Participation of Zimbabwean female students in physics: Subject perception and identity formation

GUDYANGA ANNA

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Supervisor: Dr Kathija Adam

Co-supervisor: Dr Raj Kurup

2016
DECLARATION

GUDYANGA ANNA MRS 212448463
I, Student full name & student number, hereby declare that the treatise/ dissertation/ thesis for Students qualification to be awarded is my own work and that it has not previously been submitted for assessment or completion of any postgraduate qualification to another University or for another qualification.

GUDYANGA ANNA
.............................. (Signature)
DEDICATION

To the most important people in my life: my husband Ephias; my children Tatendaishhe Blessing and wife Shaleen, Kudakwashe Emmanuel and wife Kwanele, Nyashadzashe Sharon, and Ishekudwai Blessed; my grandchildren Tapiwanashe Fortune, Tinomuvongaishe Kyle and Tinayeishe Talisa; for their unwavering love and support over the years.
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ABSTRACT

The central focus of this study was to determine the extent to which identity formation influenced Zimbabwean A-level female students’ perceptions of and participation in physics. The themes from the sub-problems included the influence of contextual factors on identity formation in relation to physics as a subject at Advanced Level (A-level), facets of identity formation considered to be of significance by female students in relation to physics, the way in which female students’ perceptions of physics influenced their participation in the subject as well as the factors of identity formation considered as contributing to developing an orientation towards physics by female students.

A qualitative approach grounded in an interpretivist paradigm was used. A tri-hybrid theoretical lens comprising of Wenger’s (1998) Social Learning Theory featuring CoP, the Feminist Stand point Theory and Sfard and Prusak’s (2005) notion of ‘telling’ identities or stories, enabled a rich understanding of the influences of identity formation on female students’ perceptions of and participation in physics. The data generating methods used were classroom observation, Draw-A-Scientist Test and semi-structured interviews conducted with nine participants. The data were collated to generate narratives.

Key findings: The contextual factors that influenced the identity formation of female students and subsequently their participation in physics at A-level included: Parental and siblings influence; cultural perceptions; impact of the O-level experience; A-level physics teachers’ attitudes; classroom and laboratory experience; male peer influence and other factors such as an understanding of the relevance of physics in daily life. Facets of identity formation considered to be of significance by female students in relation to physics included: being confident, fearless, intelligent, and courageous, liking physics and being determined. These facets motivated them to develop an identity in favour of physics. The female participants studying only mathematics perceived themselves as very intelligent but with a fear of failing physics, lacking confidence and courage.

Female students who held negative perceptions towards physics chose to do only mathematics at A-level while those with positive perceptions which influenced the formation of a positive physics identity displayed enthusiasm and commitment to achieve high levels of performance in the subject. Factors of identity formation considered as contributing positively to the development of an orientation towards physics by female students included the importance of
female physics teachers as role models, motivation from O-level science teachers, high self-confidence, high self-esteem, parental support and encouragement, and aspirations towards a physics related career. Gender insensitivity displayed by male teachers, male peer harassment and gender stereotyping are factors in identity formation considered as inhibiting the development of an orientation towards physics by female students.

This study provides physics educators, physics planners and the government with detailed information on the role identity formation plays on the participation of Zimbabwean female adolescent students in A-level physics. The findings may be used by heads of schools to sensitise academic staff on the gender dimensions of teaching and learning as well as by counsellors and parents to encourage females to enrol for physics and mathematics as their subjects of choice. This study also contributes to the strengthening of educational research in Zimbabwe, especially research aimed at emancipation of female students in Zimbabwe.

Key Words: Identity formation; Identity; Perception; Female participation; Context; Female students; Learning and Physics.
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<table>
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<tr>
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<td>O-level</td>
<td>Ordinary Level</td>
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<td>CoP</td>
<td>Community of Practice</td>
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<td>SLT</td>
<td>Social Learning Theory</td>
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<td>FST</td>
<td>Feminist Standpoint Theory</td>
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<td>NGP</td>
<td>National Gender Policy</td>
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CHAPTER 1

EXPLORING THE IDENTITY OF FEMALE STUDENTS IN RELATION TO THEIR PARTICIPATION IN ADVANCED LEVEL PHYSICS.

1.1 INTRODUCTION

“The year is 1976, I am both excited and nervous to be in the Ordinary Level (O-level) A-Stream, or more commonly known as the science stream. What a prestige and honour! Very few students make it into this stream, but I had done well in Mathematics and Science, so I have earned this. So here I am with nine other girls and forty boys ready to be received by our teachers. It did not immediately dawn on me that the girls were in a minority, or that they were not seen as part of the group, until a male physics teacher walked in and enquired, “Why are you girls in this class? You must work very hard you girls.” His words left me daunted and overwhelmed and so began the year with the girls feeling unwanted and misplaced, in this stream. I remember the first time one of the girls failed to answer a question. His [the teacher’s] words were piercing, “You have to pull up your socks, work harder to get it right. Stop wasting our time here.” It seemed unfair because when one of the boys got an answer wrong, the same teacher chided him lightly, “Not really the answer, but…”

I stuck the first month with gritted determination although the classroom continued to be an uninviting, cold and hostile place. The fear of being there was enough and to do practical classes in physics was the worst! I would go in and the teacher would constantly sit near me as if watching every move I made. His presence caused me to shake and shiver with nervousness. I was so overwhelmed that I couldn’t concentrate. I started sweating profusely and began to jumble. Before long a loud shattering noise filled the air… something had fallen off my table. I didn’t even look up and wait for him to respond. I just ran.

The shattering of the glassware was to resemble my broken dreams. After the incident in the laboratory, I immediately withdrew from the course even though I knew that this decision would be one I would regret forever.

It’s 2014, almost 40 years later. Are things any different today?” (Journal Entry, September 2014)

Whenever I think of my experiences as an adolescent female student, both in a physics classroom and the physics laboratory, I believe that what happened to me was dehumanising. The teacher’s attitude and behaviour was Antithetical to the Unhu/Ubuntu philosophy that underpins and guides the African way of life. The concept of Ubuntu is an ancient African philosophy which comes from isiZulu and isiXhosa languages which means “living in humble humanity with other people” (Nafukho, Amutabi, & Otunga, 2005, p. 11). This is clearly

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1 Ubuntu in the Zimbabwean context is the same as Unhu
articulated when the authors state that “an individual is an individual because of other individuals in society.” *Ubuntu*, therefore, focuses on character formation as the cornerstone and recognises the human being as a social being whose worldview and identity are shaped by interacting with fellow human beings (Nafukho, 2006). Character formation shapes one’s identity, that is, how an individual perceives himself/herself, be it at home or at school. Thus, for education to be meaningful, it must respond to the needs of a people (including females) and their worldviews. The worldview in turn guides teachers’ actions in relation to how they teach, what they teach, and the kind of classroom climate they create (Muropa, Kusure, Makwerere, Kasowe, & Muropa, 2013). Considering that the spirit of *Ubuntu* permeates all spheres of African life, gender prejudices of any nature in the wider society particularly in the classroom situation can be seen as an anomaly. Therefore, from the *Ubuntu* perspective, my experiences in the physics classroom are difficult to understand. However, literature suggests that gender discrimination in an educational environment is not unique to Zimbabwe but a global issue (Kalu, 2005; Zohar & Bronshtein, 2005).

My introductory narrative depicts a common incident in the context of gender discrimination in science classrooms in many countries (Hazari, Sonnert, Sadler, & Shanahan, 2010; Lips, 2008; Mwetulundila, 2011). Based on a review of a number of studies, Murphy and Whitelegg (2006b, p. 23) reported that in physics classrooms, “teachers spent more time interacting with boys, valued boys’ experiences more in the classroom and generally treated boys more favourably than they treated girls.” They further found that teachers’ practices are key in influencing female students’ experiences and attitudes to science and to physics in particular. In this context, it is interesting to note that the 2013 Human Development Report² revealed that the Gender Inequality Index for Zimbabwe in 2012 was 0.583, ranking the country number 116 out of 148 countries surveyed (National Gender Policy, 2013). In view of the fact that women constitute about 52% of the total population in Zimbabwe, (National Gender Policy, 2013) under-representation of females, as indicated by the Gender Inequality Index, can have serious consequences to the economic development of the nation. Against this background, a brief overview of the various reform policies in education and their subsequent revisions over the past few decades warrants explication as it shows that the Zimbabwean government at policy level has made consistent efforts to address the issue of gender discrimination.

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² Produced by the United Nations Development Programme, 2012 cited by National Gender Policy, 2013
1.2 HISTORICAL PERSPECTIVE

In an attempt to achieve gender equality as an independent nation, Zimbabwe introduced its first Education Act in 1980. This Education Act sought to provide equal access to all children regardless of sex. An important development that provided the impetus for gender inclusivity was that Zimbabwe is a signatory on a number of regional and international treaties\(^3\) (Gudhlanga, 2008). The purpose of these treaties was to create an enabling environment for the attainment of equity and equality between men and women. In keeping with this vision, Zimbabwe formed the Ministry of Women’s Affairs in 1980 which was later renamed the Ministry of Youth, Gender and Employment Creation (National Gender Policy, 2013). In 1992, the Zimbabwean government also introduced a gender affirmative action policy, to enable female students with lower points to enrol into universities and colleges, thus paving a way for increasing the number of females in higher education institutions.

In 1999, the Nziramasanga Commission of Inquiry into Education and Training was set up by the Zimbabwean government with the task of evaluating the education system of the country. One of the terms of reference was for the team to interrogate the issue of gender equality in education. It is important to note that one of the key findings of the Commission was that gender disparities still persisted at all levels of education (Nziramasanga, 1999). The recurrence of gender concerns, despite decades of gender activism, illustrate that gender disparities are still embedded in the Zimbabwean education system. The Commission also reported that gender insensitivity has been translated into the curriculum explicitly and implicitly at all levels, verifying another oversight by curriculum developers (Nziramasanga, 1999). Such curricula translate into practice within classrooms and schools maintaining the status quo. As a follow up to the recommendations by the Nziramasanga Commission (1999), as well as in an effort to effectively transform the provisions of regional and international legal and human rights instruments to address the issue of gender discrimination, the Zimbabwean government launched the National Gender Policy (NGP) in 2004. One of the goals of the NGP was to:

“Eliminate all forms of discrimination against boys and girls in education and skills training which includes science and technology as well as to promote and encourage girls to take on science, mathematics and technology at all levels of education” (National Gender Policy, 2004, p. 10).

\(^3\) For example, the Southern African Development Community’s Declaration to Gender and Development, the Universal Declaration of Human Rights and the Convention on the Elimination of all forms of Discrimination Against Women
Subsequently, various amendments to the 1980 Education Act culminated in the development of the Education Act of 2004. Of particular significance is that the 2004 Act emphasised the *Ubuntu* philosophy, as it states that:

“no child in Zimbabwe shall— (a) be refused admission to any school; or (b) be discriminated against by the imposition of onerous terms and conditions in regard to his admission to any school; on the grounds of his race, tribe, place of origin, national or ethnic origin, political opinions, colour, creed or gender” (Education Act, 2004, p. 620)

Unfortunately, the 2004 Education Act does not appear to be explicit enough on gender issues as it only mentions no discrimination at admission to any school. This Act takes no cognisance of the fact that by the time children go to school, they would have already been socialised into unequal positions. This is because gender differences are already socially inculcated into the lives of children from birth (Chirimuuta, 2006). According to Chirimuuta (2006), the deliberate assumption is that boys and girls are socially constructed in the same way. It ignores the fact that girl children may have inherent gender specific needs and socially constructed challenges. Thus, the 2004 Education Act places all children into a single category, suggesting that the social and education system is a gender-neutral space which does not impact the choices of female students. The reality is that if gender difference is not explicitly acknowledged at the policy formulation level, then it is highly unlikely that it will be addressed during implementation (Gudhlanga, Chirimuuta & Bhukuvhani, 2012).

The NGP was revisited in 2013 with the vision of creating “a gender just society in which men and women enjoy equity, contribute and benefit as equal partners in the development of the country” (National Gender Policy, 2013, p. 11). Underpinning the NGP are the principles of equality, integration and inclusiveness which are meant to address gender disparities in Zimbabwean society.

Despite the adoption of the NGP, Mutekwe and Modiba (2011) show that, educational institutions continue to reproduce disparities along gender lines. Many parents, educators and educational texts advance gender stereotypes that direct boys and girls to adopt highly polarised social roles in Zimbabwean society resulting in underrepresentation of females in science. The low participation of females in science is also illustrated in a study conducted by Gudyanga and Gudyanga (2012). The study was conducted in two co-educational schools, namely school A and school B. School A is located in the high density while school B is in the low density communities. See Figure 1.1 below.
The data as presented in Figure 1.1 above show that the participation of female students in science subjects over a three year period is very low in both schools (A and B) in comparison to male students. It is interesting to note that, in school B no female students opted to do Physics at A-level in both 2009 and 2010. Low enrolment of females in science in high schools leads to fewer females opting to choose science at tertiary levels. From the above, it seems that merely constituting relevant policy (for example NGP) is not enough to ensure participation of females in science.

1.3 SIGNIFICANCE OF THE STUDY

Although a large number of western studies (Coyle, 2006; Murphy & Whitelegg, 2006a; Olorode, 2005) have reported on the reasons for low uptake of physics by girls, very few studies have been carried out in developing countries. There is therefore a need to carry out this type of research in a developing country like Zimbabwe where cultural gender role patterns are distinct and pervasive. The focus of studies in western countries have been predominantly on school, classroom and student factors (Carlone & Johnson, 2007; Hazari et al., 2010; Hughes, 2001; Walker, 2001) with hardly any study examining the role of identity with regard to female students’ interest in science. In fact, there are no studies that focus on the relationship between female students’ identity and their participation in physics, hence, this is the gap in the research that this study seeks to address.
Thus, the focus of the current study is encapsulated in the main and sub-research questions described below.

