the limited sample. However, they can be used as a point of reference to indicate that high levels of self-efficacy do not always result in higher attainment of academic achievement. Variables such as self-efficacy may indicate differentiated effects depending on the type of task (Mutlu, 2022).

3.3.3 Self-efficacy and culture

Self-efficacy is a construct that is influenced by experience. Therefore, it is important to consider self-efficacy as an element of culture. Over the years, researchers have conducted cross-cultural studies on self-efficacy, investigating the differences in self-efficacy between individualistic and collectivistic cultures (Scholz et al., 2002).

Individualistic cultures prioritise the individual over the collective group. Individualistic cultures emphasise uniqueness or individuality, including personal goals, privacy, self-reliance, and self-sufficiency. Individualistic cultures are mostly observed in countries such as South Africa, Australia United Kingdom, and Western Europe. Collectivistic cultures prioritise the group over the individual. Asian cultures tend to be more collective, whereby people are mostly taught to work as a group rather than individually. Typical collectivistic cultures are found in countries such as South Korea, China, and Japan (MasterClass, 2022).

According to Scholz et al. (2002), studies investigating the relationship between culture and self-efficacy have indicated that people from individualistic cultures have high levels of self-efficacy. People from collectivistic cultures, such as Asian cultures, have been found to have low self-efficacy despite being academically successful. Scholz et al. (2002) highlighted that the academic success of Asian learners is driven by the fear of failure and disappointing their parents.

3.4 Theoretical framework

The current study utilised the self-efficacy theory of Albert Bandura. The theory suggests that academic self-efficacy may differ in strength based on the level of task difficulty, with some learners believing that they are more efficacious in challenging activities, while others only in simple activities (Sharma & Nasa, 2014). The theory emphasises the importance of individuals' perceptions of their capabilities as key determinants to successful outcomes (Ramachandran, 2012). Furthermore, self-efficacy is believed to be situational in nature rather than being seen as a stable trait (Sharma & Nasa, 2014). According to Bandura (1994), self-efficacy revolves around four main sources (mastery performances, vicarious modelling, verbal persuasions, and physiological responses).

Mastery experience refers to individual judgements of competence based on previous attainments in related tasks (Loo & Choy, 2013). Success in this area of self-efficacy builds a strong belief in personal efficacy. In an activity, mastery experiences build learners' efficacy beliefs for similar tasks in the future. Repetition of failure can result in low efficacy perceptions (Juan et al., 2018). Loo and Choy (2013), when investigating the effects of self-efficacy sources on engineering learners' academic performance, reported a significant correlation between mastery experiences and academic achievement. Oosthuizen (2021) also conducted secondary data analysis on the TIMSS 2019 survey for South Africa and reported a high percentage of mastery experiences compared to the other sources of self-efficacy amongst the learners in Grade 9.

Vicarious experiences concern observing the success and failures of others, such as peers, affecting one's perceptions towards similar tasks. When peers succeed in a particular task, it builds one's efficacy and belief that they can also compete successfully in similar tasks (Juan et al., 2018). Loo and Choy (2013) stated that vicarious experiences have low effect on self-efficacy than mastery experiences. However, when an individual is placed in an unfamiliar environment where prior experiences cannot be utilised to complete a task, observing other people performing the same task without adverse consequences can improve their efficacy in completing the task.

Social persuasions refer to feedback judgements and appraisals from significant others regarding one's engagement in related tasks. In this source of self-efficacy, constructive suggestions can change one's efficacy belief (Loo & Choy, 2013). When learners receive positive verbal feedback while performing or undertaking a task, it persuades them to believe they possess the skills to complete it. Influence is based on encouragement and discouragement towards performing the task (Juan et al., 2018).

Physiological experiences entail emotional arousals such as anxiety, composure, and fatigue that an individual experiences while undertaking a particular task, affecting their efficacy. High levels of emotional arousal debilitate individual performance (Loo & Choy, 2013). Learners' efficacy is influenced by emotional, psychological, and physical well-being (Juan et al., 2018). In addition, Loo and Choy (2013) stated that environmental factors influence how an internal state is interpreted. Individuals' sense of efficacy may differ depending on the situational factors and the meaning given to them.

Mastery experiences are the result of learners engaging in science activities. When learners interpret the outcomes of the activities and use the interpretations to develop beliefs about their capacity and capabilities to perform the activities, success in the outcomes influences confidence. Vicarious experiences are more influenced by learners observing their peers conducting science tasks and evaluating their prospects of success on similar tasks. Social modelling is more concerned with other people's judgements on the capabilities of the learners. Positive persuasion promotes positive belief in capabilities and goal attainment. Physiological arousals are developed when the learners are engaged in science tasks. It involves anxiety, excitement, or stress. The level of confidence in the learners is gauged by their physical state while engaged in the task (Juan et al., 2018).

Studies discussed in this chapter have reported that higher self-efficacy levels are associated with academic achievement. The current study investigated the effects of overall self-efficacy on the academic achievement of Grade 9 male and female learners in South Africa who participated in the TIMSS 2019 survey.

3.5 Summary

This chapter provided detailed literature regarding self-efficacy and science achievement in relation to gender. It has been reported that the relationship between academic achievement and gender is inconclusive both within and across countries. In South Africa, gender differences in academic achievement are associated with race and socioeconomic status (Reddy et al., 2020). Delaney and Devereux (2021) outlined two gender gaps currently affecting equality and equity in education. In the first gender gap, females tend to attain higher results than males in science and mathematics.

Furthermore, in the second gender gap, females tend to move away from STEM-related fields. The low representation of females in STEM fields has raised many concerns worldwide. Subsequently, more focus has been directed on finding ways to encourage females to consider following careers in mathematics and science fields.

This chapter also discussed the impact of learners' beliefs in their abilities and capabilities towards academic performance. Most studies focus on the cognitive determinants of academic achievement rather than the non-cognitive determinants, such as self-efficacy, that also impact learners' achievement. Researchers have found that learners' perceptions of their own abilities to succeed in school are highly predictive of their actual performance.

The chapter concluded with a theoretical framework. Bandura’s theory of self-efficacy was adopted as a framework to govern the current study. The framework highlights the importance of learners' belief in their own abilities to succeed in school. According to the theory of self-efficacy, learners who possess high levels of self-efficacy are reported to attain better academic achievement when compared to those with low levels. The current study utilised this theory to investigate gender-related differences in self-efficacy and their effects on the academic achievement of Grade 9 learners in South Africa. The theoretical framework will focus on specific variables in the data collection and analysis process in Chapter 4, which deals with research design and methods.

CHAPTER 4

RESEARCH DESIGN AND METHODS

4.1 Introduction

This chapter outlines the design and methods deployed in this study. The chapter describes how TIMSS data from the 2019 survey were used for secondary analysis purposes. A detailed discussion of the research methods is also provided in this chapter. The research design for the current study will be discussed from a philosophical point of view, including the advantages and disadvantages of secondary data analysis. This chapter describes how information from the TIMSS 2019 technical report and user guide was used in the current study for data analysis. The information describes how the participants and sample were selected and the instruments used in the data collection process. The chapter will conclude by describing the ethical concerns that must be considered when embarking on data analysis.

4.2 Research design

A research design is a plan used to guide the study to collect and analyse data. It involves selecting participants, the research site, and the data collection procedure to answer the research questions (Maree, 2012). In this study, South African data collected for the TIMSS 2019 by the IEA was used for secondary data analysis.

4.3 Research design approach

4.3.1 Post-positivism paradigm used in the current study

The term "paradigm" refers to a specific way of thinking about how certain problems exist, accompanied by agreements about how such problems can be solved. Every researcher understands what knowledge is and what is truth, shaping how the researcher views the world (Kamal, 2019). The current study followed a post-positivist paradigm. Post-positivists assume that reality is subjective, multiple, and mentally constructed by people. Researchers following this philosophical point of view note that reality is not fixed and is influenced by context (Maree, 2007). Post-positivist thinkers focus on searching for reliable and valid evidence in terms of the existence of phenomena rather than generalisations. Researchers who use post-positivist assumptions follow critical-realist ontology, believing that reality exists but cannot be fully understood (Nel, 2020). According to Henderson (2011), the post-positivism paradigm agrees that all measurements contain a degree of error and encourages using multiple observations and measurements in a quantitative study. Researchers working within a post-positivism paradigm are regarded as data collection tools. They cannot know everything since not everything is knowable.

The post-positivism paradigm provided a philosophical framework on which the current study was based. The paradigm offered patterns of understanding and beliefs that this study operated on.

4.4 Methodology

Methodology concerns how researchers systematically design a study to ensure the reliability and validity of the results and also addresses the research aims and objectives (Jansen & Warren, 2020). According to Maree (2012), research methodology indicates the strategies used during sampling, data collection, data documentation, and analysis processes. The current study used a quantitative secondary data analysis design to analyse data collected for the TIMSS 2019 survey.

4.4.1 Quantitative research

Quantitative research is a deductive approach to research. Researchers who follow this approach regard the world as being outside of themselves and objective reality as independent of any observations (Almalki, 2016). In quantitative research, numerical data is collected and statistically analysed to investigate patterns and averages, test relationships, make predictions and generalise results to the entire population (Bhandari, 2022). According to Apuke (2017), quantitative research methods involved explaining phenomena using numerical data that was analysed following statistical techniques.

Objectivity in quantitative research requires the data and results to be independent of the personal judgements of the researcher. Therefore, following a quantitative approach requires the researcher to faithfully represent the collected data without distorting it through biases and prejudices. As a public account, research reports must not be deceptive but honest. Reporting truthfully and honestly indicates that the researcher acknowledges the study's limitations, which could improve the study's objectivity. Public accounts are required to assume a reciprocating form. In this way, the researcher needs to keep in mind that the findings of the study are addressed to people who might disagree or agree with them. The researcher should also note that the findings might invite criticisms that need to be examined. Acknowledging other people’s criticisms enables the researcher to reflect on the research process and findings from a different point of view (Bird, 2020).

According to Bird (2020), researcher findings as public accounts ought to be rational. This means that the research findings must be reasonable and intelligible for others to question, comprehend, criticise, or support the results. Rational reports allow for the exchange of ideas and full interaction among the people who might support or disagree with the results. Accommodating other people’s criticism and concerns about the research findings may improve objectivity.

4.4.2 Secondary data analysis design

Secondary data analysis involves using data that has already been collected through primary sources and is made available for other researchers to utilise for their own research. The use of existing data provides the researcher access to high-quality datasets. It eliminates the time-consuming steps of developing instruments to collect data, which is a viable option for researchers with limited resources and time (Johnston, 2014). Secondary data allows the researcher to test new ideas, frameworks, theories and models. The challenge with secondary data is that the data sets do not contain school identifiers due to the confidentiality of participants. Therefore, the researcher cannot contact the participants for follow-up questions to collect additional data. Secondly, since the researcher was not part of the data collection process, the researcher is unaware of how the process was done and whether the data was affected by respondents' misunderstanding of specific questions in the survey. This forces the researcher to find the information through technical reports, documentation of data collection procedures and publications (Johnston, 2014).

For this study, quantitative data from the TIMSS 2019 survey obtained from learner questionnaires was reused to investigate the role of self-efficacy on science achievements between male and female learners in Grade 9.

4.5 Population for the current study

The target population in this study was Grade 9 learners in South Africa who took part in the TIMSS 2019 survey.

4.6 Sample size

The sample for this study was 20 829 Grade 9 learners from 520 schools. These learners wrote the achievement test and completed the learner questionnaire for the TIMSS 2019 (Reddy et al., 2020).

4.7 Data collecting instruments used in this study

The instruments used in the current study included the following:

- Learner questionnaire – the questionnaire was completed by the Grade 9 learners who wrote the TIMSS 2019 achievement test.
- Teacher questionnaire – the questionnaire was completed by the teachers who offered science in Grade 9 and whose learners participated in the TIMSS 2019 survey.
- Achievement test – learners completed booklets based on the matrix selection of items where plausible values were derived for science scores.

The theoretical framework established in Chapter 3 was used to choose the variables to be analysed for the current study. Data from the learner questionnaires were used to investigate the relationship between gender differences in self-efficacy and academic achievement amongst Grade 9 learners in South Africa.

From the learner questionnaire, three predictors (gender, spoken language of the test at home, and self-efficacy) were selected as well as their response options on a Likert scale (see ANNEXURE B). The home resources variable is a scale created by the IEA from items in the home questionnaire. The lack of instructional resources is another IEA scale; items can be found in the teacher data.

4.8 Data analysis

Data analysis involves collecting, modelling, and analysing data to gain insight that supports decision-making (Calzon, 2021). This study utilised the Statistics Package for Social Sciences (SPSS) V-28.0.1.0 and the IEA International Database (IDB) Analyzer (V-5.0.5) to calculate the descriptive and inferential statistics when analysing data from the TIMSS 2019 survey. According to Juan et al. (2018), the IDB Analyzer is an SPSS plug-in. It was mainly developed to analyse IEA survey data. The IDB Analyzer turns the data from the sampling design into SPSS syntax that can be used to calculate statistics and their standard errors. The SPSS syntax estimates achievement scores and related standard errors using plausible values (Fishbein et al., 2021). According to Howie et al. (2017), the IDB Analyzer applies population weights to ensure that the percentages obtained represent the intended population. Applying sample weights provides statistical summaries that represent the overall population from which the sample was drawn.

4.8.1 Descriptive statistics

Descriptive statistics summarise and organise data (Maree, 2007) in a way that describes the relationship between variables in a population or sample or shows counts and frequencies of variables (Bhandari, 2022). Descriptive statistics allows researchers to describe the data contained in many scores with few indices (Fraenkel et al., 2012). This study used descriptive statistics to show how the Grade 9 learners responded to the selected items in the learner questionnaire. The summary of the responses was used to develop a general picture of the learners' beliefs in their capabilities towards science and to describe the background variables and average science scores.

In order to conduct the descriptive statistics, the researcher studied the codebook from the TIMSS 2019 user guide. The codebook provided a complete description of the variables used in the database. Following the descriptions, the researcher only selected variables that applied to the current study for South African learners in Grade 9. The descriptive statistics in the current study were obtained from TIMSS 2019 survey items selected from the learner questionnaire using SPSS syntax that the IDB Analyzer generated. The SPSS syntax was used to generate basic information about the variables in the datasets and highlight the potential relationship between gender and self-efficacy through percentages, means and standard deviations.

4.8.2 Inferential statistics

Inferential statistics allow a researcher to make inferences or generalise observations about the population based on the findings from the sample (Fraenkel et al., 2012). Inferential statistics are used to determine the probability of the population based on the properties of the sample.

Hypothesis testing as it applies to the current study. Hypothesis testing is a process whereby the research starts with beliefs or ideas about the properties of some of the study variables. The beliefs or ideas are then tested for credibility based on a sample's information. At the end of hypothesis testing, the researcher should be able to reach conclusions that reflect on the likelihood of the ideas or beliefs of the researcher regarding what is true in the population under study (Maree, 2007).

In the current study, the following models of inferential statistics were used:

1. Factor analysis – used to investigate whether the items in the self-efficacy scale from the learner questionnaire measured one or more factors in the TIMSS 2019 survey.

2. Multiple linear regression analysis – used to measure the relationship between predictors (self-efficacy, home resources, gender, spoken language of test at home, and classroom resources) and the outcome variable (science achievement).

4.8.2.1 Factor Analysis

According to Yong and Pearce (2013), factor analysis is a data reduction method that can be used to reduce large datasets that consist of several variables into descriptive categories. Factor analysis is based on the notion that observable and measurable variables can be reduced to fewer unobservable latent variables with similar variance. The current study used Principal Component Analysis (PCA) to reduce multiple items from the TIMSS 2019 datasets into functional constructs. PCA is a technique used to reduce large datasets while minimising information loss. This method creates new uncorrelated variables that maximise variance (Jolliffe & Cadima, 2016).

Field (2018) states that a factor should be made up of three or more items. In the learner questionnaire, there were only eight items relating to self-efficacy. These items were used in the PCA to develop the self-efficacy construct to be used in the regression model.

The factor analysis was interpreted by examining the factor loadings. Factor loading is a correlation between the factor and the item (Tavakol & Wetzel, 2020). Factor loadings indicate how much a variable contributed to the factor. Larger factor loadings show that the variable has contributed more to that factor (Yong & Pearce, 2013). According to Watkins (2018), the common factor and measured variable correlations range from $-1.00 \text{ to } +1.00$. Yong and Pearce (2013) stated that factor loading below .30 should be considered unacceptable as they suggest a poor relationship between the variables. In the current study, factor analysis was used to investigate whether the loadings justified the creation of a new construct. The factor loadings for all the items were generated using SPSS. These loadings indicated how strongly each item is correlated with the factor. For this study, loadings higher than

.7 were considered acceptable. The Cronbach's alpha was included in the results, and an alpha above .700 was deemed acceptable for scale cohesion.

4.8.2.2 Missing data

Missing data are data values that are not stored for a variable in the observation of interest (Kang, 2013). Large-scale studies have missing data, especially when data was collected through questionnaires. The length of a questionnaire might make the respondent feel that it demands too much of their time and end up being discouraged from completing all the sections (Myers, 2011; Neuschmidt, 2019. Furthermore, people may not want to answer certain questions or fail to return the questionnaire. Missing data can reduce the statistical power of a study and result in biased estimates, which could lead to invalid conclusions (Kang, 2013).

According to Mack et al. (2018), missing data are grouped into three categories: Missing completely at random, missing not at random, and missing at random.

- Missing completely at random (MCAR): In this category, the missing data has no relationship with any predictor variables. When data are MCAR, it implies that the probability of missing values is constant for all the cases.
- Missing not at random (MNAR): Missing values are systemically related to the unobserved data. This is in the case where the missing data relates to factors not measured by the researcher.
- Missing at random (MAR): Missing values are systemically related to observed data. The probability of missing data is the same within groups in the observed data.

The IDB Analyzer provides two ways to handle missing data when conducting data analysis. In the first option, specific missing values can be deleted from the analysis through pairwise deletion. Another option to handle missing data can be done through listwise deletion, whereby the whole record can be deleted when there is a single missing value. The listwise deletion was used in the current study to eliminate missing data. Only cases with complete data were used when analysing TIMSS 2019 survey data. According to Kang (2013), listwise deletion can produce unbiased estimates when the assumptions of the MCAR are satisfied or less than 5% of cases are missing.

4.8.2.3 Multiple linear regression analysis

Multiple regression analysis uses several exploratory variables to predict the outcomes of a response variable. The primary objective of using multiple regression analysis is to model the linear relationship between response (dependent) variables and exploratory (independent) variables (Hayes, 2022). In multiple regression analysis, the independent variable is used to predict the value of the dependent variable. In the current study, multiple linear regression analysis was utilised to investigate the correlation between the predictor variables (self-efficacy, home resources, gender, speaking the language of the test at home, and classroom resources) and the response variable (overall science achievement). To investigate the overall strength of self-efficacy's relationship with science achievement, a general multiple linear regression model was run wherein gender was included. Thereafter, a model for males and females was calculated. Creating three models allowed the researcher to compare the strength of self-efficacy when controlling for gender in the general model and to identify the differences between males and females when the models were split.

The multiple linear regression analysis was conducted using the IDB Analyzer. Before the analysis was done, the researcher had to confirm three assumptions of multiple linear regression models from the data for the results to be reliable and valid. The first assumption was to ensure that the relationship between the dependent and independent variables was linear. This was done through correlation tables. Secondly, the researcher had to ensure no multicollinearity in the data. This was done because predictors should not be overly correlated with one another. A collinearity diagnostic test was conducted to confirm the assumption of no multicollinearity. The third assumption involved ensuring that the values of the residuals were independent. To satisfy this assumption, a Durbin-Watson statistics test was conducted to ensure that individual data points were not correlated.

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The TIMSS 2019 regression coefficient outputs are weighted and unstandardised, and $40-50$ score points indicate a year of schooling or a moderate effect size. In this study, dummy coding was used in the IDB Analyzer to overcome problems associated with categorical indices. A dummy variable is a number that represents categorical data, such as gender. According to Field (2018), dummy coding is used to represent a group of people using zeros and ones. The IDB Analyzer uses dummy codes to convert categorical variables into dichotomous variables. Also, dummy coding compares each variable category to the reference variable. The lowest category was used as the reference category in this study. The results compared each category to the reference category.

4.8.2.4 Use of plausible values

The multiple regression analysis involved using plausible values developed for the TIMSS 2019 survey. The plausible values represented the performance of an individual learner on the whole science assessment in case each learner was required to answer all the science items in the assessment. As indicated in Chapter 2, TIMSS used five plausible values to keep the burden on each learner at a minimum by administering a minimal number of assessment items to each learner. The number of items in the assessment administered to each learner was enough to produce accurate group content-related scale scores for sub-groups of the population. During the scaling process, the scores were transformed into plausible values to characterise learners taking part in the assessment while considering their background information. Plausible values cannot be seen as test scores but as imputed values. When used as a group, they provide unbiased estimates of the learner population characteristics (Martin et al., 2020).

4.9 Summary

This chapter focused on the research design, methods, and procedures used in this study. A post-positivist paradigm was used as a philosophical framework to guide the study. This paradigm assumes that social reality is knowable and measurable. The study used a quantitative secondary data analysis design. Secondary data from the TIMSS 2019 survey for South Africa was used to investigate the role of self-efficacy on science achievement amongst male and female learners in Grade 9.

Since this study was a secondary data analysis, there was no data collection stage. Data collected through the achievement test and learner questionnaire were made publicly available by TIMSS to be reused by other researchers for their own studies.

This chapter described how data was analysed through the IDB Analyzer, a software developed by the IEA to analyse TIMSS survey data. Descriptive statistics and inferential statistics were used as methods to analyse the data. In the descriptive statistics, data were summarised using the SPSS syntax generated by the IDB

Analyzer to develop a general picture regarding the variables in the data sets and highlight any potential relationship between variables. The inferential statistics used factor analysis to create constructs to check whether selected items were sufficiently related. A multiple linear regression analysis was utilised to investigate the extent of the relationship between gender differences in self-efficacy and science achievement in Grade 9 learners in South Africa when controlling for background factors such as classroom resources and home resources. The next chapter of this study focuses on the results from the data analysis process.