1.4 RESEARCH QUESTION

For the purposes of this study, the main question could be framed as follows:

To what extent does identity formation influence Zimbabwean A-level female students’ perceptions of and participation in Physics?

In order to answer the main research question, the following sub-questions were developed in relation to this study:

- In what ways do contexts influence the identity formation of female students with regard to their perceptions of Physics as a subject of choice?
- Which facets of identity formation are considered to be of significance by female students in relation to physics?
- How do female students’ perceptions of Physics influence their participation in the subject?
- What factors of identity formation could be considered as contributing to developing an orientation to physics by female students?

These questions were framed from an understanding that identity formation is embedded in a cultural context (Myers, Abell, Kolstad, & Sani, 2010). Hence, it is appropriate to state that this study is situated within the field of sociocultural psychology. This field of psychology aims to study the influence of society on individual human behaviour and focuses on the fact that our interactions with others in society affect not only our thought processes, but also our perceptions (Myers et al., 2010). The social norms and cultural aspects of society also influence the way we perceive other individuals, situations, and our overall personality. In short, it explains how we create our identities and shape our perceptions (Taylor, Peplau & Sears, 2006) which ultimately guide our actions.

A qualitative research design grounded in the interpretive paradigm using narratives was deemed appropriate because this study sought to explore how identity impacts female students’ perceptions of and participation in physics.
1.5 RESEARCH METHODOLOGY

A qualitative narrative research design grounded in the interpretive paradigm provides “richer, vital, greater depth of information that [could] present a true picture” (De Vaus, 2001, p. 9). Willis (2007, p. 8) explains that: “a paradigm is thus a comprehensive belief system, world view, or framework that guides research and practice in a field.” The interpretive paradigm acknowledges that different viewpoints interpret the world through different processes of observation (Henning, Van, & Smit, 2004). It assumes that people’s actions are only meaningful if interpreted in the context in which they take place (McNeill & Chapman, 2005).

This study is situated within the narrative inquiry which is described by Polkinghorne (2007, p. 471) as “the study of stories” or as a collection of lived experiences (Creswell & Maietta, 2002). In essence, narratives are concerned with how we make sense of our lives. In this way, the concept of identity formation is understood through the eyes of female student participants and through their subjective views. The narratives generated, therefore, focused on participants in their specific contexts.

An initial sample questionnaire was used to purposively select female students whose narratives could provide rich information required to answer the research questions of this study. Nine suitable participants were identified (more detailed profiles are provided in Section 4.5 of Chapter 4, Table 4.1). Once suitable participants were identified, various instruments were employed to develop their individual narratives. These included drawings, classroom observations and semi-structured interviews. Collectively, these were used as instruments to collate individual narratives.

The narratives were analysed using analysis of narratives which considers internal coherence and consistency (Kelchtermans, 1993) of individual narratives. Analysis narrative uses paradigmatic reasoning that identifies common themes (Polkinghorne, 1995). Participants’ narratives in this study were analysed in two stages:

- The first stage is vertical analysis (Hunter, 2010; Kelchtermans, 1993) or “within-case” (Miles & Huberman, 1994).

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4 This is an instrument that was designed to purposively sample female students with the required characteristics, e.g. age, whether studying physics and or maths, see appendix …?
5 Of the nine participants 3 were studying physics and mathematics, 1 was studying physics only and 5 were studying mathematics only.
The second stage is the horizontal analysis (Hunter, 2010; Kelchtermans, 1993) or “cross-case” (Miles & Huberman, 1994).

In other words, the narratives of individual participants were first analysed separately and then collectively to provide an overall thematic analysis. The findings are reported based on themes that emerged in an effort to address the research questions.

However, it should be noted that within this study, a number of delimitations have been identified. These are elaborated on below.

1.6 DELIMITATION OF THE STUDY

Two delimitations are noted within this study; they include:

- The participants included in this study are a small number of A-level female adolescent students who were in their lower and upper sixth classes i.e. forms five and six. Hence the results of this study are not generalisable
- Participants were not selected from a country-wide pool, but a convenience sample of three co-education schools and one girls’ only school in the Gweru district in the Midlands Province of Zimbabwe was targeted, hence the results are not generalisable to the whole of Zimbabwe as a country.

In developing this study, the concepts that require further clarification are listed below.

1.7 CONCEPT CLARIFICATION

These key concepts are briefly defined as follows:

Culture - Culture in this study is used to refer to the complex and broad set of relationships, values, attitudes and behaviours that bind a specific community consciously and unconsciously (Blum, Freeze, Hazzan, & Dias, 2006). This definition posits that culture is bound by context and history and that individuals are born into specific cultures with prevailing values and structures of opportunity. The authors further explain that like “history, culture which allows for change is dynamic, shaping and being shaped by those who occupy it, in a synergistic diffusive process” (p. 5).

Gender - Refers to conceptions of socially defined sex roles i.e. the cultural aspects of sex - how we come to know ourselves as social beings that are male and female (Franklin, 2012). In
addition to biology, gender refers to the roles, behaviours, attitudes, etc., attributed to men and women as they are born into specific cultures and moments in history. Thus, in this study, gender embraces the complex dynamics of both natural and cultural factors and influences making gender issues cultural issues.

*Context* - Context can be defined as, “circumstances, times, conditions, situations and ambience” (Collins & Hands, 2006, p. 211) to which the female students are exposed to in society. However, for the purposes of this study, context is considered to be the historical, cultural, family background and institutional circumstance(s) or situation(s) impacting on female students as they interact in their communities of practice (CoP).

*Identity* - Implies the ability of the individual to be aware of the different meanings that he/she associates with herself/himself and the meanings that others assign to him/her. This happens through interactions with others; hence identity is seen as both a process and a product of social interaction (Beauchamp & Thomas, 2009). In this study the way one views oneself and is viewed by others, and wishes to be in future is their identity.

*Identity Formation* - The creation, establishment, organisation, development, genesis, and generation or coming into existence of oneself (Soanes & Stevenson, 2009). Identity formation is the development of distinct personality of an individual regarded as a persisting entity.

*Perception* - A process by which people interpret and organise sensations to produce a meaningful experience of the world (Soanes & Stevenson, 2009). It is the intuitive recognition of truth or action by which the mind refers to its sensations to external cause. In the context of this study, perception is awareness, a conception or an interpretation of what kind of subject physics is in as far as female adolescents’ participation in the subject is concerned.

*Ubuntu/Unhu* - is an ancient African philosophy which comes from isiZulu and isiXhosa languages which means “living in humble humanity with other people” (Nafukho et al., 2005, p. 11).

*Community of Practice (CoP)*- A community of practice is an emergent relationship between people who have come together around a joint enterprise, and is characterised by the existence of mutual engagement in the social practices, and in the process developing a shared repertoire of practices, understandings, routines, activities, common stories, and ways of speaking and acting (Wenger, 1998). In other words, it is a set of social relations and meanings appropriated
by participants. Wenger (1998) rather describes a community of practice as an entity bounded by three interrelated dimensions – mutual engagement, joint enterprise and a shared repertoire. Communities of practice are therefore, a specific type of community that constitutes the most important arenas in which individuals learn.

This study consists of six chapters and a brief description is given below.

1.8 ORGANISATION OF THIS STUDY

This chapter introduced and provided an overview of the study by specifying the background, research questions, significance, methodology, delimitations, and it clarified various concept pertinent to this study.

The second chapter provides a review of relevant literature with a focus on identity and identity formation as well as the various contextual factors that influence identity. These factors are nested in gender development theories and identity models. However, a critical evaluation was required as these were developed for western and not African contexts. In addition, current literature explicating research that has been conducted on female student perceptions and participation in physics is included.

Chapter three explores the theoretical framework of the study. Wenger’s (1998) social learning theory and in particular the notion of learning in communities of practice, Sfard and Prusak’s notion of telling identities as stories as well as the feminist standpoint theory are specific theoretical lenses through which this study is framed.

The philosophical assumptions, qualitative research design and the process of narrative inquiry are explained in depth in chapter four. In addition, the sampling process, the data generation instruments, data analysis and ethical considerations are provided.

Chapter five presents a detailed analysis of results and also provides an overview of the interpretation of the findings against the research questions specifically and the literature in general.

The sixth and final chapter outlines the relevant conclusions linked to the research questions and significance of the study. It also provides a personal reflection of the research journey, implications of findings for education and recommendations for further research.
1.9 SUMMARY

The under-representation of females in the sciences as described earlier is both a global and a Zimbabwean phenomenon. Despite both international and national recognition and concern for the lower numbers of women participating in physics, changes in policy seem to be making little if no difference on the ground. These observations point to the reflection that there is a disjuncture between policy formulation and implementation. A deeper understanding of the under-representation within the context of identity and identity formation could provide tangible clues as to what change parameters would influence a shift in perception amongst young women. Hence, the next chapter provides a comprehensive literature review detailing a synthesis of a body of knowledge linked identity and identity formation as well as the various contexts and gender related theories and identity models that are thought to influence the self, perceptions of the self and choices made in relation to career orientations.
CHAPTER 2

SITUATING THE STUDY IN THE LITERATURE

“Who am I? What do I believe I am capable of? What informed the pathways I chose to follow?” (Adapted from Interview Questions)

2.1 INTRODUCTION

The term identity is derived from the Latin word *identitas*, which is derived from the word *idem*, meaning, the same, (Petersoo, 2007, p. 117). The term is defined differently by various theorists who attempt to explain it. For example, Castells (2004, p. 6) defines identity as, “people’s source of meaning and experience,” while Polman and Miller (2010, p. 884), consider it to be “the story that each one of us is creating for ourselves.” Identity is personal and it is influenced and shaped by the context in which we live. Humans have a natural tendency and desire to belong to a group or a community of practice (CoP) as “identity illustrates the desire and the need for human beings to interpret themselves as being part of something, or a certain entity” (Puusa & Tolvanen, 2006, p. 30).

This chapter begins by exploring the concept of identity and identity formation; it considers gender and identity as well as the contexts that influence identity. Finally, it explores students’ perceptions of and participation in physics as a consequence of and as a driver of identity formation.

2.2 IDENTITY AND IDENTITY FORMATION

Identity has always been explored at an individual level, and with the passage of time its investigation has been extended to include activities at a group level (Puusa & Tolvanen, 2006). This is mainly because identity cannot be viewed as separate from the social milieu in which it is located. Throughout the process of identity construction, individuals attempt to make meaning of who they are in relation to how others perceive them. The classifications and associations that take place do so through the interaction process within what Jenkins (2004, p. 17) terms, the “human world.” Jenkins (2004, p. 17) identifies the following orders through which people can understand how the human world is constructed and experienced. In the first instance he identifies *the individual order* (first order) which relates to the interaction that happens in the mind of the individual. Secondly, there is *the interaction order* (second order) which involves the interaction that takes place in the form of relationships between or amongst
individuals in their CoP. The impact of the first and second order interactions on identity is scrutinised in the context of personal and social identity.

2.2.1 Personal Identity

In his seminal identity theory Mead (1934, p. 135) proposes that the “self is not initially there, at birth.” It arises in the process of social experience and activity, developing in the individual as a result of his/her relations to this process. The I and the Me are identified as key components of identity by Mead (1934). These two components are parts of a whole, but are separable in behaviour and experience. This idea is also more recently subscribed to by Jenkins (2004), when he outlined the concepts of the Self and the Person.

Human beings use the words I and Me constantly in day-to-day interactions, when referring to actions and associations, or when giving explanations of why they make certain decisions about anything that concerns them. According to identity theorist, James (1890), the I is that part of our identity that reflects on the Me and is constituted as the unchanging self as experienced by the person. The Me on the other hand is that part of who I am which can be observed and known and is composed of social categories. The I gives us novel behaviour and experiences, while the Me emanates from our assumptions of the attitudes of others towards us, and is more closely aligned with expectations and social responsibilities (Mead, 1934). By virtue of being phases of a social process, the I is the historical precedent of the Me. Mead (1934) argues that the two components are interrelated. He further asserts that incorporation of others’ attitudes towards the Me is the mechanism by which the community becomes part of the individual. The response which the I is capable of becomes the mechanism by which an individual can alter society (ibid.). Bauman (2004, p. 19) also argues that when one believes that one can actually be someone other than who one is, then it opens possibilities for realisation and action.

Personal identity is never a finished product, but it is continually evolving. The new experiences, new insights of oneself, social changes, exposure to other world views, and deeper reflection lead to regular revisions of one’s personal identity (Parekh, 2009). Personal identity therefore, provides a vantage point from which one can view one’s past and construct meaningful narratives of one’s life (ibid.) which connects to one’s social identity.
2.2.2 Social Identity

According to Jenkins (2004, p. 4), all human identities are essentially “social identities.” We invariably belong to a diversity of social groups that are to some degree more prominent to us in different contexts (Reicher, 2004). Social identity is grounded upon the assumption that “society is made up of social categories that stand in power relations to one another,” (Hogg & Abrams, 1988, p. 14). When one behaves in terms of a certain social identity, one is guided by the “norms, values and beliefs that define the relevant identity” (Reicher, 2004, p. 929). Identifying ourselves or others is a matter of meaning, and “meaning always involves interaction agreement and disagreement, convention and innovation, communication and negotiation,” (Jenkins, 2004, p. 4). From this perspective, participation in a CoP shapes one’s identity.