CHAPTER 5

FINDINGS AND RECOMMENDATIONS

5.1 Introduction

This chapter encompasses a detailed presentation of the results of the current study. The results will provide an overview of the relationship between self-efficacy and academic achievement of Grade 9 male and female learners who took part in the TIMSS 2019 survey. The current study's findings will be presented in three sections: 5.2 descriptive statistics, 5.3 data processing, and 5.4 multiple linear regression models. As indicated in Chapter 4, descriptive statistics were used to summarise and organise the data. The data processing included reducing data into descriptive categories that were used in the regression models. This chapter starts with presenting the descriptive statistics of the relevant variables utilised in the linear regression models.

5.2 Findings – Descriptive statistics

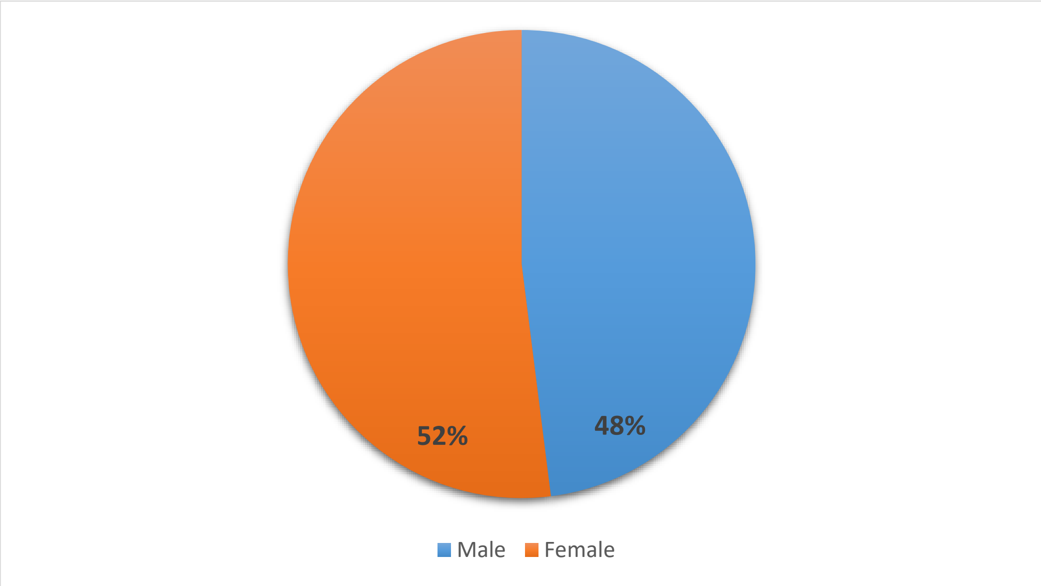
The descriptive statistics in this study relate to the learners' weighted responses to each category of a chosen variable. The IDB Analyzer was used to generate the weighted percentages and mean scores for the plausible values (PVs).

5.2.1 Gender

Figure 5.1 shows the percentages of learners by gender who participated in the TIMSS 2019 survey.

Figure 5.1

Percentage of male and female learners in the study



There were more female learners in the TIMSS 2019 survey than males. In the study, 52% $(n = 11067)$ of the participants were females. Male learners accounted for 48% $(n = 9719)$. The number of male learners was 2% less than that of females. However, the gender of the selected learners was weighted to represent the population from which the sample was taken. In this regard, there was no gender bias.

Table 5.1 shows the difference in mean scores for science achievement between female and male learners.

Table 3.1

Mean scores of science achievement by gender

Gender	Mean PV	SE	*t*-value
Females	376	3.17	2.81
Males	364	3.58	

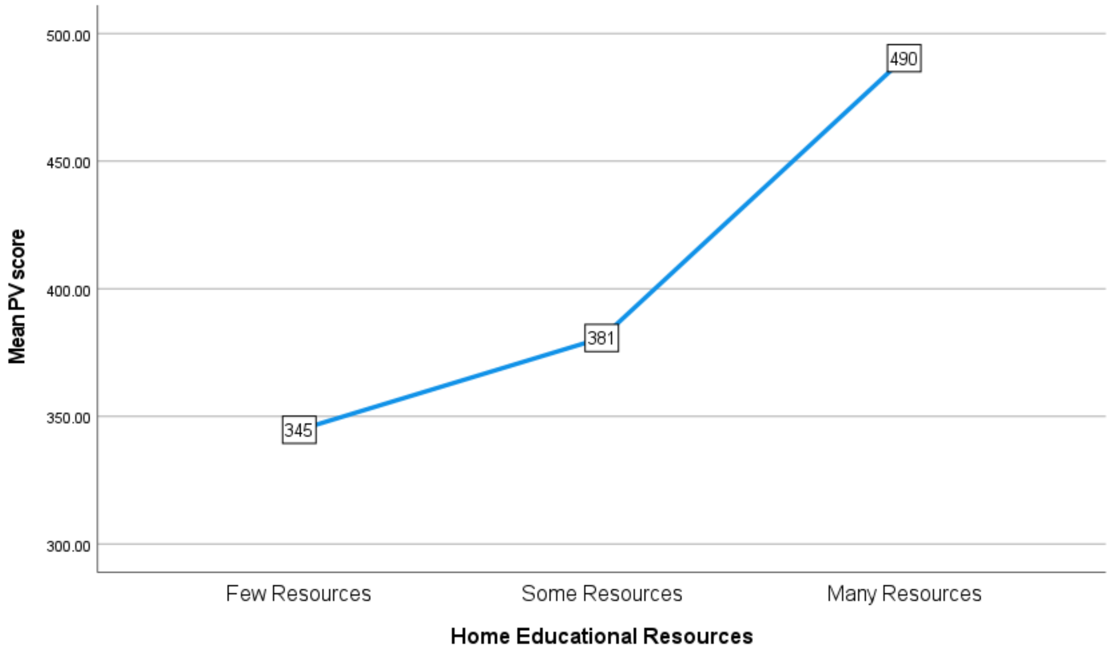
The mean scores for science achievement between males and females reflected a statistically significant difference of $t = 2.81$. The mean difference between the two genders showed that female achievement was significantly higher.

5.2.1.1 *Home Educational Resources*

The questionnaire requested learners to indicate the availability of resources at their homes, such as internet connection, number of books, and whether the learner had his or her own room. A scale was derived by the IEA, and three categories were generated based on the cut points identified. Figure 5.2 represents the different categories of home resource availability created by the IEA.

Figure 5.2

Different categories for home educational resources

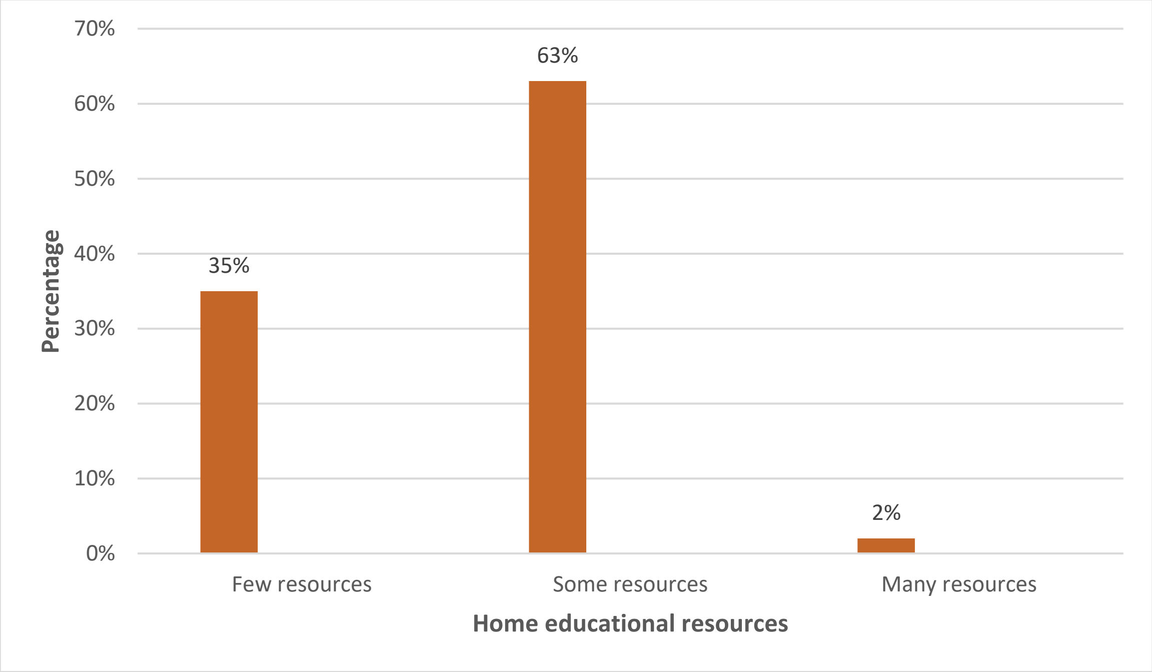


Learners from homes with many educational resources had a higher mean score $(490, SE = 10.52)$ than those with few resources $(345, SE = 3.62)$. This difference indicated that learners from homes with many educational resources had an advantage of three years of schooling ahead of those with few resources. Figure 5.3

shows the percentage of learners across the three categories for home educational resources.

Figure 5.3

Learner percentage across the categories for home educational resources



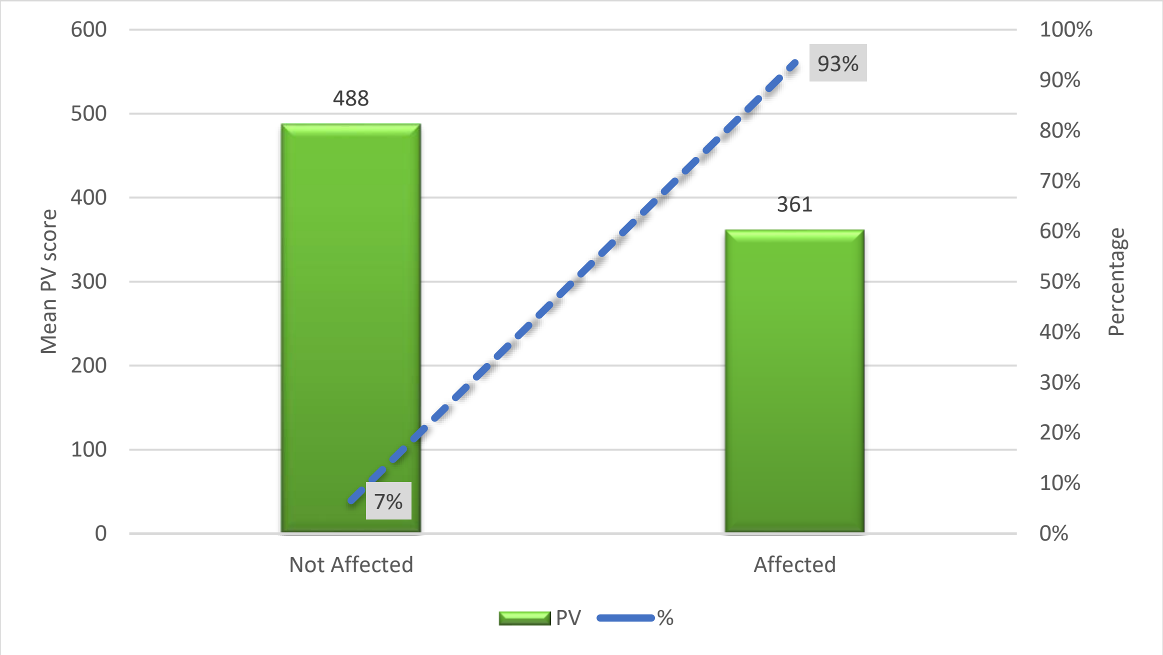
From the data presented in Figure 5.3, 63% $(n = 12\,981)$ of the learners came from households with some resources. In comparison, 35% $(n = 7\,042)$ came from homes with fewer resources. Only 2% $(n = 599)$ of the learners come from households with many educational resources. These findings indicate that most South African learners come from disadvantaged backgrounds.

5.2.1.2 Instruction resources

Educators completed the teacher questionnaire, requesting them to indicate whether they were affected by a shortage of science resources. The results are shown in Figure 5.4.

Figure 5.4

Instructions affected by science resources



Most teachers (93%) reported being affected by the shortage of instructional resources for science. Only 7% of the Grade 9 teachers reported having access to adequate resources. Learners whose teachers indicated not being affected by instructional resources for science had a mean score of $488\ (SE = 22.04)$. Therefore, the achievement of the learners whose teachers reported not being affected by a shortage of resources can be expected to be 127 points higher than for those teachers whose teaching was affected.

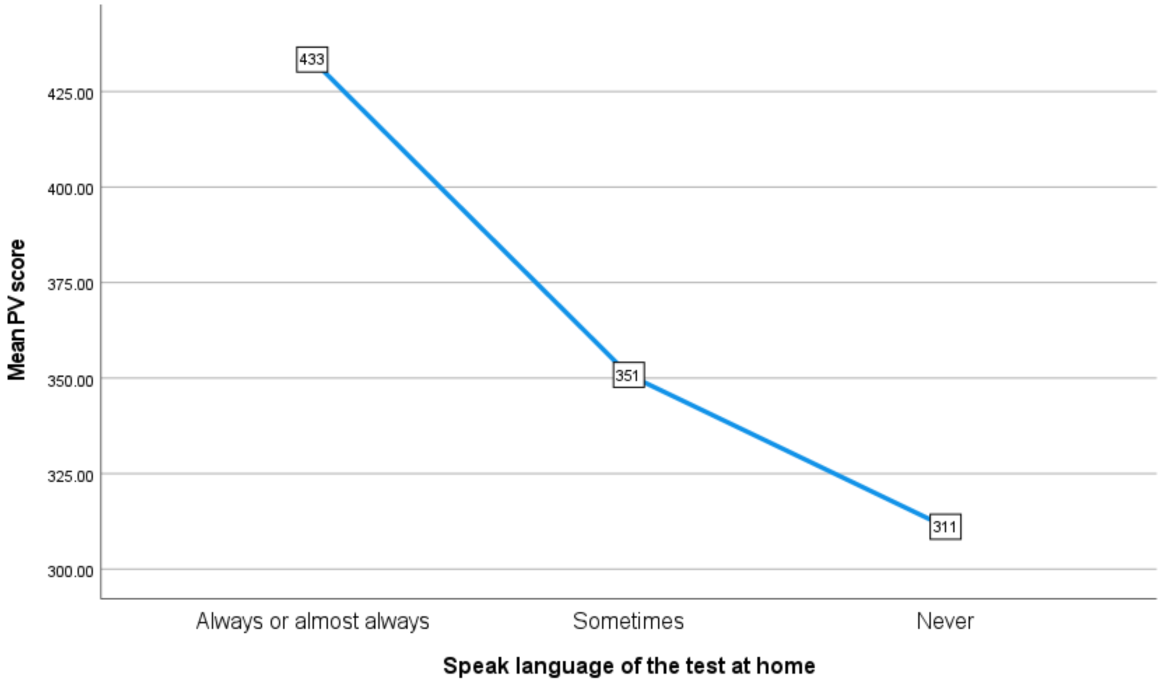
5.2.1.3 Language of the Test

In South Africa, the language of teaching and learning is either English or Afrikaans after Grade 3. When learners speak the language of the test (LoT) at home, they tend to understand the test better than those who hardly or never speak the LoT.

Figure 5.5 represent the mean scores of learners who speak either English or Afrikaans at home.

Figure 5.5

Learners speaking the language of the test at home



Learners who always or almost always speak the language of the test at home can be expected to have a higher mean score of 433 $(SE = 3.94)$. This is 122 points more than those who use any language other than English or Afrikaans. Therefore, learners who always use the language of the test tend to be ahead of those who never use the language by three years of schooling (40 – 50 points equate to a year of schooling). Table 5.2 shows the percentage of learners who speak the language of the test at home.

Table 5.2

Percentage of learners speaking the language of the test at home

	N	Percentage
Always or almost always	7533	27.6%
Sometimes	11784	64.6%
Never	1283	7.7%

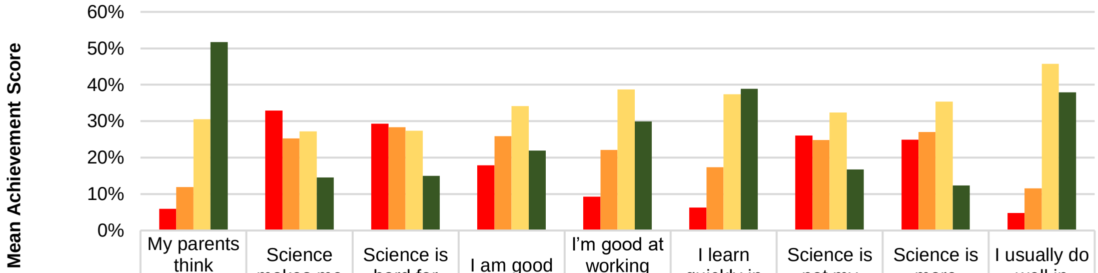
The majority of the learners (64.6%) in Grade 9 reported that they sometimes use the language of the test at home. Only 7.7% of the learners said they never spoke the language of the test at home. A study by Geide-Stevenson (2018) revealed that English proficiency positively impacts learners' academic performance when they write tests in English. Learners who always use the language of the test at home accounted for 27.6% $(n = 7\,533, SE = 0.89)$, indicating that more than two-thirds of learners may have been at a linguistic disadvantage.

5.2.1.4 Self-efficacy questionnaire items

Part of the questionnaire (Question 24) completed by the learners asked them about their perceptions towards science. The learners were given response options on a Likert scale (disagree a lot, disagree a little, agree a little, agree a lot). These were scored based on their responses to the self-efficacy statements. The results are shown in Figure 5.6.

Figure 5.6

Percentages of learner's responses to self-efficacy statements



	My parents think sciences is important	Science makes me confused	Science is hard for me	I am good at science	I'm good at working out science problems	I learn quickly in science	Science is not my strength	Science is more difficult	I usually do well in science
Disagree a lot	6%	33%	29%	18%	9%	6%	26%	25%	5%
Disagree a little	12%	25%	28%	26%	22%	17%	25%	27%	12%
Agree a little	31%	27%	27%	34%	39%	37%	32%	35%	46%
Agree a lot	52%	15%	15%	22%	30%	39%	17%	12%	38%

Disagree a lot   Disagree a little

When combining the results for 'agree a little' and 'agree a lot', the results showed that statements with positive responses were 'I learn things quickly in science' (76%), 'My parents think it is important to do well in science' (83%), and 'I usually do well in science' (84%). Only 42% of the learners experienced a negative physiological state when doing science. These learners reported that science confused them and was difficult compared to other subjects. More than half (56%) of the learners received favourable judgements from their teachers regarding their abilities and capabilities towards science. These findings indicated that teachers, as sources of social persuasion, play an important role in the academic performance of the learners.

5.2.1.5 Self-efficacy scale

The self-efficacy scale the researcher created based on four of the nine items was divided into two categories: more and less self-efficacy. Table 5.3 represents the scale created for self-efficacy.

Table 5.3

Self-efficacy scale created by the researcher

	N	**Percentage**	**Percentage (s.e)**

Self-efficacy	More	5105	24.94	0.61
	Less	15009	75.06	0.61

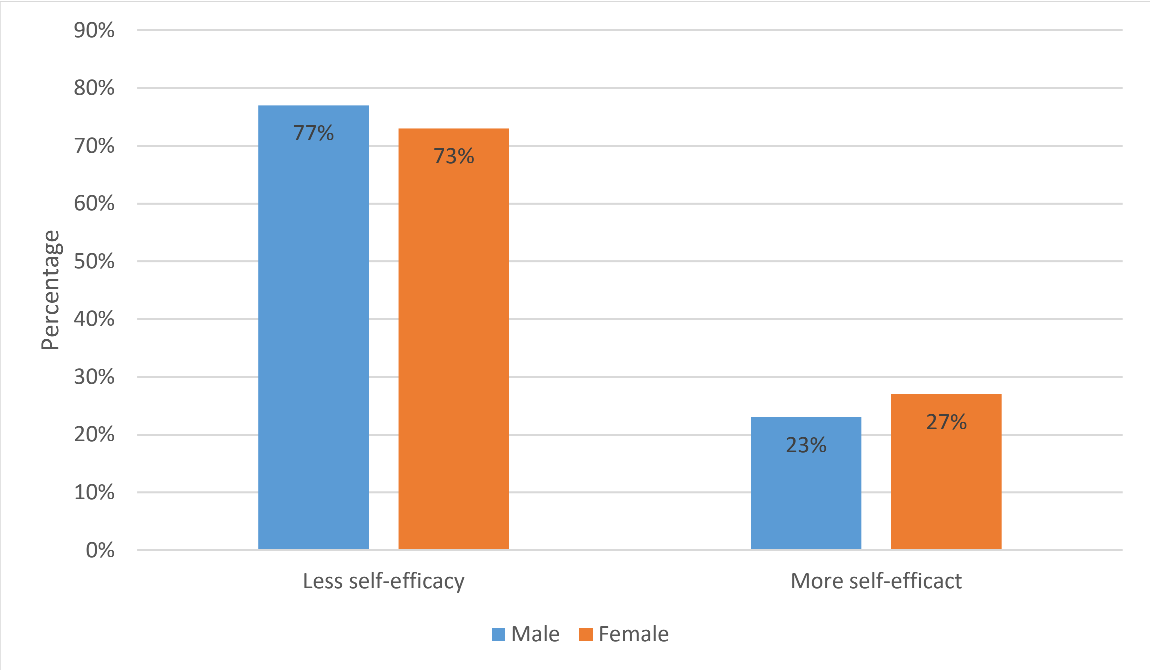
From the scale created by the researcher, the category for less self-efficacy was higher (75%) than that of more self-efficacy (25%).

5.2.1.6 Self-efficacy scale by gender

Figure 5.7 represents the self-efficacy scale for male and female learners.

Figure 5.7

Self-efficacy scale by gender



In total, 77% of males reported less self-efficacy, which was higher by 4% compared to females, and the difference was statistically significant (t = 7.22). In the category of more self-efficacy, females reported a total of 27%, which was higher than males by 4%. However, this difference was not significant (t = 1.47).

5.3 DATA PROCESSING

Once the descriptive statistics were completed, the researcher created scales for the factor analysis.