According to Vryan, Adler, and Adler (2003), social identity is shaped and forged with socially constructed categories of people (like female students), or the position within a social structure, such as a school environment. This identity ‘stays’ as long as positions in socially structured relationships remain stable.

We define ourselves and others in the light of our social identities across many of the different kinds of contexts in which we find ourselves, thus, providing continuity even as we step in and out of various situational identities (Vryan et al., 2003, p. 371).

People depend on mutual recognition by others and sometimes they manifest social identities in their situational enactments. The notion of role as part of social identity is remarkable, in that roles are attached to certain positions or tasks, within which a person may or may not identify. Identities are shaped by the so-called internalised role expectation. There is thus a need to take into cognisance identity in the context of a sociocultural milieu in which female students are born, raised and embedded. Therefore, this encourages the need to investigate the ways in which identity formation influences female students’ perceptions of physics and their participation in the subject.

2.2.3 Identity Formation

Generally, identity formation is “an ongoing process of negotiating and resolving conflicts between previously incorporated and new experiences,” (Santora, 2003, p. 2). Jenkins (2004) and Moshman (2005) expound that individuals negotiate their identity within the interaction order. On the other hand, Castells (2004, p. 7) claims that “people use various construction
apparatus from their past, such as their belief systems, their location in space and time, their genetic composition and their organisations to ‘construct’ their identity.” Luhrmann and Eberl (2007, p. 117) contend that identity is “not something that can be found, but needs to be constructed.” In addition, during the identity formation process, people act and interact. They “recognise themselves as social actors, as well as being recognised by others as a particular type of a person,” (Munday, 2006, p. 91). Hence, one negotiates the meanings of one’s experience as a member of a social community when constructing identity. In view of this, one needs to explore identity issues in terms of gender categorisation in society.

2.3 GENDER AND IDENTITY

Sex refers to “the biological and reproductive classification” of an organism, while gender refers to “the cultural aspect of sex” (Franklin, 2012, p. 1; Scantlebury & Baker, 2007, p. 258). According to Schmitt, Leclerc, and Dubé-Rioux (1981, p. 122) gender serves as an important social category in all cultures, because each culture develops a “rich network of associations that surround its concepts of maleness and femaleness.” However, “individuals within a culture may differ from one another in the degree to which they utilise cultural definitions of masculinity and femininity as standards against which they perceive, categorise, and evaluate gender-related [roles and] information” (Schmitt et al., 1981, p. 122). In other words, gender is “a way in which social practice is ordered.” (Connell, 2005, p. 1804).

Our “socialisation into gender appropriate roles begins when our sex is identified” (Franklin, 2012, p. 5). Even before birth, parents “invest in gender appropriate toys for their unborn babies” (Franklin, 2012, p. 36). For example, “infants’ bedrooms are decorated differently reinforcing gender differences” (ibid, p. 31) and their toys are stereotyped from a very early age. Hence, gender is probably one of the very first influences on identity, thus, Gender Development Theories (GDT) are explored in some detail in the sections below.

2.3.1 GENDER DEVELOPMENT THEORIES (GDT)

A number of GDT are described in literature (Franklin, 2012; Lips, 2008), however, for the purposes of this study, two theories, that is Social Cognitive Theory (SCT) and the Gender

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6 Male or Female
7 In other words, how we come to know ourselves as social human beings that are male and female (Franklin, 2012, p. 1; p. 2)
8 Prenatally or at the moment of birth
Schematic Theory (GST) are considered. I chose these two theories because their focus is directly related to how one views oneself in relation to gender and how that might result in different perspectives based on gender. These two theories link directly to the Feminist Standpoint Theory (FST which serves as one of the theoretical lenses that informs this study and is described in detail in the next chapter).

One element of concern that needs noting is that theorising about gender has been predominantly a Eurocentric occupation (Dawes & Biersteker, 2011) with very little recorded information from an African perspective. Dawes and Biersteker (2011) in a chapter on early childhood development in the *Handbook of African Generative Curriculum* confirm much of what is described in SCT and GST with respect to identity in an African context. In this respect, one of the outcomes of this study might be a contribution to the body of knowledge that relates to the influence of identity and identity formation in an African context.

### 2.3.2 Social Cognitive Theory (SCT)

Human learning is “cognitively mediated” (Lips, 2008, p. 190). SCT conceptualises gender development and functioning as the product of the interplay between cognitive, affective, biological, and socio-structural influences. It argues for the influential effect of cognitive factors (thinking and memory) in self-development, adaptation, and change. Hence, it adopts “a multifaceted social construction model of gender” (Bandura & Bussey, 2004, p. 679) where both mental activities (cognitive) as well as family or peers have an influence on shaping gender identity.

When informed about a child’s biological sex, parents and others in the community often relate to the child based on the gender-role expected of the child (Lips, 2008). According to SCT, children are encouraged or coerced to fit in with social expectations provided by their societies (Lips, 2008). This is one reason why boys and girls learn to behave differently since they are treated differently by their parents and their communities. SCT emphasises the power of observational learning and reinforcement. Bandura (1977) as cited by Lips (2008) suggests that the child develops gender identity through a learning process that involves imitation, modelling, and reinforcement. The theory rests on the assumption that boys learn to be masculine and girls learn to be feminine because gender-role appropriate behaviour is rewarded and gender-role inappropriate behaviour is punished or ignored. Children learn which behaviours are gender-role appropriate by observing and imitating adults and peers and through
trial and error. In SCT, peers function as one of the inter-dependent societal subsystems that contribute to gender differentiation. However, it must be noted that peers are not the initiating motivators or the originators of gender development (Bandura & Bussey, 2004).

“Gender labelling assumes special significance in early gender development because it gives salience to sorting people on the basis of gender, aggregates the features and activities that characterise each gender, and provides the basis for categorising oneself” (Bandura & Bussey, 2004, p. 680). Once gender self-categorisation occurs, it takes on added significance as children increasingly recognise that the social world around them, composed of institutional arrangements, norms, incentive systems, environmental supports, constraints and opportunities, is heavily structured around this categorical differentiation (ibid.). While SCT adds the dimension of imitation and modelling, it is gender schemas used by the children that regulate their behaviour to achieve culturally acceptable notions of femininity and masculinity.

2.3.2.1 Gender Schematic Theory (GST)

Gender Schematic Theory and SCT are interrelated. SCT portrays the child as both actively constructing gender categories and responding to environmental cues while GST is based on the idea that children form organised knowledge structures (schemas9), which are gender-related conceptions of themselves and others. These schemas influence children’s thinking and behaviour (Martin & Ruble, 2004). GST begins with the observation that the developing child invariably learns his or her society’s cultural definitions of “femaleness and maleness” (Bem, 1983, p. 603). It proposes that, in addition to learning content-specific information about gender, the child also learns to invoke a heterogeneous network of sex-related associations in order to evaluate and assimilate new information (ibid.). The child, in short, learns to “encode and to organise information” in terms of an evolving gender schema, that is, a network of associations that organises and guides an individual’s perception (Bem, 1983, p. 603). This may include general expectations about people, social roles, and events and how to behave in certain situations. GST thus construes perception as a constructive process in which the interaction between incoming information and an individual’s pre-existing schema determines or influences what is perceived.

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9 A schema is a mental structure or cognitive repertoire, which contains general expectation and knowledge of the world.
It is crucial to understand that these “schemas and stereotypes are a by-product of that particular environment,” (Franklin, 2012, p. 102). Campbell, Shirley, and Candy (2004) claim that the acquisition of gender schemas begins during infancy. This acquisition of gender schemas occurs in three stages which according to Franklin (2012, p. 103) are:

1. **Beginning of awareness** – children of between 2 and 3 years develop gender schemas.
2. **Rigidity** – between five to seven years, the knowledge is organised into very strict gender schemas with no flexibility, for example, ‘only girls can wear pink’.
3. **Flexibility** - which occurs around seven years of age for example, children learn to realise that boys can wear pink.

It is during these three stages that gender schemas become integrated into cognitive models. Franklin (2012, p. 103) further explains that “once these gender schemas have become internalised, the child begins to use these as a marker for their own behaviour.” Girls develop aspects of how they should behave. Bem therefore argues that:

> “The gender schema becomes a prescriptive standard or a guide and self-esteem becomes its hostage. Here, then enters an internalised motivational factor that prompts an individual to regulate his or her behaviour to that which conforms to the cultural definition of *femaleness* and *maleness*” (Bem, 1983, p. 605).

It is becoming evident that the gender schemas are used by the child (female student) to “regulate their behaviour to achieve culturally acceptable notions of femininity” (Franklin, 2012, p. 104). Franklin claims that GST proposes that individuals are *schematic* (i.e. conforms strongly to gender schemas) or *aschematic* (i.e. are not concerned with gender schemas). However, it must be noted that it would probably be very difficult to raise children in an aschematic way in a schematic society. This is because there are a number of set assumptions in any given society and these assumptions affect how we perceive gender in daily interactions and events. Thus, different contextual factors which impact on identity formation within the framework of gender categorisation need to be examined.

### 2.4 CONTEXTUAL FACTORS SHAPING IDENTITY

Context can be defined as, “circumstances, times, conditions, situations and ambience,” (Collins & Hands, 2006, p. 211) to which people are exposed to in society. More specifically, for the purposes of this study, context is considered to be culture, the family, the socio-economic background of parents, the teachers, the school and peers that may influence female students as they interact in their respective CoP. The self has to negotiate with each of the communities (for example, family, school, peers etc.) if it is not going to be an outcast. This
negotiation can have an influence on the students’ decision making process. These contexts were thought to have a significant influence on female students’ identity formation which consequently influences their perceptions of physics as a subject of choice (Angell, Guttersrud, Henriksen, & Isnes, 2004; Kubeka, 2014; Moshman, 2005). Since choices made by female students could be highly influenced by the social environment, culture is an essential concept that needs exploration as part of the contextual milieu in this study.

2.4.1 Culture

Culture is “a system of shared beliefs, values, customs, behaviours and artefacts that the members of society use to cope with their world and with one another” (Hofstede, 2011, p.3). Cultural values and norms are passed down from generation to generation through learning. In its broadest sense culture is cultivated social behaviour through formal and/or informal learning (Mamwenda, 2005). The essential core of culture consists of traditional ideas and their attached values, attitudes, knowledge and skills (Hofstede, 2011). Culture is an important factor because people’s lives are strongly influenced and shaped by prevailing cultural norms. In essence, it gives identity to a group of people (Bala, Chalil, & Gupta, 2012).

Hofstede (2011, p.3) adds that culture is considered to be “the collective programming of the mind that distinguishes the members of one group or category of people from others.” Generally, the differences observed amongst people (diversity) are as a result of differences in culture. Culture, though deeply rooted and embedded in any society, is not static but is dynamic in two ways. Firstly, it changes with time, progress and modernity. Secondly, people can choose the contexts within which they follow/adhere to culture. For example, at home amongst family members’ cultural norms have a stronghold but amongst peers one may be allowed to exercise more freedom.

Culture and tradition are intertwined, since tradition can be considered as an integral part of culture. Tradition has been defined by Mwamwenda (2005, p. 89) as “a practice, custom or story that is memorised and passed down from generation to generation originally with no need for a written system.” As traditional values and norms are generally transferred by the stories that parents tell their children from a very early age, the children develop the expected norms and behaviour.

Children’s cognitive development and functioning are highly influenced by social events which generally originate from traditions. Culture dictates the training, development and refining of
the mind from a young age by elders within the norms that are regarded as acceptable by that social group (Mwamwenda, 2004). Hence, “if the cultures of child-rearing practices are gender-stereotyped, then boys and girls will be brought up very differently from each other,” (Van Leuvan, 2004, p. 249). This is probably a universal observation linked to the fact that since there are only two sexes in society based on culture and tradition, boys and girls are socialised differently. Thus, the way individuals behave is dependent on how central they consider gender schemas to be as it is difficult to raise children in an aschematic way in a schematic society (Bem, 1983). In this context, Zimbabwe being a gendered society (schematic), culture and traditional values play an important role in shaping female students’ identity and in essence it is “inheritable from their parents,” (Mwamwenda, 2005, pg. 374-375).

2.4.2 The family

The family is the most naturally occurring group or CoP in any society. It is the most important and primary socialising agent, especially during the first years of life for a child. The family is “a highly complex social organism that mirrors and actively interacts with its social and cultural context” (Scabini & Manzi, 2011, p. 566). As a “unique relationship context that influences the contents and processes of identity” (ibid.), the family as a CoP, organises its primary relationships with its members. It is these relationships that connect and bind together different genders and different generations over time to give rise to a new generation. As a result, the family influences aspects of personal identity in major ways. In this regard, the family is not a neutral environment but it is a context that deeply affects the individual, especially during adolescence when identity development is in progress. This aspect is important to this study as the participants are adolescents attempting to develop the kind of identity they would want in the future as adults.

Meece, Glienke, and Burg (2006) suggest that socialisation experiences play an important role in gender differentiation. The fact that gender differences occur so early in development, the home environment plays an important role in the shaping of competency, beliefs and interests in children. Parental beliefs about their children’s abilities have a strong influence in their children’s own beliefs about their academic abilities (Bleeker & Jacobs, 2004). For example,

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10 That is, are not concerned with gender schemas
11 That is conform strongly to gender schemas
cultural stereotypes reinforce the belief that men excel in mathematics and science. Hence, the finding that women are underrepresented in maths and science is not surprising.