5.3.1 Scales – IEA and researcher created

The IEA grouped items from the highest level of education of either parent, the number of home study support, and the number of books at home to create a scale for home educational resources. The IEA also grouped items from science instructional resources and general school resources to create a scale for instruction affected by science resources.

5.3.1.1 Scales created by the IEA

ANNEXURE C represents the scales created for the home educational resources scale. The scale had three categories which were differentiated by the scale cut score ranging from few resources to many resources. The scale cut score between 'few resources' and 'some resources' was 8.4, while that of 'many resources' and "some resources' was 12.2 (Martin et al., 2020). ANNEXURE D shows the scale for instructions affected by the science resources scale. The scale was also divided into three categories, each with a scale cut score. The scale cut score between 'Not affected' and 'Somewhat affected' was 11.1. while 'Affected a lot' and 'Somewhat affected' were at 7.5 (Martin et al., 2020).

A reliability test for home educational resources and instructional resources was conducted. The Cronbach Alpha coefficients are shown in Table 5.4.

Table 5.4

Reliability test for home educational resources and instructional affected by science resources

IDCNTRY	**Predictor**	**N of items**	**% of variance**	Cronbach's Alpha
South Africa	Home educational resources	3	47	.42
	Instruction affected by science resources	13	36	.85

There were three items tested for reliability in the home educational resources. The coefficient for home educational resources was $.42$, and the amount of variance explained was 47%. In the instruction affected by science resources, 13 items were tested, and a coefficient output of $.85$ was obtained. Furthermore, the total variance explained was 36%.

5.3.1.2 Self-efficacy scale creation

Only four of the nine items were used in the scale creation after the factor analysis revealed two factors. To measure the internal consistency between self-efficacy items, a Cronbach's Alpha test was conducted as indicated in Table 5.5 to ensure the four items were internally consistent.

Table 5.5

Reliability test for self-efficacy items

Cronbach's Alpha	N of Items
.790	4

The results showed an acceptable reliability coefficient with a score value of $.790$. Table 5.6 represent the correlations between the four self-efficacy items.

Table 5.6

Correlations between self-efficacy items

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Science is more difficult for me	8.12	6.456	.589	.743
Science is not my strength	8.19	6.327	.564	.756
Science is harder for me	8.04	6.038	.648	.713
Science makes me confused	8.02	6.165	.595	.740

There was a high correlation between the self-efficacy items and the scale total. 'Science is more difficult' $(.743)$, 'Science is not my strength' $(.756)$, 'Science is hard for me' $(.713)$, and 'Science makes me confused' $(.740)$. All the self-efficacy items scored an alpha coefficient above .70 in the test, indicating an acceptable internal consistency.

5.3.1.3 Factor Analysis

A Kaiser-Meyer-Olkin (KMO) test was conducted for each item to measure the sampling adequacy in the self-efficacy construct. The test was used to determine the suitability of the data for conducting factor analysis (Nasaireh, 2020). The results are shown in Table 5.7.

Table 5.7

KMO for sampling adequacy

Kaiser-Meyer-Olkin	.781

The KMO revealed an acceptable value of .781, indicating that factor analysis can be performed on the items. Following the KMO test, a principal component analysis (PCA) was conducted. The results are shown in Table 5.8.

Table 5.8

Principal component analysis

	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component	**Total**	**% of Variance**	**Cumulative %**	**Total**	**% of Variance**	**Cumulative %**
1	2.458	61.440	61.440	2.458	61.440	61.440
2	.593	14.822	76.262			
3	.529	13.220	89.482			
4	.421	10.518	100.000			

The first factor explains 61% of the variance in this model for self-efficacy. Therefore, the percentage for the first component is acceptable as it is above the 60% threshold of the total variance explained.

A rotated component matrix was conducted to investigate the correlation between the variables and the estimated components. The results are shown in Table 5.9.

Table 5.9

Correlations between variables and estimated components

	Component	
	1	2
USUALLY DO WELL IN SCIENCE	.769	
LEARN QUICKLY IN SCIENCE	.787	
GOOD AT WORKING OUT PROBLEMS	.817	
I AM GOOD AT SCIENCE	.773	
PARENTS THINK SCI IMPORTANT	.537	
SCIENCE IS HARDER FOR ME		.827
SCI MAKES ME CONFUSED		.771
SCIENCE IS MORE DIFFICULT FOR ME		.779
SCIENCE NOT MY STRENGTH		.736

From the results, two components were obtained. The items in the first component had no discrimination power. The majority of the learners responded with “agree” or “agree a lot” to the items in the first component. Therefore, the results could not be used in a model. Only the items in component two were considered for the multiple linear regression model.

5.3.1.4 Missing data

Whenever data is collected through questionnaires, there is always a possibility of some questions not being answered. Missing data can have a serious effect on the conclusions that can be drawn from the data (Kang, 2013). It is vital to know the percentage of the learners who did not answer all the questions (missing values) because missing values could hinder the validity and reliability of the results (Cheema, 2014). Table 5.10 represents the descriptive statistics for the predictor variables concerning missing data.

Table 5.10

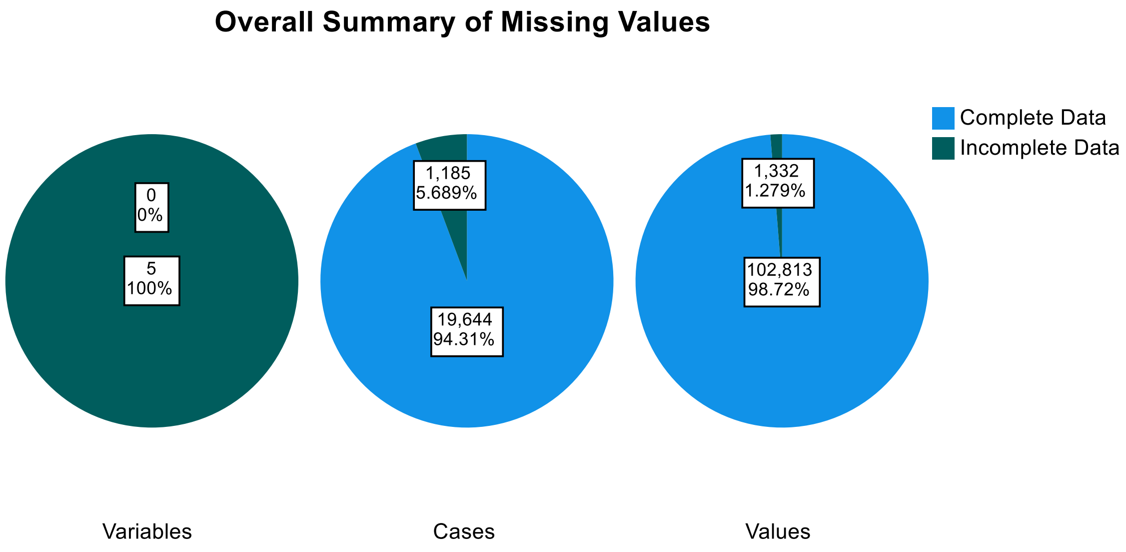
Descriptive statistics for missing data

	N	Min	Max	Mean	Std. Dev
Self-Efficacy	20114	1	2	1.25	.435
Instruction affected by Science Resources	20601	1	2	1.93	.250
Home Educational Resources	20622	1	3	1.69	.522
Gender of Learner	20786	1	2	1.47	.499
Speak language of the test at home	20690	1	3	1.70	.579
Valid N (listwise)	19644				

Out of 20 829, a total of 645 cases were missing listwise. The missing data comprised a small percentage of the entire data; therefore, the statistical power of the results for the current study was not affected. Figure 5.8 shows the overall summary of the missing data in the TIMSS 2019.

Figure 5.8

Overall summary of missing values



Only 1185 (5.7%) of the $20\,829$ cases were missing listwise. Missing values amounted to only 1.3% of the $104\,145$ values.

5.3.1.5 Assumptions of regression models

The linear relationship was assessed before the regression model was run to ensure the appropriate use of the predictors (Field, 2018).

Assumption 1: the linear relationship between predictors and science achievement

The assumption that predictors have a linear relationship with science achievement was assessed with the correlation matrix shown in Table 5.11.

Table 5.11

Correlation between predictors and outcome variables

		1ST PLAUSIBLE VALUE SCIENCE	Self-Efficacy	Instruction affected by Science Resources	Home Educational Resources	Gender of Learner	Speak language of the test at home
	1ST PLAUSIBL	1.000	.,186	-.342	.238	-.038	-.368

		1ST PLAUSIBLE VALUE SCIENCE	Self-Efficacy	Instruction affected by Science Resources	Home Educational Resources	Gender of Learner	Speak language of the test at home
Pearson Correlation	E VALUE SCIENCE						
	Self-Efficacy	.186	1.000	.014	.037	-.044	-.031
	Instruction affected by Science Resources	-.342	.014	1.000	-.189	.005	.203
	Home Educational Resources	.238	.037	-.189	1.000	.049	-.163
	Gender of Learner	-.038	-.044	.005	.049	1.000	.045
	Speak language of the test at home	-.368	-.031	.203	-.163	.045	1.000
Sig. (1-tailed)	1ST PLAUSIBLE VALUE SCIENCE		.000	.000	.000	.000	.000
	Self-Efficacy	.000		.026	.000	.000	.000
	Instruction affected by Science Resources	.000	.026		.000	.226	.000
	Home Educational Resources	.000	.000	.000		.000	.000

	1ST PLAUSIBLE VALUE SCIENCE	Self-Efficacy	Instruction affected by Science Resources	Home Educational Resources	Gender of Learner	Speak language of the test at home
Gender of Learner	.000	.000	.226	.000		.000
Speak language of the test at home	.000	.000	.000	.000	.000	

The results revealed that self-efficacy has a small but significant positive relationship with PV1. Instruction affected by science resources indicated a moderate and significant negative relationship with PV1. Home educational resources showed a significant positive relationship between PV1 and self-efficacy. The gender of the learners and speaking the language of the test at home was the only predictor that showed a significant negative relationship between self-efficacy and all the PVs.

Assumption 2: Independent errors

The residuals in terms of the predictors should be normally distributed with independent errors. When the errors are independent, their value will not be related to any other set of values of independent variables (Anderson et al., 2017). To satisfy this assumption, a Durbin-Watson test was conducted to detect autocorrelations of the residuals in the regression model. Table 5.12 shows the results of the Durbin-Watson test.

Table 5.12

Durbin-Watson test for predictor variables and outcome variables

R Square	Adjusted *R* Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
			R Square Change	*F* Change	df1	df2	Sig. *F* Change	
.261	.260	88.33	.261	1383.717	5	19638	.000	1.286

The Durbin-Watson test obtained a mean value of 1.286, indicating a positive correlation between the predictor and outcome variables. The values are lower than desirable but not to the point of concern as they are above the 1 threshold (independence of errors). The dependent variable was normally distributed, as shown in Figure 5.9 and Figure 5.10.

Figure 5.9

Histogram showing distributions of the dependent variable

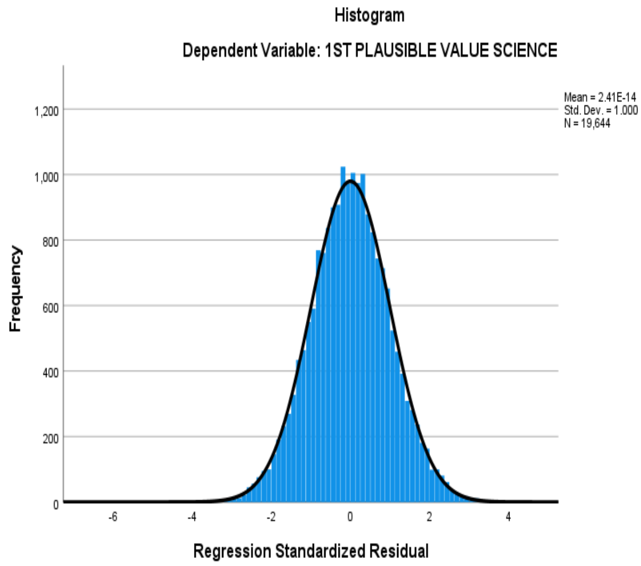
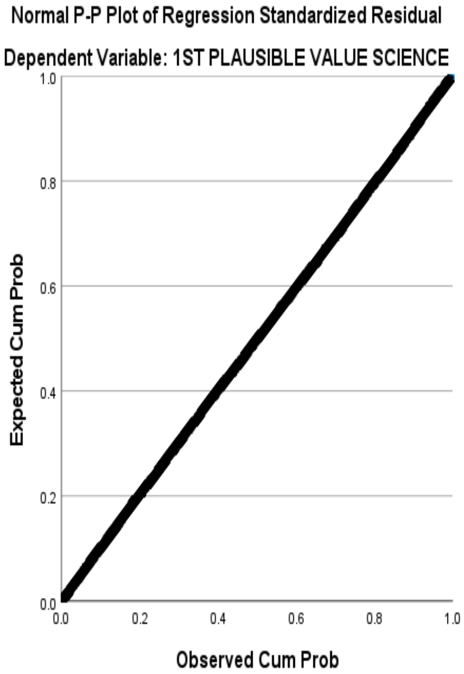


Figure 5.10

P-P plots showing distributions of the dependent variable



Assumption 3: No multicollinearity

The independent variables are not highly correlated with each other. According to Anderson et al. (2017), the predictor variables should not be too highly correlated, as the predictive power of the independent variables could be reduced. This assumption was tested using a correlation matrix. Table 5.13 represent the Variance Inflation Factor (VIF) values and correlation between the predictors.

Table 5.13

VIF values and correlation between predictors

95,0% Confidence Interval for B		Correlations			Collinearity Statistics	
Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
576.828	601.607					
38.263	43.949	.186	.198	.174	.995	1.005
-111.129	-100.997	-.342	-.281	-.252	.933	1.072
24.445	29.318	.238	.153	.133	.943	1.060

95,0% Confidence Interval for B		Correlations			Collinearity Statistics	
Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
-7.251	-2.277	-.038	-.027	-.023	.993	1.007
-53.006	-48.605	-.368	-.307	-.278	.939	1.064

The results showed that predictor variables were not highly correlated as they lacked multicollinearity. The VIF values (< 3) and correlations amongst predictors (< 0.7).

5.4 MULTIPLE LINEAR REGRESSION MODELS

The multiple linear regression analysis was conducted using three models. First is the general model for the total sample, followed by gender (male and female) models.

5.4.1 General model for the total sample

Since the variables have met the multiple linear regression analysis assumptions, the results are presented in terms of model functioning and the coefficients for each predictor. Table 5.14 represent the percentage of variance accounted for by the general model.

Table 5.14

Percentage of variance

IDCNTRY	*R*-squared	Adjusted *R*-squared	*R*-squared standard error
South Africa	.26	.26	.02

The amount of variance was $.26\ (SE = .02)$. The results indicated that 26% of the variance of the dependent variable (PVs) under study was explained by the independent predictors, a small but significant amount. After obtaining the variance explained by the model, IDB Analyzer was used to obtain multiple linear regression coefficients (see Table 5.15).

Table 5.15

Multiple linear regression coefficients for the general model

Description	*B*	beta	b.se	beta.se	b.t
(CONSTANT)	477 .52		16 .72		28 .56
Instruction affected by lack of Science Resources	-85 .75	-0 .21	18 .30	0 .04	-4 .68
Gender of Learner – Male	-7 .41	-0 .04	2 .21	0 .01	-3 .36
Sometimes Speak language of the test at home	-62 .56	-0 .29	4 .54	0 .02	-13 .78
Never speaking language of the test at home	-98 .99	-0 .26	7 .07	0 .02	-14 .01
Some Home Educational Resources	21 .51	0 .10	3 .25	0 .01	6 .62
Many Home Educational Resources	82 .00	0 .12	9 .86	0 .01	8 .32
More Self-Efficacy	43 .51	0 .18	2 .51	0 .01	17 .34

The results showed that all the predictors were significant $(t < -1.96;\ t > 1.96)$. Having more home educational resources can increase learners' achievement in science by 82 score points $(SE = 9.86)$. These results indicated that learners whose homes had many educational resources had a higher chance of obtaining better results. More self-efficacy was also found to have a significant relationship with learner achievement. Learners who had more self-efficacy could gain 43.5 score points $(SE = 2.51)$. Higher levels of self-efficacy are associated with higher academic attainments in the current study. Gender, instruction affected by science resources, and speaking the language of the test at home had a significant negative relationship with science scores. Although gender has a significant relationship with science achievement, the effect size is negligible (only 7 score points).

5.4.2 Model for males

Table 5.16 shows the percentage of variance for male learners.

Table 5.16

Model for male learners

IDCNTRY	*R*-squared	Adjusted *R*-squared	*R*-squared standard error	Adjusted *R*-squared standard error
South Africa	.24	.24	.02	.02

The amount of variance in the model for males accounted for 24% $(SE = 0.02)$. The results indicated that the predictors accounted for 24% of the science achievement. Table 5.17 represent the outputs of multiple linear regression from the IDB Analyzer.

Table 5.17

Multiple linear regression coefficients for males

Description	B	beta	b.se	beta.se	b.t
(CONSTANT)	465.96		21.09		22.09
Instruction affected by lack of Science Resources	-83.91	-.20	22.36	.05	-3.75
Sometimes Speak language of the test at home	-62.76	-.29	5.19	.02	-12.08
Never speak language of the test at home	-93.61	-.26	8.36	.02	-11.20
Some Home Educational Resources	23.32	.11	3.69	.02	6.32
Many Home Educational Resources	83.37	.12	12.24	.02	6.81
More Self-Efficacy	47.20	.19	3.40	.01	13.88

The presented results show that all the predictors were significant $(t < -1.96;\ t > 1.96)$ in the model for males. It has been shown that males from homes with many educational resources could gain 83.37 score points $(SE = 12.24)$ towards their science achievement, which is about a year and a half ahead of those with some home educational resources. The model had also shown that more self-efficacy could increase learners' science achievement by 47.20 score points $(SE = 3.40)$.

5.4.3 Model for females

Table 5.18 shows the percentage of variance for female learners.

Table 5.18

Model for female learners

IDCNTRY	*R*-squared	Adjusted *R*-squared	*R*-squared standard error
South Africa	.27	.27	.02

The amount of variance in the model for females accounted for 27% $(SE = 0.02)$. Table 5.19 represent the outputs of multiple linear regression from the IDB Analyzer.

Table 5.19

Multiple linear regression coefficients for females

Description	*B*	beta	b.se	beta.se	b.t
(CONSTANT)	481.37		14.46		33.30
Instruction affected by lack of Science Resources	-87.43	-.22	15.71	.03	-5.57
Sometimes Speak language of the test at home	-62.49	-.30	4.72	.02	-13.24
Never Speak language of the test at home	-106.47	-.25	8.09	.02	-13.17
Some Home Educational Resources	19.82	.10	3.63	.02	5.46
Many Home Educational Resources	80.44	.12	11.63	.02	6.91
More Self-Efficacy	40.46	.18	3.16	.01	12.82

All the predictors had a significant relationship with science scores. The model revealed that females from homes with many resources could gain $(80.44; SE = 11.63)$ a year and a half ahead of those from homes with some resources. More self-efficacy has also shown a significant relationship with female achievement.

Female learners with more self-efficacy could gain 40.46 score points ($SE = 3.16$) towards science achievement.

The results showed that females lost slightly fewer score points for self-efficacy and many home educational resources. On the other hand, males had slightly higher score points for the two predictors. Instruction affected by science resources and speaking the language of the test showed a significant negative relationship in all three models. However, the results from the female model were slightly lower across the two predictors.

5.5 CONCLUSION

This chapter provided the detailed results of the current study. The descriptive statistics were obtained for gender, instructions affected by science resources, speaking the language of the test at home, home educational resources, and self-efficacy. Factor analysis was also conducted, and factor loadings were obtained for each predictor variable. Reliability tests were also conducted to ensure that variables measured the correct constructs. Lastly, multilinear regression analysis was conducted for the general model and gender (male and female).

The results showed that there were slightly more females than males in the study. However, the gender of the learners was weighted such that it did not affect the study's findings. The majority of the learners (63%) reported that they do not have enough educational resources at home. Furthermore, it was reported that 65% of the learners sometimes use the language of the test at home, but less than a third speak it most of the time at home. Most (93%) of the teachers were affected by instructional resources for science, and the learners whose teachers were affected by instructional resources had significantly lower scores. The score was 127 points less than those whose teachers were unaffected. There was a significant difference in self-efficacy between male and female learners. Female learners reported more self-efficacy than their male counterparts.

The current study was not seriously affected by missing data. Only 1.3% of the values were missing listwise. Therefore, the statistical power of the results was not affected. Instructions affected by science resources had a higher percentage of missing data than other predictors.

Three assumptions were verified before conducting the regression analysis. The mean value was obtained from a Durbin-Watson test, which indicated a positive correlation between the predictor variables and science scores. There was no multicollinearity since the VIF values were < 3. Furthermore, the correlations amongst predictors were < 0.7, and therefore all the assumptions were met.

In the multiple linear regression analysis, three models were developed (a general model and models for males and females). The general model accounted for 26% of the variance for science scores. The model for the males explained 24% of the variance, while the females' model in total explained 27%. Across the three models, all predictors had a statistically significant relationship with science scores ($t < -1.96$; $t > 1.96$). Amongst the five predictors, gender of learners, instruction affected by science resources, and speaking the language of the test at home had a significant negative relationship with the science score as expected (the more an individual is affected by a lack of resources, the lower their achievement).

When comparing the three models, it was found that many home educational resources and higher self-efficacy had a statistically significant positive relationship with science scores. Across the three models, home resources showed that learners with many educational resources could gain score points of 80 and above, indicating a year and a half of schooling ahead of those whose homes had some resources. Self-efficacy has also shown a score point of 40 and above across all the models, indicating that learners with more self-efficacy could gain a year of schooling.

When investigating the relationship between gender differences in self-efficacy and science scores. The findings of this study revealed that higher self-efficacy was associated with higher science scores. With regard to gender, more females reported higher self-efficacy levels and academically achieved better than their male counterparts. This chapter focused on the results of this study. The next chapter will present the conclusions and recommendations.

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

This chapter presents the conclusions drawn from the findings of the current study on gender differences in self-efficacy in relation to Grade 9 science achievement in South Africa. The conclusions were based on the study's purpose, research questions, and results.