Paradoxically, Hannam (2008) found that parents may encourage their daughters to pursue a medical career but due to stereotyping, they dissuade them from taking physics in school. This assertion poses a vital question in relation to this study as such entrenched beliefs could significantly impact female students’ participation or non-participation in physics. Pey-Tee and Subramaniam (2013, p. 113) when referring to female participation in physics careers speculate that “this discouraging attitude of parents could be one of the reasons that contribute to the low intention among students to pursue a physics-based career...”

In addition, the more academically educated parents are, the more likely they are to critically analyse societal norms and values compared to parents from disadvantaged socio-economic backgrounds. In privileged homes, parental attitudes toward education are more positive and parents are better able to support their children’s choices (Gudyanga, 2014). Such parents usually provide additional resources that their children may need. It has also been observed that parents from disadvantaged backgrounds may motivate their children to get an education as it increases their opportunities for a better life, hence, they may support female students choosing to take science related studies.

While it is evident that the family as a contextual factor plays a significant role in the identity development which impacts the perception and participation of female students in physics, teachers and the school also play a crucial role in their identity development.

2.4.3 Teachers and School

All schools in Zimbabwe (including the ones sampled in this study) generally subscribe to the Zimbabwean culture since schools are considered micro-societies. They, therefore, reflect the norms, values and beliefs of the wider society and are considered to be an extension of the home.

Like the family, schools act as “powerful agents of gender socialisation because they represent a vast social environment where children come together and learn about who they are by watching and interacting with others” (Haralambos & Holborn, 2008, p. 600). Meece et al. (2006, p. 361) noted that “children have an opportunity to validate, refine, and enact their gender beliefs and behaviour.” Schools also impact children’s “gender role conceptions, beliefs
and social identities as children observe and imitate traditional gender roles and encounter gender stereotypes in their classrooms” (ibid.). A school’s instructional and extracurricular activities may also play an important role in reinforcing gender stereotypes. The hidden curriculum also reinforces gender stereotyping. For example, teachers may apportion work based on gendering, like girls must clean classrooms and boys must carry furniture.

In addition, Meece et al., (2006) contend that teachers are important sources of information that children draw on to form their identity. Teachers can provide and encourage different recreational and learning activities that could support the development of specific skills and interests (ibid.). Additionally, teachers serve as important role models since they communicate information about their own abilities and skills. It is possible to ascertain that the implicit and explicit actions of teachers as role models form a major influence on female students’ identity formation. Teachers for example, may or may not encourage female students to participate in sporting activities such as football or rugby which are considered to be masculine. Hence, the importance of how teachers interact with female students cannot be ignored as this could have a negative or positive impact on the way female students develop their individual identities. Extrapolating from the above, it is highly likely that the classroom experiences that teachers provide can shape female students’ perception with regards to their roles in the CoP (Murphy & Whitelegg, 2006a; Zohar & Bronshtein, 2005). Hazari et al. (2010) have shown that students can modify their behaviour in order to form an identity they want to be recognised with in adult life.

Lyons (2006) demonstrated that the family and the school as interrelated communities of practice influence each other and work together to motivate female students who are capable to enrol in physics. Lyons (2006) argued that a student is more likely to enrol in the physical sciences if either the student’s science teachers or a key family member advocates for the physical sciences. This affirmation helps the student to overcome his/her fear of the subject as well as its relevance (Lyons, 2006). Apart from the family, school and teachers, peers constitute another CoP which imposes a strong influence on identity formation. The impact of peers is particularly noteworthy during adolescence.

2.4.4 Peers

It has been reported that “students rated parents and peers as having the greatest influence on their decisions of enrolment choices” (Lyons, 2006, p. 298). Once children begin to interact
with other children, their peers begin to exercise a strong influence on their attitudes and identities. Children who conform to gender stereotypes are accepted by their peers more than those who do not conform (Rudman & Glick, 2008). Therefore, girls are motivated to conform to prescriptions of femininity and boys to prescriptions of masculinity. Female peer groups reinforce the feminine identity, hence, there is a lot of pressure within peer group settings. Many adolescent students do what is necessary to gain the approval and acceptance of their peers, sometimes against the expectations of culture, parents and teachers. Lips (2008) claims that peers are also part of the mediators and interpreters of cultural views of gender as children become socialised primarily by identifying with their peer group and taking on the group’s norms of attitudes and behaviour. In addition, the peer group as a CoP filters cultural transmissions. For example, adolescents quickly learn from their peers what home behaviours are acceptable or not. Usually they do not transfer behaviour learned at home to the peer group unless it is shared and approved by most of the other peers.

The argument above shows that peer groups play a crucial role in the secondary socialisation of the adolescent female students (Kubeka, 2014) in that they can offer them a bridge for the gradual attainment of ‘independence’ from the parents (Gouws, Kruger, & Burger, 2008). The Zimbabwean female students are not really ‘free’ from the influence of their parents and their community. They have to adopt what is grounded in the fabric of the community’s culture, hence, they have to obey their parents and also respect their elders. However, in their peer groups, adolescents may make their own decisions and share their actual thoughts and feelings with the peer group more than with their parents. Because of this, conflicts may arise if their decisions are contrary to what are expected by the parents. Adolescence is the period where children can spend a lot of their time thinking and feeling confused about who they are exactly and who they might want to become in future (Kroger, 2007). Moreover, high school is a time of experimentation providing female students with the opportunity to try out new behaviour patterns with the peer group as a reference framework. Amendments are made when the feedback from peers is negative.

Group identity also influences the development of individual identity (Gouws et al., 2008). Acceptance by peers and popularity are highly important to students because they fear isolation. They may gain the opportunity to learn new roles and experiment with them within the group. The peer groups offer an opportunity for adolescents to compete with members of his/her own age group on an equal footing for a place in society (Kroger, 2007). Adolescents
can speak freely about their fears, feelings, dreams and ideals amongst their peers, thus gaining the opportunity to discharge emotional tension. Peers can help to also resolve conflicts within the group and between a peer member and others amicably. Thus, we learn our unique selves through socialisation with significant others in our society (Kubeka, 2014). In this regard, the family, teachers, school and peers are primary contexts influencing identity but female role models in physics may have a significant role to play as well.

2.4.5 Female role models in physics

Lockwood (2006, p. 36) states that “role models are individuals who provide an example of the kind of success that one may achieve, and they also provide a template of the behaviours that are needed to achieve such success. By identifying with an outstanding role model, individuals can become inspired to pursue similar achievements.” An area of concern found in the literature (Angell et al., 2004; Lockwood, 2006; Lyons, 2006; Owen, Dickson, Stanisstreet, & Boyes, 2008) revolves around the low presence and visibility of females in the field of physics. This is to be expected as there is an under-representation of females in careers related to the physical sciences. Females, therefore, do have very few if any female role models to emulate.

Lockwood (2006, p. 44) proposes that female role models may be especially beneficial for women for a variety of reasons:

- Outstanding women can function as inspirational examples of success, illustrating the kinds of achievements that are possible for women around them.
- They demonstrate that it is possible to overcome traditional gender barriers, indicating to other women that high levels of success are indeed attainable.
- Female role models can also serve as proxies, guides to the potential accomplishments for which other women can strive.
- Finally, by demonstrating their competence in traditionally male occupations, highly successful women may undermine traditional gender stereotypes about women, thus reducing the damaging potential of stereotype threat effects.

To examine the sociocultural factors that influence identity formation from a theoretical perspective, Moshman (2005) highlights Marcia’s Identity Status Model (1966) that expands on Erikson’s Psychosocial Theory (1963). It should be noted that Marcia’s model is derived from a western context, therefore, its application and relevance to Zimbabwe needs to be evaluated.
2.5 MARCIA’S IDENTITY STATUS MODEL

Marcia’s (1966) model highlights the role of social contexts in the construction of identity during adolescence. He used the term identity status to label and describe four unique developmental identity stages (Marcia, 1987). The suggested four statuses represent varied modes of identity formation that depend on the way in which adolescents explore them and make commitments (Moshman, 2005). The diagram (Fig 2.1) depicts Marcia’s Model.

![Marcia's Identity Status Model](image)

**Figure 2.1: Marcia’s Identity Status Model**

Figure 2.1 shows the four modes namely, Identity Diffusion, Foreclosure, Moratorium and Achievement Statuses. Marcia (1987) believes that any late adolescent above the age of eighteen years should be categorised into any one of the four statuses. Gouws et al. (2008) believe that Marcia’s model foregrounds two dimensions of identity construction, namely exploration and commitment. Exploration here refers to the adolescent’s search of various identity alternatives available to him/her. Commitment involves making decisions and personal investments in an identity. The decision to commit to an identity is, however, preceded by a crisis (ibid.). Crisis is a term that is used to describe a series of internal conflicts that are linked to the stages of development. The way a person resolves a crisis will determine their personal identity and hence their future development.

Table 2.1 provides a summary for the four identity statuses
Table 2.1: Marcia’s stages of identity formation (Rosen, 2007, p. 74)

| Identity Diffusion          | - No identity crisis yet.  
|                            | - No commitments         
|                            | - Often confused and over whelmed |
| Fore closure               | - May or may not have experience a crisis  
|                            | - Made commitments based on outside forces (e.g. parents, society) but not through own process.  
|                            | - Often makes quick choices without consideration |
| Moratorium                 | - Major crisis  
|                            | - No commitments but working on them  
|                            | - Lots of rebellion, desertification. |
| Identity achievement       | - Experienced and struggled with resolved crisis  
|                            | - Made commitments decisions on their own  
|                            | - Still worry about achieving goals, but do well under stress and anxiety. |

2.5.1 **Identity Diffused Status (no commitment and little systematic exploration)**

Adolescents with an identity diffused status (Table 2.1) are considered to have the least developmental advancement as they are not committed to any direction in their lives, regardless of exploration opportunities (Marcia 1987). They have no set occupational or ideological direction and, therefore, they hold an immature identity (Marcia, 2002). Adolescents in this stage score low on self-esteem and high on measures of depression (Kroger, 2003). They often feel hopeless about their future and make no attempt to resolve their status or construct a desired identity.

2.5.2 **Identity Foreclosure Status** (commitment without much prior exploration)

Identity foreclosure means that the adolescent blindly accepts the identity and values that were given at childhood by families and significant others (Table 2.1). The adolescent's identity is foreclosed until they are able to determine their true identity independently. The adolescent accepts values and attitudes of parents without examining their meaning (Moshman, 2005). Foreclosed adolescents (see Table 2.1) have lower self-esteem, but they show fewer symptoms of depression (Kroger, 2003). The adolescents’ commitments are not self-chosen and alternative commitments have not been investigated (Moshman, 2005).
2.5.3 Moratorium Status (ongoing exploration with little commitment)

This status refers to an adolescent who has acquired vague or ill-formed occupational commitments and he/she is still undergoing an identity search (crisis). At this stage, adolescents are seeking and exploring processes and questions about values and goals in his/her own life (Marcia, 2002). They are beginning to commit to an identity but they are still developing it (Moshman, 2005). Moratorium adolescents generally have lower self-esteem and show high levels of depressed mood and anxiety because of their continuing exploration (Berman, Weems, & Stickle, 2006). During this phase, the individual experiments with a wide range of commitments. He/she is ready to choose any of the options available but has not made a particular choice yet (Gouws et al., 2008). He/she may eventually resolve his/her crisis by making either a positive or a negative commitment.

2.5.4 Identity Achievement Status (commitment following exploration)

Identity achievement is the state of having developed well-defined personal values and self-concepts (Table 2.1). Adolescent identities may be expanded and further defined in adulthood, and they are committed to an ideology and have a strong sense of ego identity. Ego identity is one’s idea of his or her own importance or worth and a feeling of superiority to other people (Zimmermann & Becker-Stoll, 2002).

At this stage the adolescent has arrived at self-defined commitment. The individual has made choices and is committed to pursuing them (Marcia, 2002). Adolescents in this stage are able to comply with a series of values and goals. Researchers indicated that few students achieve this status by the end of high school (Arefi, d’Angelo, Mayer, & Reinartz, 2011) as they are young and immature. Adolescents, who have reached identity achievement status, embody more self-esteem and are more likely to think abstractly and critically. Adolescents at this status report high self-esteem and low depression and are at the most advanced level of development. Arefi et al. (2011) suggest that active involvement in the process of exploring and commitment is required to achieve desired identity.

2.5.5 Marcia’s Model from Zimbabwe’s Perspective

The identity statuses of late adolescents who are young adults as described by Marcia is based on a western cultural setting. However, the cultural values, norms and family structure in an
African context vary in many respects and, therefore, Marcia’s model needs to be interpreted to examine its adaptability to the African and in particular to the Zimbabwean context.

For example, an African young person generally does not display the behaviours characteristic of the diffusion status stage for various reasons. Usually Zimbabwean young people generally have direction, a vision and they do not generally feel hopeless about their future because the culture, extended family as well as the elders in society are highly supportive during the development of children into adolescence. It is because of this support that adolescents are able to make guided decisions early on in life. However, Zimbabwean adolescents’ choices are not really self-made but consultation with the elders and a duty of obedience play a role in developing commitment. Thus, the adolescent’s commitment is not really ‘self-defined’ in the African context. Under normal circumstances, children conform and do not want to go against the norm, thereby pleasing family at the expense of individual desire. Hence, the diffusion status will be an exception rather than a norm in African societies.

With regard to identity foreclosure status there are similarities as well as some differences between children brought up in the Zimbabwean and western cultures. This stage is similar to the African children in that obedience to parents and elders is the norm. Children in an African society must obey their parents and elders who instil cultural values, beliefs and ideas from a very tender age. Thus, there is a perpetuation of societal values and tradition. On the other hand, at eighteen, children from a western society are generally independent unlike the Zimbabwean child who is never independent of the parents and the extended family, even if one is married and has one’s own family. A person in the Zimbabwean context is expected to participate and contribute to all extended family matters. Even at fifty years, one is still a ‘child’ to his/her parents. In addition, unlike their counterparts in western societies, the adolescents in Zimbabwe accept guidance despite conflicts and peer pressure.

The moratorium status as described in Marcia’s model is not necessarily applicable to the Zimbabwean children in totality. Generally, the majority of Zimbabwean young people believe in themselves, have high self-esteem and have high ambition to succeed academically and in life. For any child who may appear to face any challenges in life, the extended family provides support since the life-style is not individualistic. The African adolescent is never really ‘free’ to explore alternatives as an individual and their choices are generally negotiated with parents and elders who are highly influential in the choices they make.
Young adults attaining a stage of self-defined commitment (identity achievement status) in an African context largely depends on socio-economic status of parents as well as parenting styles. Kroger (2007) points out that Marcia’s Identity Status Model has been applied in several studies that have investigated the influence of parenting styles on adolescents’ identities. According to the results of these studies, most adolescents with identity achievement status were from families that emphasise individuality and connectedness, whereas adolescents with identity foreclosure status mostly came from child-centred families.

However, there seems to be a difference between the parenting styles of the educated and the uneducated parents in Zimbabwe. The educated parents, especially if they are of middle socio-economic status, encourage their children to study science subjects. This is supported by (Gudyanga, 2014, p. 45) who claims that:

Parents of higher socio economic status [and] higher level of education encourage their sons and daughters to learn sciences [e. g. physics]. They value sciences [physics] by virtue of their academic enlightenment. They also recognise tremendous opportunities that can arise from being more scientifically and technologically literate and better prepared to participate in the 21st century science and technological workforce. Parents (whether it is the father or mother) have a critical role to play in encouraging and support[ing] their children’s science [physics] learning at home, in school and through their communities.

The author contends further that, the more intensely parents are involved in the education of their children, the more confident and engaged their children become as learners. It can therefore be argued that Zimbabwean parents having a higher educational level are most likely to support their children’s choices of going against the norm. Zimbabwean educated parents of low socio-economic background also support their daughters’ choice of studying physics emotionally but may not be in a position to support them materially due to financial constraints. However, only two of the four stages of Marcia’s identity status model are applicable to Zimbabwean students. These are fore closure and identity achievement statuses which have been explained above.

Issues of identity cannot be separated from issues of learning “because learning transforms who we are and what we can do, it is an experience of identity” (Wenger, 1998, p. 215).

2.6 IDENTIFY AND LEARNING

One’s identity assists one to look for answers to frequently asked questions such as, “Who am I?” “Who do I want to be?” “Who could I be?” “What are my goals in life?” “How do I handle
my relationship with other human beings?” and “What is my place with society as a human being?” (Puusa & Tolvanen, 2006, p. 29). Thus, identity can be understood as referring to the different meanings that individuals ascribe to themselves.

Typically, human beings characterise themselves based on structural features of membership to a group or with the help of characteristics that an individual associates himself/herself with. In other words, identity is formed by different characterisations of oneself. There is social interaction during identity formation as well as during learning. The individual’s conception of who one is may be picked up from learning as individuals interact with others.

To learn is to take up a new practice or to change one’s position in a community. Therefore, this implies that learning can change identity and the self. Wenger (1998, p. 151) defines identity as follows:

An identity then is a layering of events of participation and reification by which our experience and its social interpretation inform each other. As we encounter our effects on the world and develop our relations with others, these layers build upon each other to produce our identity as a very complex interweaving of participative experience and reificative projections. Bringing the two together through the negotiation of meaning, we construct who we are.

Lave and Wenger (1991) stress the social nature of learning and knowing, which can only develop through meaningful student engagement, experience, and practice within a social community. As students develop knowledge, competence, and meaning from these social interactions, they begin to construct their identities (who they wish they to be, in relation to these communities). Hence through learning and interacting within a learning community student perception and subsequent participation in physics is influenced.

### 2.7 FEMALE STUDENTS’ PERCEPTIONS OF AND PARTICIPATION IN PHYSICS

Research findings with regard to female students’ perception of physics indicate that students view physics as “difficult”, “uninteresting or boring”, and “irrelevant” (Angell et al., 2004, p. 690; Checkley, 2010, p. 1; Lyons, 2006, p. 285; Whitelegg, Murphy, & Hart, 2007, p. 33). Students’ perception of physics as being difficult increases with age and this is related to an increase in mathematical demand and increased sense of inadequacy (Whitelegg et al., 2007). In most cases female students generally consider physics to be irrelevant to their lives as well as to their world of work because of how they are socialised. Checkley (2010) argued that many
high school students have a fear of physics as a result of the level of difficulty which the students associate with the subject. This fear results in students’ developing a negative attitude towards physics and affects the socio-economic development of a country. For example, when fewer students take physics “it limits the number of people capable of working in technological fields” (Angell et al., 2004, p. 702).

As outlined earlier, Checkley (2010, p. 3) argued that “decreased numbers of scientifically literate students also result in a lack of females choosing careers in science [physics]”. The result is that a decreased population of scientifically literate people would lead to a decreased number of female role models in the subject. Female students need female role models if they are to construct a positive identity and to participate fully in physics. It is from observing others that one forms an idea of how new behaviour should be performed and later this coded information serves as a guide for action. Thus the role models play an important function of inspiring female students.

Female students may be reluctant to participate (or engage) in science, especially physics because they often perceive the identities of scientists as inconsistent with their own (Brotman & Moore, 2008). “[The] widespread images of ordinary scientists as white men effectively discourage many talented young women ….from exploring physics as an option” (Ong, 2005, p. 596). In other words, if certain subjects (or careers) are generally perceived (by the dominant view) to be occupied by people of certain traits (e.g. gender, physique, social class, etc.), then students who do not wish to be associated, or who do not have the advertised characteristics, may opt for other subjects (or careers) that are more consistent with their self-identity.

2.8 SUMMARY

The epitaph of this chapter asked the questions, “Who am I? What do I believe I am capable of? What informed the pathways I chose to follow?” In exploring the literature that provides insights into various dimensions that inform possible answers to these questions in general, and specifically in connection with the perception and participation of female students in physics, one can conclude that identity and identity formation are shaped by a variety of contextual factors with strong linkages to gender categories. As the research for this study is located within an African context, a critical evaluation of available gender development theories and identity formation models was elucidated in this chapter. The applicability of these theories in the Zimbabwean context was discussed and a pertinent finding was that in this society, cultural
values and norms as well as parental/family influence largely contribute to perceptions of the self (identity) and the choices one makes. The chapter concludes with an evaluation of research that has already been conducted predominantly in western contexts around perceptions and the participation of female students in physics. While these provide an overview and synthesis of a body of knowledge that informs this study, further exploration of appropriate theoretical frameworks was deemed necessary to further refine the lens through which the research questions of this study will be answered. The next chapter provides an in-depth overview of a hybrid of three theoretical frameworks that were chosen to inform this study.
CHAPTER 3
THEORETICAL FRAMEWORK

“If you want to know me, then you must know my story, for my story defines who I am” (McAdams, 1993, p. 11).

“I was living in a rural area, where there was neither electricity nor piped water. I was socialised to use paraffin lamps or candles in this rural community. My parents were not formally educated. My mother was a housewife and a subsistent farmer while my father was employed as a class one truck driver... From an early age, I helped my mother with all household chores early morning before going to school and after school as well. Daily I would start my school lessons in this community of practice (CoP) when I was already tired. I then realised that when I am physically tired, mentally I was also tired...

My mother was very loving, but my father was very authoritarian and uncaring since he would be drunk all the time. It was one day when I was coming from school that I witnessed my father beating up my mother, demonstrating patriarchy at its worst. A patriarchal culture is marked by supremacy of the father in the family. Male supremacy still governs many girl children’s and women’s lives. Patriarchy includes all social mechanisms that reproduce and exert male dominance over females... From my experience, I have always wondered the kind of identity that I was developing.” (Journal Entry, December, 2014)

3.1 INTRODUCTION

Considering the various socio-cultural and gender-related factors that influence identity formation as discussed in the previous chapter, it becomes apparent that the shaping of identity largely occurs in learning communities. Hence, a hybrid of three theoretical frameworks, namely Wenger’s Social Learning Theory (SLT), Sfard and Prusak’s notion of telling identities as stories and Feminist Standpoint Theory (FST) was deemed appropriate for the purpose of this study. Wenger’s SLT is considered first.

3.2 WENGER’S SOCIAL LEARNING THEORY (SLT)

SLT is premised on the fact that learning is a social commitment and that learning within a CoP “shapes not only what we do but also who we are and how we interpret what we do” (Wenger, 1998, p. 4). This implies that the development of one’s identity is closely integrated with the learning that takes place as a result of one’s participation in a community. Therefore, issues of identity are difficult to separate from those of learning. Wenger’s SLT illustrates the ways and means by which members in a CoP engage with each other in creating new
knowledge. SLT is built on four assumptions about what matters in learning and about the nature of knowledge and knowing, including:

- **Humans are social beings** (a central aspect of learning);
- **Knowledge** is a matter of competence with respect to valued enterprises;
- **Knowing** is a matter of active engagement in the world; and
- **Meaning** is our ability to experience the world and to engage with it in a meaningful way (Wenger, 1998, p. 4).

These four assumptions conceptualise learning as an inter-play of four components mediated by social participation, namely: meaning (learning as experience), practice (learning as doing), community (learning as belonging) and identity (learning as becoming) (Wenger, 1998, p. 5). These components are represented diagrammatically in Figure 3.1 below:

![Figure: 3.1 Components of a Social Learning Theory (SLT) Source: (Wenger, 1998, p. 5)](image_url)

These four components which are deeply interconnected and mutually defining together provide a structured framework for SLT.
3.2.1 Meaning (learning as experience)

Wenger (1998, p. 5) defines meaning as “a way of talking about our ability individually and collectively in order to experience our life and the world as meaningful.”

This means that meaning making is integral to all human activities. Wenger elaborates that:

The negotiation of meaning is a productive process, but negotiating meaning is not constructing it from scratch. Meaning is not pre-existing, but neither is it simply made up. Negotiating meaning is at once both historical and dynamic, contextual and unique (Wenger, 1998, p. 54).

From this quotation, the concept of meaning negotiation captures the dynamic relation of living in the world i.e. meaning making is dependent on the world but it is not imposed on people by the world. The negotiation of meaning involves the two interacting processes of participation and reification (Wenger, 1998). The author suggests that it is through the convergence of the processes of participation and reification that meaning is negotiated i.e. this renegotiation of meaning emerges and grows from the interactive process of participation and reification (ibid.). For Wenger (1998), practice is central to meaning making processes and thus the negotiation of meaning.

3.2.2 Practice (learning as doing)

Practice “resides in a community of people and the relations of mutual engagement” (Wenger, 1998, p. 73). As Tusting (2005, pp. 36-37) notes:

This concept of ‘social practice’ offers a way of analysing human activity which brings together the cognitive and the social aspects of human existence. Rather than focussing only on local activity, only on structures and thought or only on broader social structures, it offers us a way of conceptualising the socially situated nature of human activity.

Practice, therefore, resides in a community of people and the relations of mutual engagement by which they can do whatever they do; hence, membership in a community of practice is a matter of mutual engagement (Wenger, 1998). Participation is taking part in and being a part of the community suggesting both action and connection (Wenger, 1998). According to the author participation is the social experience of living in the world in terms of membership in social communities and active involvement in social enterprises. In this case it is both personal and deeply social, shaping not only the individual, but also the collective which is the community. Participation defines the way one belongs to the community in which one engages.
in some undertaking and through which an identity is developed. It involves those goal-directed activities through which we negotiate meaning e.g. talking, thinking, feeling, belonging and doing. Participation in collaborative activities is closely intertwined with reification (Thorpe, 2003). The author explains further that reifications are representations of practice which give form to experience and provide a focus for participation. In other words, reification is “making into a thing… the process of giving form to our experience by producing objects that congeal this experience into ‘thingness’” (Wenger, 1998, p. 58). It occurs when conceptions (like culture) are used to capture a situation and can refer to both a process and its product. The reified products emerge from the process of reification and this process of reification shapes our experience. Hence, the negotiation of meaning is captured in the interplay of reification and participation. As Tusting (2005, p. 39) articulates the interplay by elucidating the meaning of reification as:

A book (reification) is not involved in a process of negotiation of meaning until a person reads it (participation). An insurance claims form (reification) is not involved in negotiation of meaning until someone fills it in and processes it (participation). You cannot have a conversation (participation) without drawing on words, linguistic structures and ways of using language (reification). Participation in meaning making always implies reifications and vice versa.

Although reification of a best practice is good, it requires participation to actualise it and make sense of it. Clarke (2008, p. 32) captures this interrelationship between reification and participation which results in identity as follows:

The dual aspects of meaning, ‘reification’ and ‘participation’ are part of Wenger’s overall model linking the ongoing (re)creation of a community with the negotiations of meaning entailed by the evolution of its practices, necessitating ongoing learning and resulting in identity (trans)formation.