The current study is a secondary analysis of the TIMSS 2019 survey data for South Africa. The data were used to investigate gender-related differences in self-efficacy and their association with science achievement amongst Grade 9 learners. The data used in this study was extracted from responses provided by learners in the student questionnaire, teachers, and overall science achievement scores.

6.2 Summary of the study

The Grade 9 learners in South Africa participated in the TIMSS 2019 survey conducted by the TIMSS and PIRLS study centre on behalf of the IEA. The study was conducted in grades 4 and 8 internationally. However, South Africa is one of the few countries that administered the study in grades 5 and 9 (Reddy et al., 2020). According to the TIMSS 2019 survey report, male Grade 9 learners in South Africa had lower achievement in science when compared to their female counterparts (Mullis et al., 2020).

The current study investigated the effects of gender-related differences in self-efficacy and how they contributed to the science achievement of the Grade 9 learners in the TIMSS 2019. Self-efficacy is a significant predictor of academic achievement (Nasir & Iqbal, 2019). Learners with high levels of self-efficacy tend to achieve better academic results when compared to those with low levels (Gor et al., 2020). Since self-efficacy is associated with better academic attainment, teachers must assess the self-efficacy levels of their learners at classroom level and have mechanisms in place to improve the efficacy of those with low levels (Aurah, 2017).

Research has shown that academic performance in science can be affected by school, home, classroom, and broader factors (Howie et al., 2017; Isdale et al., 2017; Spaull & Kotze, 2015). However, the current study focused on self-efficacy while controlling for background factors. Chapter 3 outlined the current issues facing education in relation to gender. Self-efficacy was also discussed in relation to gender, achievement, and culture in relation to relevant literature and the framework. Bandura's theory of self-efficacy was adopted as a theoretical point of view that governed the study. The theory was used as a framework to limit the scope of the relevant data and enable the researcher to focus on specific variables.

The current study was grounded in post-positivism, which advocates that reality is subjective, multiple, and mentally constructed by people (Nel, 2020). The study's design was secondary data analysis, where quantitative data from the TIMSS 2019 was analysed using statistical techniques (descriptive and inferential). Descriptive statistics were used to summarise the data and highlight any possible relationships between variables. Inferential statistics were conducted through the application of multiple linear regression analysis.

6.3 Findings from the study

The TIMSS 2019 results revealed a statistically significant difference between male and female learners, with female performance higher than males. The results have also shown a growing gender gap in science amongst Grade 9 learners in South Africa. Reddy et al. (2020) emphasised that the poor performance of male learners should be seen as a concern. Therefore, special attention should be given to the growing gender gap to achieve the global movement towards sustainable development on gender equity and equality by 2030.

The current study examined whether gender differences in self-efficacy had any relationship with science achievement. The results were in line with previous studies conducted on this topic (Aurah, 2017; Gor et al., 2020; Jamil & Mahmud, 2019). The findings of this study showed that self-efficacy had a strong relationship with science achievement. There was a significant gender difference in self-efficacy amongst the Grade 9 learners in South Africa, with females reporting higher (4% more) than males. The difference in the higher category was statistically significant. These findings support the theory of self-efficacy, which argues that learners with stronger beliefs in their abilities and capabilities attain better academic achievements than those with low levels (Ramachandran, 2012). According to Oosthuizen (2021), science self-efficacy should be encouraged and nurtured so that learners can reflect on their capabilities and abilities towards the subject.

The availability of home resources for learning was also explored for the role of home educational resources. TIMSS constructed a scale for home educational resources from the learner's questionnaire. The findings indicated a strong relationship between home educational resources and science achievement. These findings were in line with those of studies conducted earlier by other scholars (Howie et al., 2017; Spaull & Kotze, 2015). The results also revealed that only 2% of the Grade 9 learners in South Africa came from homes with many educational resources. Learners whose homes had adequate educational resources performed better in science.

Speaking the language of the test at home had a statistically significant relationship with science achievement. These findings were consistent with those of Spaull and Kotze (2015) and Isdale et al. (2017). Proficiency in English has been found to be associated with better academic achievement of learners when writing the test in English (Geide-Stevenson, 2018). The current study's results showed that learners who always speak the language of the test at home achieved better than those who sometimes use the language or do not at all. More than two-thirds (63%) of the Grade 9 learners in South Africa indicated that they only speak the language sometimes, which may have implications for their science achievement.

The vast majority (93%) of the teachers reported that they were affected by a lack of instructional resources for science. Reports from studies conducted earlier indicated that learners who are taught with instructional materials perform better than those taught without any resources (Abubakar, 2020; Adalikwu & Iorkpilgh, 2013; Edoho et al., 2020). The learners whose teachers reported being affected by instructional resources performed poorly in science $(M = 361;\ SE = 3.26)$ compared to those whose teachers said they were not affected $(M = 488, SE = 22.04)$.

Three models (general, male, and female) were created for the multiple linear regression analysis. All the five predictor variables (self-efficacy, gender, speaking language of test at home, home educational resources, and instruction affected by science resources) in the three models had a significant relationship with science scores $(t < -1.96;\ t > 1.96)$. The model for males showed that if most of the learners were in the high-self-efficacy category, they could have gained 47 points more, and the females could also have gained 40 more points.

6.3.1 Findings in relation to the literature

This study examined the effects of gender differences in self-efficacy on science achievement. Stoet and Geary (2018) asserted that gender differences in self-efficacy are associated with the academic strength of the learners. The results of the current study showed that the higher levels of self-efficacy amongst the female learners in Grade 9 were associated with their high achievement in science in the TIMSS 2019 survey. However, these findings were inconsistent with some of the previous studies (Gor et al., 2020; Musisi et al., 2021) that reported the academic strength of male learners lies within the area of science as, in some contexts, they achieve better results in the subject than females. Schina et al. (2019) and Juan et al. (2018) reported that females demonstrate low self-efficacy, even when they outperform their male counterparts in science. However, the current study found that females reported higher self-efficacy.

The findings of the current study were important for female learners as confidence is known to affect their participation in mathematics and science (Aurah, 2017), especially concerning the current low representation of females in STEM fields. Despite the progress made in increasing opportunities, female participation in STEM fields remains drastically low. Female students account for less than a third of careers associated with STEM (LiveTiles, 2022). The findings of the current study showed that female learners' beliefs in their abilities towards science were associated with their achievement in the subject. If the trend continues into tertiary, more females could be encouraged to follow careers associated with STEM fields in the future.

6.3.2 Findings in relation to the research questions

The main research question of the study was the following:

- **To what extent do gender differences in self-efficacy correlate with learner achievement in Grade 9 science in South Africa?**

The findings of the current study revealed that self-efficacy has a significant relationship with science achievement. These findings were in line with Bandura's theory of self-efficacy, which is grounded on the idea of a high level of self-efficacy associated with better academic performance.

Regarding the extent to which self-efficacy was associated with science achievement amongst the Grade 9 learners in South Africa, the results showed a significant relationship (*r* = 0.26). The female's higher achievement in science was associated with higher levels of self-efficacy (doing better in a subject could increase one's self-belief). The differences in science scores between the two genders were statistically significant ($t = 2.81$), with females obtaining a mean score $(376;\ SE = 3.17)$ higher than males by 12 score points.

- **What difference in self-efficacy exists between male and female learners in Grade 9?**

The findings showed a significant difference in self-efficacy between the two genders. More females were in the high self-efficacy group (27%) compared to males (23%). Because this was a large-scale study, a 4% difference was statistically significant. In this regard, the alternative hypothesis was accepted, which stated a significant difference in self-efficacy between the genders in Grade 9.

- **To what extent do gender differences in self-efficacy contribute to science achievement when controlling for background factors such as socio-economic status?**

When issues relating to the socio-economic background of the learners were kept constant, the results revealed a small degree of difference in self-efficacy between the two genders. However, male learners could gain seven points more if they were in the high self-efficacy category. As the achievement gap in science between males and females slowly increases, this is another aspect that, when addressed, could make a small but important difference in supporting males.

6.3.3 Reflections on the theoretical framework

Based on Bandura's theory of self-efficacy as a theoretical point of view, this study examined the concept of self-efficacy and its effects on science achievement amongst Grade 9 male and female learners. According to Sharma and Nasa (2014), academic self-efficacy has gained increasing recognition as a predictor of academic achievement. It functions as a multifaceted and multilevel set of beliefs that influence how learners think, feel, motivate themselves, and behave when doing various educational tasks. The development of self-efficacy is closely intertwined with the learner's competencies, experiences, and developmental tasks in different domains across the stage of life (Sharma & Nasa, 2014).

The theory of self-efficacy suggests that learners with high levels of self-efficacy achieve better when compared to those with low levels or that low achievers have lower self-efficacy (Kolo et al., 2017). The theoretical framework guided the selection and interpretation of the variables from the TIMSS 2019 data for Grade 9 as well as drawing conclusions for the current study.

The theoretical framework utilised in this study was chosen based on its relationship with the academic achievement of learners. The framework was ideal for this study as it related to the concepts investigated in this research and could be easily applied to the TIMSS data. Items in the learner questionnaire relating to self-efficacy were selected based on the four sources of self-efficacy. Due to fewer items in the TIMSS data for each aspect (mastery performances, vicarious modelling, verbal persuasions, and physiological responses) of self-efficacy, the researcher grouped all the items and examined them as general self-efficacy instead of investigating the construct based on each of the four sources. A scale was created for low and high self-efficacy. The low self-efficacy category was associated with low achievement, and the higher self-efficacy category with higher achievement.

6.4 Contributions of the research

The current study adds to the existing literature concerning how self-efficacy affects the academic performance of learners in relation to gender. Studies conducted earlier reported that differences in self-efficacy by gender contributed largely to learner performance. The current study revealed that more (4%) females reported higher self-efficacy in the high-self-efficacy group and attained better results in the TIMSS 2019 survey. However, the difference in achievement was relatively small. Self-efficacy was significantly associated with science achievement for both genders. Male learners could have gained more score points if they were in the high-self-efficacy group. Although the effects of self-efficacy on science performance were small, in this study, they were significant. If the gender gap continues to widen, it might be important to address issues of confidence in science among male learners.

Home educational resources were found to play an essential role in the academic performance of learners. Learners from homes with many educational resources attained better academic achievements when compared to those with fewer resources. Many learners reported not having adequate educational resources at home. This shortage of educational resources indicates that South Africa is still far from overcoming inequalities in terms of socioeconomic resources.

The study also showed that speaking the language of the test (English or Afrikaans) greatly improved learner achievement. Learners who always speak the test language had higher mean achievement compared to learners who never use the language of the test at home. These findings indicate that if learners are taught in the language they use at home, it could significantly impact their academic performance. Studies reported that female learners show higher English proficiency than males across the years of schooling. The PIRLS 2016 results for South Africa showed that higher English proficiency in female learners emerges during the early years of schooling (Howie et al., 2017), continuing in secondary school (Spaull & Makaluza, 2019). The competency in English between the two genders could be a conduit through which the feelings of self-efficacy are enhanced or diminished.

Learners whose teachers had a shortage of instructional resources performed poorly compared to those whose teachers said they were not affected by a lack of instructional resources. These findings show that the majority of the schools in South Africa are still struggling with too few science resources in the classroom despite the intervention strategies the South African government has applied in education.