As female students participate as they engage in the physics A-level CoP, new uses or meanings are uncovered and a new reification would occur, influencing participation anew, and vice versa. In fact, Wenger (1998) argues that participation and reification are dimensions of both practice and identity. With specific reference to this study, the female students are said to participate in different communities of practice, for example, at home, in the society, at school, when learning their physics theory or practical lessons as well as in their peer groups etc. As they mutually engage, they will be going through the process of shaping and re-shaping their identities.
Wenger (1998) argues that it is shared practices that hold a community together, i.e. a community of practice is, a community engaging in a shared practice and that through negotiation of meaning, participation and reification, we engage in practice and ultimately form CoP. The author discusses that the concept of practice connotes doing, but more than just doing in and of itself, it is “doing in a historical and social context that gives structure and meaning to what we do and this always makes practice a social practice.” From Wenger’s conception of practice, it goes without saying that practice varies from one CoP to the next and from one historical context to the next. As Grossman et al. (2009) rightly point out, practice may vary from context to context and the nature of practices has consequences for what members of a community are able to see and learn about practice.

3.2.3 Identity (learning as becoming)

According to Van Zoest and Bohl (2008) identity includes not only our knowledge and experiences, but also our perceptions of ourselves, others’ perceptions of us, and our perceptions of others’ perceptions of us that develop as we participate in communities with one another. As stated in the previous chapter, our identities do not exist only within ourselves, but rather are strung between us and the others with whom we interact. In a sense, then, our identities (Van Zoest & Bohl, 2008, p. 320) are the “vehicles from within which we participate with others in community i.e. vehicles that provide both potentials for and limitations to our participation, and that are modified as we learn and grow through mutual participation in joint enterprises with others.” Thus, a person’s own, and others’, perceptions of his/her location and trajectory within a community are key aspects of that person’s identity in practice.

The notion of identity is defined by Wenger (1998, p. 5) as “a way of talking about how learning changes who we are and creates personal histories of becoming in the context of our communities.” This means that identity is acquired and shaped in the engagement in practices of the community. As Hodges and Cady (2012, p. 113) point out, for Wenger, the process of learning is intrinsically linked to identity through “new ways of belonging and being within a community of practice.” Lave and Wenger (1991, p. 13) argue that from a social perspective, learning should be conceived of as “a process of social participation rather than a matter of acquisition of knowledge and cognitive skills in the head” but should involve the construction of identities (Lave & Wenger, 1991b). In social learning the learner acquires a new social

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12 i.e. our values, beliefs, desires, motivations, and self-identifications
“identity” as a result of a process of social recognition by the community, making this sociocultural theory an important lens through which to analyse the behaviour of female students as they interact in the laboratories and physics classrooms. I also used this theory as a lens to assess the facets of identity formation that are considered to be of significance by female students as they learn in their CoP.

The engagement within and between communities of practice is dynamic and at times may not be complementary. It should be noted that where tensions develop and are later resolved by negotiation a new pathway to inform identity is likely to be developed. For example, when a female student decides to pursue a career in physics contrary to the norms of her community, she navigates an uncharted pathway. If resolved, then she contributes to change in the reconceptualisation of her female identity. Hence, the Zimbabwean female students would be authoring their own identities in relation to physics as they engage in the A-level CoP. Lave and Wenger (1991, p. 115) point out that “learning and a sense of identity are inseparable; they are aspects of the same phenomenon.”

In this respect, Tan, Barton, Kang, and O’Neill (2013, p. 1145) claim that a village/home/school/science classroom/ can be construed as a CoP where students are continually “authoring identities-in-practice and developing certain ways of being in the science classroom, while engaging in activities and tasks in relation to the people in the locality, teachers and their peers.” The term identities-in-practice is used to emphasise that identities take shape as one engages in the practices of a community, and learns the ways of talking, knowing, doing and being of that community (Tan et al., 2013). They explain further that these identities-in-practice are related to who students are, who they can be, and who they want to be, as sanctioned by the norms of the classroom. The identities-in-practice that female students author occur in response to context - to the CoP in which they participate and the people and resources available there while identities-in-practice are authored in the moment and being authored against a historical background (ibid.). On one hand, Prusak (2003) argues that sociocultural context affects individual learning and this makes Wenger’s (1998) social learning theory an important lens in this study.

Identity is not only formed through participation (what we are) in certain practices but also through non-participation (what we are not) in other communities (Wenger, 1998). The author contends that what we are not can even become a large part of how we define ourselves i.e. non-participation is, in a reverse kind of fashion, as much a source of identity as participation.
Our relations to CoP involve both participation and non-participation, and our identities are shaped by combinations of the two (Wenger, 1998). The researcher used the concept of participation and non-participation as an important lens to analyse the behaviour of female students in both the theory and practical lessons. Identity is not developed at birth; it is formed by engagement and participation in a community of practice (CoP). Female students’ identity is shaped by their communities as they participate and engage in their communities of practice (Wenger, 2000).

3.2.4 Community (learning as belonging)

A community of practice (which contributes collectively towards shaping a holistic identity of the individual) is an emergent relationship between people who have come together around a joint enterprise, and is characterised by the existence of mutual engagement in the social practices, and in the process developing a shared repertoire of practices, understandings, routines, activities, common stories, and ways of speaking and acting (Wenger, 1998). The author further describes a CoP “… as a living context that can give newcomers access to competence and one that also invites personal experience of engagement by which to incorporate that competence into an identity of participation” (p. 214). A community is not necessarily friendly or harmonious; it has a purpose i.e. it is circumscribed by a joint enterprise consisting of people who differ, have different skills and knowledge but who have a mutually defining identity. This may be the case in the different categories of schools where male and female students engage in a physics A-level CoP.

According to Johnson (2007, p. 281), “a community of practice is defined in Wenger’s 1998 text as a community of people with a mutual engagement in a joint enterprise and with a shared repertoire of resources at their disposal.”
In other words, Wenger (1998) describes a CoP as an entity bounded by three interrelated dimensions or components namely: joint enterprise (what is it about), mutual engagement (how does it function), through negotiated meaning and a shared repertoire (what capability is produced) as shown in Figure 3.2. Communities of practice (which evolve over time), draw their coherence from what he refers to as “mutual engagement, joint enterprise, and shared repertoire” (Wenger, 1998, pp. 73-85). Therefore, an individual’s sense of community develops out of mutual engagement (participation) in the CoP’s joint activity (Wenger, 1998). A person’s lifeworld constitutes engagement and learning in various communities of practice which operate in a wider socio-cultural milieu as discussed in the previous chapter.

### 3.2.4.1 Mutual Engagement

Wenger (1998, p. 73) explains that mutual engagement is an important element of coherence, because practice in communal activities does not happen spontaneously, nor does it exist in the abstract but “it exists because people are engaged in actions whose meanings they negotiate with one another” and “the relations that constitute practice are primarily defined by learning” (Wenger, 1998, p. 131). On the other hand, Clarke (2008, p. 30) defines Wenger’s (1998) mutual engagement as “participation in an endeavour or practice whose meanings are negotiated among participants.” Wenger (1998, p. 75) argues that what makes engagement possible “is much a matter of diversity as it is a matter of homogeneity.” He asserts that:

> In real life, mutual relations among participants are complex mixtures of power and dependence, pleasure and pain, expertise and helplessness, success and failure,
achievement and deprivation, alliance and competition, ease and struggle, authority and collegiality, anger and tenderness, attraction and repugnance, fun and boredom, trust and suspicion, friendship and hatred. Communities of practice have it all (Wenger, 1998, p. 77).

In fact, the point that there is heterogeneity within a community may in some instances be a good thing as Goos and Bennison (2008, p. 42) note, within a community of practice as alluded to previously, productive relationships arise from diversity and these may involve tensions, disagreements and conflicts. Engagement in social practices, via CoP provides learning within a social context where new social identity is acquired by the female students; thereby foregrounding motivation in the subject (Williams, Davis, & Black, 2007). However, participants are connected by their negotiation of an enterprise linked to the larger social system in which their community is nested.

Members of a community are different from one another and may have different aspirations but their “responses to dilemmas and aspirations are connected to the relations they create through mutual engagement …they work together, … they talk with each other all the time, exchange information and opinion…” (Wenger, 1998, p. 75). Hence, mutual engagement among members of a community of practice has the potential of helping members overcome differences and diversity.

3.2.4.2 Joint Enterprise

Joint enterprise is another important element of coherence in communities of practice. Wenger (1998) suggests that it is based on members communally negotiating understandings and responses; taking ownership of responses to situations beyond their control; and being mutually accountable for their actions. A joint enterprise therefore is the result of mutual engagement, and “refers to the focus of activity that links members of a community of practice” (Clarke, 2008, p. 31). There are three important points about the enterprise that keeps the CoP together and these are:

- It is the result of a collective process of negotiation that reflects the full complexity of mutual engagement.
- It is defined by the participants in the very process of pursuing it. It is their negotiated response to their situation and thus belongs to them in a profound sense, in spite of all the forces and influences that may be beyond their control.
- It is not just a stated goal, but creates among participants’ relations of mutual accountability that become an integral part of the practice (Wenger, 1998, pp. 77-78).
This suggests that the joint enterprise is never fully imposed on the group or predetermined, but rather, it is the negotiated result of participants of a CoP to deal with the situation as they experience it. Communities of practice are not “self-contained entities” but develop within “larger contexts - historical, social, cultural and institutional with specific resources and constraints” (Wenger, 1998, p. 79) that is, it is situated within a broader system (institution) that limits and influences it. But while there is a broad enterprise to which the community owes its (initial) existence, this broad enterprise is appropriated and given meaning within the CoP in ways that are not determined by the institution. The enterprise is never fully determined by an outside mandate, by a prescription, or by any individual participation. Even when a community of practice arises in response to some outside mandate, the practice evolves into the community’s own response to that mandate.

3.2.4.3 Shared Repertoire

Wenger (1998, p. 83) defines a ‘repertoire’ as “a community’s set of shared resources,” thereby emphasising both the ‘rehearsed character’ and the ‘availability for further engagement in practice’ of a community’s repertoire. In other words, Clarke (2008, p. 31) says that shared repertoire “refers to the common resources for creating meaning that result from engagement in joint enterprise.” A shared repertoire is a source of community coherence that is created over time in the process of negotiation of meaning within the joint enterprise of the community (Wenger, 1998). The repertoire of a community combines both reificative and participative aspects (artefacts, ways of talking and being, etc.). Hence, the repertoire of a community combines two characteristics that allow it to become a resource for the negotiation of meaning:

- it reflects a history of mutual engagement

However, with reference to my study, Lave and Wenger (1991, p. 49) define learning as “a mutual engagement in social practice.” For individuals like the female A-level students, it means that learning is an engagement which is situated within a specific culture and is a contribution to the practices of their communities. Because learning transforms who we are and what we can do (as stated earlier), it is therefore an expression within which develops, a “joint enterprise” where members negotiate meaning. Wenger (1998) emphasises that learning is inevitable since failing to learn something involves learning something else. As one learns (Van Zoest & Bohl, 2008, p. 322) either within or outside of a community, “one develops new
ways of participating with, and within, communities.” Wenger (1998) further argues that shared histories are fundamental to learning and identity formation within a community of practice:

We are connected to our histories. . . through our experience of participation as our identities are formed, inherited, rejected, interlocked, and transformed through mutual engagement in practice from generation to generation (Wenger, 1998, p. 89).

History cannot be divorced from the culture of a people. Shared history is also fundamental to learning and identity formation. Hence this CoP lens was an effective tool to find the extent to which context\(^\text{13}\) influence identity formation of female students with regard to their perception of physics as a subject of choice in this study. I used the ideas of CoP for data interpretation. The following sections considers the social contexts of SLT.

Wenger (1998, p. 11) explains the social “intellectual context” of his SLT by placing it at the intersection of two ‘axes’ of intellectual traditions as shown by Figure 3.3.

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Figure 3.3 Social context of SLT (Adapted from Wenger, 1998, p. 12)

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\(^{13}\) The historical, cultural, societal and institutional circumstance(s) or situation(s) impacting on female students as they interact in their communities of practice (CoP).
The vertical axis has the two ends labelled ‘theories of social structure’ and ‘theories of situated experience.’ The former emphasises institutions, norms, cultural systems, discourses and history. Theories of social structure seek underlying explanatory structures that account for social patterns and tend to view action as a mere realisation of these structures in specific circumstances. The latter emphasises agency and intentions. Theories of situated experience address the interactive relations of people with their environment. In this sense ‘learning as participation’ is caught in the middle. He explains that: “It [learning] takes place through our engagement in actions and interactions, but it embeds this engagement in culture and history. Through these actions and interactions, learning reproduces and transforms the social structure in which it takes place” (Wenger, 1998, p. 13).

However, Wenger (1998) points out that the horizontal axis (the ends of which are labelled ‘theories of social practice’ and ‘theories of identity’) is the axis with which his work is mostly concerned but adds that this is “set against the backdrop of the vertical one” (p. 13). At one end of the horizontal axis, theories of social practice focus on the production and reproduction of ways of engaging with the world. They are concerned with everyday activity and real-life settings while emphasising social systems of shared resources by which groups organise and coordinate their activities, mutual relationships and interpretations of the world. At the other end, theories of identity focus on the social formation of the person, the creation of membership and the formation of social categories. Theories of identity address “issues of gender, class, ethnicity, age and other forms of categorisation, association, and differentiation in an attempt to understand the person as formed through complex relations of mutual constitution between individuals and groups” (Wenger, 1998, p. 13). Wenger explains that on this horizontal axis learning is again caught in the middle since it “is the vehicle for the evolution of practices and the inclusion of newcomers while also (and through the same process) being the vehicle for the development and transformation of identities” (p. 13). The two intellectual traditions described above form the background to develop an understanding of three dimensions of a community of practice as described by Wenger (1998).

However, Wenger’s social learning theory as stated earlier is a sociocultural theory just as Sfard and Prusak’s (2005) notion of telling identities as stories, which is one of the theories that I have used in my study.
3.3 SFARD AND PRUSAK’S (2005) THEORY

The sociocultural theorists, Sfard and Prusak, (2005) have embraced the concept of identity as the missing link between learning and its sociocultural context. Juzwik (2006) claimed that these theorists articulated the promise of story or narrative in defining identity as an analytic tool in sociocultural research on learning. In other words, Sfard and Prusak made an attempt to operationalise the notion of identity to justify its potential as an analytic tool for investigating learning. According to Goode (2010), the key development in Sfard and Prusak’s approach is equating story-telling and identity-building. However, Sfard and Prusak (2005, p. 14) define identity as a “set of reifying, significant, endorsable stories about a person.” These stories, even if individually told, are products of a collective storytelling. The authors equate identities with stories about persons.

“We did not say that identities were finding their expression in stories but “we said they were stories.”

“In telling identities, one authors specific identities by deciding what events and experiences to include or omit in describing who one is in response to a specific moment in time, reflects on one’s past actions and also possible future trajectories.”

(Sfard & Prusak, 2005b, p. 14)

Stories are culturally patterned practices which form the socio-cultural basis for interdependence in a community of practice. They are told in a specific context as central space in which identity is constructed and that active construction of identity occurs within a specific culture. In CoP female students mutually construct roles of self in gender-linked interactional patterns and learning being situated in a specific culture just like identity formation. In narrating who they want to be in science, female students construct possible selves (Markus & Nurius, 1986 as cited by Tan et al., 2013) in science, one of these being the self-one believes one might become in the future. This study implements the suggestions of Sfard and Prusak and uses the collection of narratives as a methodological strategy for studying the extent to which identity formation influences Zimbabwean A-level female students’ perceptions and participation in physics. Hence, this is another important lens used for data generation as well as interpretation of the narratives of female Zimbabwean students.

Since identities are stories (Sfard & Prusak, 2005), by narrating their stories, female students who have different standpoints will be authoring their identities as they interact in their CoP (Wenger, 1998). There is need to describe the Feminist Standpoint in detail.
3.4 Feminist Standpoint Theory (FST)

Harding (1986, p. 24) defines feminism as a “political movement for social change.” However, feminist epistemology arises out of the confluence of Marxism and postmodern deconstruction (Delanty, 2005). The notion of standpoint was developed from Marxism, but it was from postmodernism that a new critical edge was discovered with the notion of deconstruction (ibid.). The point raised by Marxists (Stanford Encyclopedia of Philosophy, 2006) is that society is structured primarily along the lines of two classes: the working class (proletariat) and the capitalists (the bourgeoisie) who own the means of production. As the privileged class, the capitalists have a motivation to maintain the status quo, and this interest interferes in their ability to understand the exploitation of the working class upon which their capitalist privilege depends. The working class, however, as the socially underprivileged, can achieve a richer understanding of social relations; they not only have a motivation to understand the true nature of the exploitation to which they are subjected to (in order to be able to end to the exploitation), but their position offers the potential for a dual vision. Since they are subject to the rules of the capitalists who wield social power, the working class has an understanding of the capitalists’ view of the world. But additionally, they have an experiential understanding of their own lives as the exploited. Thus, their position as socially underprivileged affords them the possibility of an epistemic privilege stemming from this dual vision (Stanford Encyclopedia of Philosophy, 2006).

Feminist standpoint theory draws on these ideas, but rests on a gendered division of labour rather than class divisions (ibid.). Hartsock (1983)’s articulation of the theory argues that woman’s contributions to subsistence (livelihood which relies on agriculture or farming to feed themselves and their families) and childrearing result in a systematic difference of experience across the genders. Accordingly, the activities of women that place them in a socially underprivileged position can form the basis of a privileged epistemic standpoint, through which a deeper understanding of patriarchal institutions and ideologies can be reached (Hartsock, 1983). Feminist standpoint theory has developed in response to feminist theorists’ recognition that gender cannot be understood in isolation from other social categories. For example, Patricia Hill Collins has put forth the idea of a black women’s standpoint, identifying specific epistemic resources in black women’s experience that are important to the development of black feminist thought (Collins, 1990).
Feminist methodology can be defined as a concern with exploring the nature of social experience of women with a view to explaining the mechanism through which power operates in order to bring about the emancipation of women (Delanty, 2005). On the other hand, Harding (1986, p. 26) argues that “men’s dominating positions in social life results in partial and perverse understanding, whereas women’s subjugated position provides the possibility of more complete and more perverse understandings.” In the same vein, the females have an understanding of the man’s view of the scientific world. But additionally, they have an experiential understanding of their own lives as the underrepresented in science subjects but especially in physics. Thus, their position as scientifically underprivileged affords them the possibility of an epistemic privilege stemming from this dual vision.

Feminist approaches in light of females’ access to science are based on the central insight that:

- social reality is a gender construction and the normative aim of social science should be both to deconstruct this and to point to an alternative
- far from being objective, science in general is ideologically laden with male values.

(Delanty, 2005, p.123)

FST then, involves a commitment to the view that all attempts to know are socially situated. The social situation of an epistemic agent - her gender, class, race, ethnicity, sexuality and physical capacities - plays a role in forming what we know and limiting what we are able to know. They can affect what we are capable of knowing and what we are permitted to know (Roychoudhury, Tippins, & Nichols, 1995). In general, FST argues that there is a gender bias in problem definition, interpretation and normative critique (Smith, 2006). However, the premise of feminist standpoint theory is that the difference in the social experience of men and women give them different ways of looking at life and interpreting events, and hence different standpoints (Smith, 1987). This basic premise was applied by Harding (1998) to critique science. She argues that men and women have different standpoints in life, yet science is developed primarily from the perspective of one group, namely, male Eurocentric one. Women’s experiences have been neglected as starting points of scientific research and as generators of evidence for or against knowledge claims. Could it be that women are greatly underrepresented in science and specifically in physics that science is developed from man’s perspective?

Women, as a result of their “different lived experiences, have a distinct standpoint” which can bring in different experiences and engender certain pattern of thought and understanding that
is absent from science (Roychoudhury et al., 1995, p. 898). This is not to say, that all women have the same standpoint but that any attempt to include women’s voices and to situate science in their lived experiences may be simplistic (ibid.). Furthermore, it has been noted that the multiple and shifting nature of individual experiences and the diversity in women’s voices is due to their varied and different positions of culture, race, class, and ability (Miller, 1993). Could this also be true for Zimbabwean female students? Feminist standpoint theorists (Harding, 2004; Smith, 2006), in general, argue that it is not surprising that many women are strangers to science because the logic of science dominated and developed by men can never be totally compatible with women’s standpoints. Therefore, the low participation of Zimbabwean female students needs to be explored from this perspective. The demand for the development of a feminist science must not be interpreted as a separatist goal to generate two disjointed versions of science - feminist and masculinist - but seen as an attempt to connect two different perspectives (Roychoudhury et al., 1995). Thus the FST was used as a lens during sampling and purposively selecting female students with different standpoints.

Many scholars of gender issues (Kelly, 1985; Rosser, 1989) have claimed that the inherent masculinity of science is the prime reason for female students’ avoidance of science. They suggest that science is masculine at the surface level, at the deeper epistemological level, and in the nature of the knowledge that is accepted as scientific. At the surface level of teaching-learning milieu, men comprise the majority of those who study, teach and practice science (McCullough, 2004). This means that young women have few role models and female mentors available in physics. Hence, this means that the examples and applications used in teaching are frequently masculine, and classroom interactions sanction male dominance as a norm, even the assessments are gender biased (McCullough, 2004; Murphy & Whitelegg, 2006b).

At a deeper level, scientific thinking and knowing embody a masculine worldview (Bentle & Watts, 1987). It is likely that women would feel as outsiders in science classes when their emotional and connected ways of knowing are not sanctioned or their experiences are marginalised (Roychoudhury et al., 1995, p. 899). If the conceptual schemes underlying science are grounded in the experiences of the dominant group, namely, the western males, then women have to alienate from the real-life experiences and try to assume the male viewpoint (Smith, 1987). This, according to standpoint theorists, may be impossible for many women. Therefore, scientific endeavours need to be embedded in both men’s and women’s differing experiences and lives so that they are not forced to adopt an incompatible perspective. To meet these
challenges there is a need to recognize that ideas about gender have shaped science just as much as ideas about science have shaped constructions of gender (McCullough, 2004a). Teachers and students need opportunities to understand that there is a rich diversity of meanings and practices in science, so that learning physics and coming to belong does not mean learning the attributes that are culturally associated with masculinity, or replacing these with those culturally associated with femininity. Rather, the goal would be for students to understand the potential for developing scientific understanding from different ways of practising science that give value to different modes of access and ways of knowing (Murphy & Whitelegg, 2006a).

There is a consensus among feminist standpoint theorists that a standpoint is not merely a perspective that is occupied simply by dint of being a woman. Whereas a perspective is occupied as a matter of the fact of one’s socio-historical position and may well provide the starting point for the emergence of a standpoint. A “standpoint is earned through the experience of collective political struggle, a struggle that requires, as Hartsock puts it, both science and politics” (Harding 2004, p. 8). The formation of a standpoint requires shared experiences of oppression and of struggle against that oppression. A feminist standpoint may be taken (implicitly) as the position of all women, but what account is taken of class, race, sexuality, and other markers of difference, which structure the power relations that generate oppression, the shared experience of which forms the basis of the standpoint? By way of emphasis of this point, Hartsock uses the label ‘feminist standpoint’ whereas Smith uses the label “women’s standpoint”, reflecting the way in which standpoint theory argues for “women’s place” as a starting point for enquiry (Harding 2004, p. 21).

3.4.1 Applicability to the study

Feminist epistemology and philosophy of science considers the ways in which gender does and/or ought to influence our conceptions of knowledge, the knowing subject, and practices of inquiry and justification (Pressley, 2005). As highlighted in the above discussion, it identifies ways in which dominant conceptions and practices of knowledge attribution, acquisition, and justification systematically disadvantage women and other subordinated groups, and strives to reform these conceptions and practices so that they serve the interests of these groups (Stanford Encyclopedia of Philosophy, 2012).
Pressley (2005, p. 75) argues that significant knowledge practices disadvantage women by:

- excluding them from inquiry
- denying them epistemic authority
- denigrating their "feminine" cognitive styles and modes of knowledge
- producing theories of women that represent them as inferior, deviant, or significant only in the ways they serve male interests
- producing theories of social phenomena that render women's activities and interests, or gendered power relations, invisible
- producing knowledge (science and technology) that is not useful for people in subordinate positions or that reinforces gender and other social hierarchies.

Lack of women in science has led to “masculine theories and interpretations” McCullough (2004, p. 21). One example would be the use of gender to define botanical groupings and the use of sexual metaphors in botanical reproductions. Why would plant reproduction be anything like human reproduction? She argued that the male researchers created a gendered situation where a non-gendered explanation might have sufficed; and their gendered taxonomy ranked ‘male’ parts of a flower higher than ‘female’ parts. Therefore those who do the science might affect the science itself (Schiebinger, 1999). This is just one example of how gender has unnecessarily infiltrated aspects of theoretically objective science. In other words, it is now understood that science is not as objective as it was once perceived. Who the scientists are affects how the science grows and what the science is. Taking feminist and masculinist science ideas into the classroom, Rosser (1989) argues that the science classroom is also heavily gendered and the masculine nature of science classes contributes to the lack of women in science. She contends that using women’s studies methods, theories, and pedagogies in the science classroom might serve as a way to attract and retain female students (Rosser, 1990).

On the other hand, physical science can be shown to also have inherent masculine or sexual characteristics. The “building of atomic and hydrogen bombs during the Second World War shows just how gendered science can be” (Cohn, 1996, p. 189). The creators of the bombs spoke of giving ‘birth’ to the bombs, and the babies were of course male: ‘Fat Man and Little Boy.’ The language surrounding the creation of the bombs was strikingly sexual. In this respect, feminist standpoint theory claims that there is a gender bias in problem definition, interpretation and normative critique (Smith, 2006). To change female students’ participation in physics it is therefore essential to understand how gender operates and why many “girls may not feel a sense of ‘belonging’ in physics” (Murphy & Whitelegg, 2006a, p. 284). From the feminist standpoint approach, a sure way of taking on board the females’ perspective in physics may be to increase their participation in physics education.
Delanty, (2005) saw standpoint epistemology going beyond this general claim in that it aims to develop a new methodological approach based on a new ontology and a radicalised epistemology. Feminists, who adopt this standpoint position (Smith, 1987; Harding, 1991; Collins, 1990), argue that scientific knowledge is constrained by the social location of the scientist, and therefore the existence of the woman in social research leads to quite different kinds of experience which in turn require a different approach to that of mainstream science, as historically practised.

Delanty (2005) reached the conclusion that a feminist standpoint approach is reflexive. Reflexivity is “not merely self-reflection but it refers to a self-transformative capacity” (Delanty, 2005, p. 120). Feminist standpoint’s reflexivity is characterised by its recognition of the social position of the researcher in social science. The social researcher must question their own role in the research process since they are part of the object. Feminist standpoint’s reflexivity also has an emancipatory agenda, shown by its will to deconstruct the existing male-centred constructions in order to realise new possibilities for women. However, as pointed out by Hartsock in Delanty (2005) the deconstruction moment in feminism differs very much from other postmodern thought in that it is more constructivist rather than deconstructivist. It aims to transform women’s social experience by creating forms of knowledge that can liberate women from patriarchal social relations (Stanford Encyclopedia of Philosophy, 2006).