6.5 Limitations of the study

Since this study was a secondary data analysis, the methodological choices were limited. No follow-up questions could be asked to the participants. Therefore, fewer items were analysed for self-efficacy. Regarding gender, the TIMSS 2019 data only had information about males and females. Therefore, the current study could not shed further light or new insights into the movement towards embracing different gender identities. Since the data was collected through a self-reporting questionnaire, some of the responses may be untruthful, especially on the information relating to home educational resources. According to Demetriou et al. (2015), self-reported answers may be exaggerated, especially on sensitive questions, as the respondents may feel embarrassed to reveal personal details, and various biases may result, such as social desirability bias.

6.6 Recommendations

- **Language of the test and language spoken at home are crucial to science achievement**

English and Afrikaans are two of the 11 official languages in South Africa, and they are the most preferred languages of instruction in high schools. The use of English or Afrikaans as a medium of instruction has always been a major disadvantage to many learners who are not native to these languages (Gordon & Harvey, 2022). Speaking the language of the test at home was reported to have a significant relationship with science achievement. Learners who do not speak the LoT at home may lack English or Afrikaans proficiency. This forces the teachers to find alternative ways, such as code-switching, to ensure learners understand the subject matter. A study that investigated code-switching in classrooms conducted in Limpopo province by Kretzer and Kaschula (2019) reported that the official language policy document of the schools differs significantly from the daily language policy within classrooms. The findings revealed that teachers use code-switching to help learners understand the concepts by moving from English or Afrikaans and reverting to their native language.

The impact of self-efficacy by gender on learners' academic performance cannot be fully analysed without considering if the LoT is spoken at home. A poor foundation in the LoT (English or Afrikaans) could contribute to lower achievement, or it may be that not speaking the language frequently at home is what causes the problem (causality unknown). The current study suggests that to understand the effect of self-efficacy on learner achievement, researchers should also consider the language of the test as it poses a greater impact on the performance of the learners.

- **Researchers may need to rethink how they measure self-efficacy when using TIMSS data**

The majority of the self-efficacy items in the learner questionnaire were associated with mastery experience. The other three sources (vicarious experiences, social persuasion, and physiological state) of self-efficacy had only one or two items which could be classified as other forms of self-efficacy. Therefore, self-efficacy cannot be fully measured based on the four sources. In this regard, researchers may not be able to rely only on the scale found in TIMSS to measure all aspects of self-efficacy, especially when learners highly endorse all items. Therefore, this research suggests that researchers should create their own scale to measure self-efficacy when using TIMSS data or conduct qualitative studies in addition to using the TIMSS data.

6.7 Reflections of the researcher

I have been teaching science in a secondary school for over five years. In the early years of my teaching career, I offered Mathematics in grades 8 and 9, then moved to Grade 9 Natural Sciences and grades 10 to 12 Life Sciences. In the FET phase, I noticed a big gender difference in the number of learners doing sciences. There were more females than males in the Grade 10 to 12 science stream. While in Grade 9, there was no significant difference in the number of male and female learners.

I also realised that the females in all the grades (Grade 9 to 12) were passing science more than their male counterparts. The females also showed more interest in doing science than the males. From the situation, I felt the need to conduct a study to investigate whether females' beliefs in their capabilities and abilities in science impacted their achievement compared to males. Based on the findings of this study, the high levels of self-efficacy in female learners could be part of the reason for their higher performance in science. These findings are significant as they have implications for achievement differences. The higher achievement of females in science shows that male learners need attention such that they can also succeed and pursue careers in STEM fields.

6.8 Synthesis and conclusion

Learners' beliefs in their capabilities and abilities towards science play an important role in their academic achievement (Aurah, 2017). There is a strong correlation between self-efficacy and science performance. Learners with higher levels of self-efficacy achieve better results than those with low levels (Gor et al., 2020). Since higher levels of self-efficacy were associated with higher science achievement, it could be important for teachers to deploy more strategies that seek to provide learners with opportunities to achieve in the subject. If the learner's performance in the subject increases, their self-efficacy could increase. Whenever low levels of self-efficacy are detected, appropriate intervention strategies should be deployed to raise the learners' self-efficacy through goal setting, self-regulated learning, and vicarious learning (Aurah, 2017). These intervention strategies include using moderate to difficult tasks, using peer models, capitalising on learners' interests, encouraging mastery experiences, giving frequent, focused feedback, and encouraging learners' attributions (Margolis & McCabe, 2006; Mihaly, 2022).

Even though there is a correlation between self-efficacy and science achievement, the chances of learners passing science are drastically reduced without adequate resources in schools and homes. Most of the learners in South Africa come from disadvantaged backgrounds, which contributes negatively to their education. To improve learner performance in science, concrete measures need to be put in place to reduce the shortage of resources in schools. The departments of education should investigate ways to ensure that all schools are supplied with adequate instructional resources for science. Teachers should also receive training on using science resources to enhance learners' understanding of the subject matter.

The findings of the current study may present an opportunity for other researchers to conduct qualitative studies that seek to find ways to improve the teaching and learning of science in schools and investigate the role of speaking the language of the test at home and the role of self-efficacy in male achievement. If more learners could achieve better results in science, their self-efficacy could increase or vice versa.

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ANNEXURES

ANNEXURE A

Overview of the science curriculum for Grade 9 in South Africa and the topics assessed in TIMSS 2019

Topic	Sub-topics in Grade 9 in CAPS	Content area in CAPS	Science sub-topics in TIMSS 2019
Life and living	The cells as the basic unit of life	Cell structure, the difference between animal and plant cells.	Cells and their functions

Topic	Sub-topics in Grade 9 in CAPS	Content area in CAPS	Science sub-topics in TIMSS 2019
		Cells in tissues, organs, and systems	Life processes of an organism
		Body systems	Diversity, adaptations, and natural selection
	Human reproduction	Purpose and puberty, reproductive organs, and stages of reproduction	Ecosystems Human health
	Circulatory and respiratory systems	Breathing, gaseous exchange, circulation, and respiration	Life cycles, reproduction, and heredity
	Digestive systems	Healthy diet, the alimentary canal, and digestion	
Matter and material	Compounds	The periodic table and names of compounds	Chemical change Composition of matter
	Chemical reactions	Chemical equation for chemical reactions Balanced equations	Properties of matter
	Reactions of metals with oxygen	The general reactions of metals, iron, and magnesium with oxygen. Formation and prevention of rust	
	Reaction of non-metals with oxygen	General reaction of non-metals, carbon, and sulphur with oxygen	
	Acid and bases, and pH value	The concept of pH value	
Energy and change	Forces	Types of forces Contact and field forces	Electricity and magnetics

Topic	Sub-topics in Grade 9 in CAPS	Content area in CAPS	Science sub-topics in TIMSS 2019
	Electrical cells as energy systems	Electric cells	Energy transformation and transfer
	Resistance	Uses of resistors and the factors that affect the resistance in a circuit	Light and sound Physical states and changes in matter
	Series and parallel circuits	Series and parallel circuits	
	Safety with electricity	Safety practices	
	Energy and the national electricity grid	Electricity generation, nuclear power in South Africa, and the national power grid	
	Cost of electricity	The cost of power consumption	
Planet Earth and beyond	The earth as a system	Spheres of Earth	Earth in the solar system and the universe
	Lithosphere	Lithosphere and formation of rocks	Earth's history, processes, cycles
	Mining of mineral resources	Extraction of ores, refinery of minerals, and mining in South Africa	Earth's resources, their use and conservation
	Atmosphere	Atmosphere, troposphere, stratosphere, mesosphere, thermosphere, and the greenhouse effect	Earth's structure and physical features
	The birth, life, and death of stars	The birth, life, and death of stars	

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ANNEXURE B

Variables and response options on the learner questionnaire

Type of variable	TIMSS 2019 Variable name	TIMSS 2019 variable description	Response options	Predictors
Gender	BSBG01	Are you a girl or a boy?	1. Boy 2. Girl	Gender
How much do you agree on these statements about science?	BSBS24A	I usually do well in science	1. Agree a lot 2. Agree a little	Self-efficacy
	BSBS24C	Science is not one of my strengths.		
	BSBS24D	I learn things quickly in science		
	BSBS24G	Science is harder for me than any other subject		
	BSBS24E	I am good at working out difficult science problems		
	BSBS24B	Science is more difficult for me than for many of my classmates.		
	BSBS24F	My teacher tells me that I am good at science.		

Type of variable	TIMSS 2019 Variable name	TIMSS 2019 variable description	Response options	Predictors
	BSBS24H	Science makes me confused.	3. Disagree a little 4. Disagree a lot	
Home resources	BSBG04	About how many books are there in your home? (Do not count magazines, newspapers, or your schoolbooks.)	1. None or very (0-10 books) 2. Enough to fill one shelf (11-25 books) 3. Enough to fill one bookcase (26-100 books) 4. Enough to fill two bookcases	Home resources IEA scale

Type of variable	TIMSS 2019 Variable name	TIMSS 2019 variable description	Response options	Predictors
			(101-200 books) 5. Enough to fill three or more bookcases (more than 200)	
Do you have any of these things at your home	BSBG05A BSBG05B BSBGO5C BSBG05D BSBG05E	A computer Study table/desk for your use Your own room Internet connection Your own mobile phone	1. Yes 2. No	

Type of variable	TIMSS 2019 Variable name	TIMSS 2019 variable description	Response options	Predictors
2. Resources for science instruction	3. BCBG13CA	4. Teachers with a specialisation in science	1. Not at all 2. A little 3. Some	5. Instructions affected by science resources IEA scale
	6. BCBG13CB	7. Computer software/applications for science instruction	4. A lot	
	8. BCBG13CC	9. Library resources relevant to science instruction		
	10. BCBG13CD	11. Calculators for science instruction		

Type of variable	TIMSS 2019 Variable name		TIMSS 2019 variable description		Response options	Predictors
	12.	BCBG13CE	13.	Science equipment and materials for experiments		

ANNEXURE C

Scale for home educational resources

Number of books in the home	**Number of home study support**	**Highest level of education of either parent**	**Scale cut score**	**Scale category**
1. 0-10 **2. 11-25**	1. None	1. Did not go to school or finished some primary or low secondary 2. Finished low secondary 3. Finished upper secondary	0 - 8.4	Few resources
3. 26-100	2. Internet connection or own room	4. Finished post-secondary education	8.4 - 12.2	Some resources

Number of books in the home	Number of home study support	Highest level of education of either parent	Scale cut score	Scale category
4. 101-200 **5. More than 200**	3. Both internet connection and own room	5. Finished university or higher	12.2 and above	Many resources

ANNEXURE D

Scale for instruction affected by science resources

Resources	Response options			
	Not at all	A little	Some	A lot
A. General school resources				
Instructional material (textbooks)				
Supplies (e.g pencil, papers, material)				
School building and grounds				
Cooling/heating and light systems				
Technological component staff				

Audio-visual resources for delivery of instruction

Computer technology for teaching

B. Resources for science instruction

Teachers with a specialisation in science

Computer applications/ software for science instruction

Library resources relevant to science

Calculators

Science material and equipment for experiments

Scale category	Not affected	Somewhat affected	Affected a lot
Scale cut score	11.1 and above	7.5 – 11.1	0 – 7.5