A hybrid of three theoretical frameworks thus underpins this study. Gender and Identity Formation are nested within a Feminist Standpoint Epistemology, Sfard and Prusak’s (2005) notion of “telling” identities or “telling” stories as well as Wenger’s (1998) social learning theory featuring CoP. (See Figure 3.4 below).
Figure 3.4: A hybrid of three theoretical frameworks within which Gender and Identity Formation is nested.

As shown by figure 3.4 humans are considered to be social beings in each of the three theories. Learning in Wenger’s social learning theory is viewed as social participation which is composed of four components: Meaning (learning as experience), practice (learning as doing), community (learning as belonging) and identity (learning as becoming). It is used as lens to interpret the behaviour of female students, learning and authoring their identities in a CoP. Identities as stories framework by Sfard and Prusak (2005) is used for data generation and its
interpretation. Lastly the FST was used to select female students with different standpoints. However, context is the central space in which identity is constructed during the gender-linked interactional patterns which occur in a specific culture.

3.5 SUMMARY

This chapter has presented the analytical toolkit used in this study. I used the analytical tools to elucidate the meanings within the stories of female A-level students with aim of showing the extent to which identity formation influences Zimbabwean A-level female students’ perceptions of and participation in physics. All the three theories used in this study are sociocultural in nature. These are Wenger’s (1998) SLT, Sfard and Prusak’s (2005) notion of telling identities as stories as well as FST (Figure 3.4) which were elaborated on in great detail in this chapter. All these frameworks provided theoretical lenses used to respond to the research questions. The methodology that guided the study and the tools for generating and analysing data which are conceived within the context of the theoretical approaches discussed here will be discussed in the next chapter.
CHAPTER 4

PHILOSOPHICAL ASSUMPTIONS & RESEARCH METHODOLOGY

I was going to leave the rural life to a boarding high school where there was piped water and electricity. I had laboured enough in this community. Taking introspection into my life, could it be true that the rural participants experienced what I also experienced many years ago? (Journal Entry, March, 2015)

4.1 INTRODUCTION

This chapter discusses philosophical assumptions which consists of a stance towards ontology (“the nature of reality”), epistemology (“how the researcher knows what she knows i.e. a related view of the type of knowledge that can be generated and standards for justifying it”), axiology (“the role of values in the research”) and methodology (“a disciplined approach to generating that knowledge”) (Taylor & Medina, 2013, p. 2). Philosophical assumptions are considered first and then the methodology which included the actual data generation procedures. The researcher explores the ways in which she engaged in data analysis as well as the ethical considerations. Four principles of ethical practice (Christians, 2005) namely, informed consent, deception, privacy and confidentiality, and accuracy were explained. A conclusion is drawn at the end of the chapter.

4.2 PHILOSOPHICAL ASSUMPTIONS

A philosophical paradigm constitutes the lens through which social reality can be interpreted, as alluded to in the introduction. Interpretivists have different ontologies and the ontological stance embraces the idea of subjective and multiple realities. Such ideas have implications for the researcher’s decisions on how to access the participants’ different and subjective ways of looking at reality. Therefore, each and every participant in this study has her own reality. The participants’ epistemology is centred on the construction of new knowledge during data generation from the participants’ experiences. The epistemological assumption requires that the researcher gets as close as possible to the participants being studied. The closer I get to my participants, the more I can claim to know what I know (Creswell, 2013).

Axiology (role of values) relates to ethical considerations and our own viewpoints (Dillon & Wals, 2006). The axiological assumption of this study is that the under-representation of females in physics is an indicator of certain injustices in society caused by several sociocultural and economic factors and this resonates well with the Feminist Standpoint Theory (FST). The
axiological assumption also requires that, as the researcher, I position myself in the study, by first admitting the value-laden nature of both the study and the information gathered in the field, and then secondly, by actively reporting my values and biases. Methodology is considered next.

4.3 METHODOLOGY

For the purposes of this study, it is important to distinguish research methodology from research methods from the outset. The term methodology is used in this study to denote an approach to data generation whilst the term research method is used to denote the manner or technique of data generation (DeMarrais & Lapan, 2004; Swann & Pratt, 2003). Examples of research methods include surveys, interviews, and observation (ibid.). There is, therefore, a marked difference between methodology as an approach and method as a technique of doing something. However, DeMarrais and Lapan (2004) and Swann and Pratt (2003), have recently observed that the term methodology is sometimes, misleadingly, used in place of method. For the purposes of this study I have maintained the difference and used the term methodology for the approach and method for the technique.

4.4 RESEARCH PARADIGM

Philosophical considerations mean the use of abstract ideas and beliefs that informed my research and it is important in the sense that the philosophical insights shaped how I formulated my problem and research questions in this study and how I sought information to answer my research questions (Creswell, 2007, 2013). A paradigm represents a worldview that defines, for its holder, the nature of the "world," the individual's place in it, and the range of possible relationships to that world and its parts (Guba & Lincoln, 1994, p.107). A paradigm constitutes the lens through which social reality can be interpreted. My theoretical paradigm is interpretivism (discussed next) and the research design is qualitative narrative inquiry (discussed in 4.5).

4.4.1 The Interpretive Paradigm

A researcher working in this paradigm wants to find out what people are doing and experiencing, while taking into account the conditions (context) in which the people being studied live (Henning et al., 2004). As a researcher, I became part of the social situation by:
… confronting the social world under research, by raising questions about this world in order to discover relations between categories, by formulating propositions about these relations, by organizing these propositions into analytical schemes and to test the questions, data, relations, propositions and analysis through renewed examination of the social world (Goodman, 1992, p. 120)

I, as a researcher, wanted to identify and interpret the ways in which contexts influence the identity formation of female students with regard to their perceptions of physics as a subject of choice.

Interpretive research does not seek to generalise settings to a broad population; rather the intention is to understand deeper structures that can be used to inform other settings (Spillane, 2000). The intent of the research is to increase understanding of the phenomenon with the cultural and contextual situations; where the performance of interest was examined in its natural setting and from the perspective of the participants without imposing the researcher’s “outsider’s priori understanding on the situation” (Orlikowski & Baroudi, 2001, p. 5). The findings of this study cannot be generalised to the whole district but is specific to the female students in schools that were part of the sample. The purpose was to understand the factors of identity formation considered as contributors to developing an orientation towards physics by female students.

The participants in this study were asked to narrate their life stories and experiences at home and at school in relation to their participation or non-participation in physics. Consequently, these narrations shed light on the extent to which contexts influenced the identity formation of female students with regards to their perception physics as a subject of choice and the facets of identity formation considered to be of significance by female students. However, as stipulated by the main research question, the primary task was to investigate the extent to which identity formation influences Zimbabwean A-level female students’ perceptions of and participation in physics. In this regard, it was important that I located this study in the interpretive paradigm. I therefore resolved to use narrative inquiry to unpack the complexity of identity formation, as articulated by the participants in this study in light of the myriad of influences that are available to them.

Participants shared their personal stories with me during interviews. They expressed their lived experiences and explained how they viewed themselves vis-à-vis their participation in physics and what it meant to them to be part of a CoP. They did this by expressing their feelings, thoughts, aspirations, attitudes and perceptions about their reality.
The ultimate aim of the interpretivist research is to offer a perspective of the situation and to analyse the situation under study (Nieuwenhuis, 2007). This provides insight into the way in which a particular group of people make sense of their situation or the phenomenon they encounter (Nieuwenhuis, 2007). Accordingly, the greatest strength of qualitative approach lies in the richness and depth of explorations and the descriptions it yields. In effect, this means that the researcher becomes the instrument through which the data is collected and analysed. The most common critique against the interpretive research paradigm is directed at the subjectivity and failure of the approach to generalise its findings beyond the situation studied (ibid.). Issues of subjectivity were addressed by triangulation of data sources, meaning comparing and cross checking the consistency of information derived at different times and by different means for example, semi-structured interviews and classroom observation. The more sources tapped into for understanding, the more believable the findings will be. A detailed account is given in section 4.7.

A summary of interpretivism as a paradigm is shown in Figure 4.1. Nieuwenhuis (2007) explains the main tenets of the interpretivism by placing it at the intersection of two ‘axes’ as shown in figure 4.1. The vertical axis has the two ends labelled reality and product. The former emphasises that reality is multiple and is constructed inter-subjectively through meanings and understandings developed socially and experientially. Reality is negotiated within cultures, while the latter emphasises that data cannot be generalised. The investigator and the object of the investigation are linked in such a way that who we are and how we understand the world is a central part of how we understand ourselves and others, hence there is richness and depth of information. Findings or knowledge (product) claims are created as the investigation proceeds i.e. findings emerge through dialogue.
However, Nieuwenhuis (2007) points out that the horizontal axis has the ends of which are labelled methods and phenomena. At one end of the horizontal axis – phenomena- emphasis is on meanings that are constructed and interpreted. Since we cannot separate ourselves from what we know, the researcher’s values are inherent in all the phases of the research process. Meanings are emergent from the research process as well. The other end of the axis is labelled methods. Interpretive approaches rely heavily on naturalistic methods such as interviewing and observation which I used in this study. Data were generated as I interacted with the female participants in their CoP as has been alluded to.

### 4.5 RESEARCH DESIGN

A research design is a plan according to which the researcher intends to investigate the research problem (Babbie, 2005; Denzin & Lincoln, 2003; Mouton, 2002). It is the entire process of research from conceptualising a problem to writing research questions, and on to data generation, analysis, interpretation, and report writing (Creswell, 2007, 2013). Its function is to ensure that evidence is obtained which is instrumental in answering the research questions as accurately as possible (De Vaus, 2001). This study utilised a qualitative research approach, which situates me, as the researcher, in the world of the participants in the study (Denzin & Lincoln 2000). Situating this study in a qualitative research approach requires that the research process takes an insider perspective (Babbie & Mouton 2001). Henning et al. (2004, p. 5) state that the qualitative researcher wants to “discover how human interactions take place, and why
these interactions happen in the manner in which they do in certain situations.” The researcher examines the qualities, characteristics or properties of a phenomenon in order to grasp, comprehend and explain their world (Henning, Van & Smit, 2004). Denzin and Lincoln (2003, p. 13) state that qualitative researchers are guided by a set of principles that emphasise the “socially constructed nature of reality, the personal relationship between the researcher and what is being inquired, and the situational constraints that shape the inquiry.”

This study is of such a nature that one cannot conduct experiments, especially when one needs to find meaning in the lived experiences of the female participants and relationships (rapport between the teacher and the female participants and among male and female students) as they participated in physics lessons. To get an in-depth understanding of the relationships and experiences of these students, I needed to adopt a qualitative approach to research, which assisted me not only to report on the findings, but to constantly engage with the study throughout by means of argument and reasoning.

Qualitative research is descriptive in nature, since its purpose is to investigate, unearth and uncover more about the specific phenomenon, and then provide detailed, comprehensive descriptions (Struwig & Stead, 2001; Wisker, 2001). It is primarily interpretive (Creswell, 2007, 2013). The assumption is that knowledge is obtained through people’s descriptions of their “intentions, beliefs, values and reasons, meaning-making and self-understanding” (Henning et al., 2004, p. 20). It is a method of inquiry that is “systematic and interactive,” and is employed to give an exposition of the life experiences of the participants and also to give meaning to them (Mouton, 2002, p.161) thereby gaining an in-depth understanding of the human perspectives at the individual level. Qualitative research takes place in the “participants’ natural environment” (Creswell, 2013, p. 175). This affords researchers an opportunity to enter the world of their participants and get the opportunity to obtain a “rich understanding of their world as they experience it” (Babbie, 2007, p. 312; Creswell & Plano, 2007, p. 30). The world of the participants is therefore seen as it “really is” (Anastas, 2004, p. 62). For the purpose of this study, interviews and lesson observations were conducted in the physics laboratory where the female students did their theory and physics practical lessons. This allowed me as the researcher, to observe the participants in their natural settings. The observations were carried out without trying to manipulate the natural context (Patton, 2002). As a qualitative researcher I therefore sought an in-depth understanding of phenomena as they occur naturally and no attempt was made to manipulate the situation. During these observations the researcher...
recorded the number of students in class, the gender ratio, where female students sit (in front, at the back or well spread out), whether they were comfortable in carrying out experiments or handling apparatus and their interaction patterns in class.

In this study, the data are reported verbatim through the words uttered by the participants to provide a true description of their reality (Creswell, 2007; Holloway & Wheeler, 2002). Creswell (2007, p. 169) explains that the responses from the participants are recorded by means of what he calls “thick, rich description.” This thick description must be substantiated with abundant practical evidence and a theoretical foundation (Henning et al., 2004). The researcher reviewed the literature and used it to provide evidence for the purpose of the study and the research problem under investigation. Due to the varying and complex responses of the participants, the researcher concentrated on one specific issue and did an in-depth study on it; for example, the female students were asked to narrate their sense of identity (how they perceive themselves) in relation to physics. The narrations shed light on their perceptions of physics. The narrations also provided insight into the various identities that participants attributed to themselves. As stipulated by the main research question, the main task was to find the extent to which identity formation influences Zimbabwean A-level female students’ perceptions of and participation in physics.

4.5.1 Narrative inquiry

The research design of the study was narrative inquiry. It focuses on the whole person and how identity elements are integrated via one’s life story (Clandinin & Huber, 2002). It is concerned with how we make sense of our lives. Narrative inquiry emphasises that people make sense of themselves through the stories they tell about themselves. Our lives are told and represented through narratives and history is of itself a narrative (Avraamidou & Osborne, 2009, p. 1686). According to Schank and Berman (2002, p. 288) a story is “a structured, coherent retelling of an experience or a fictional account of an experience … and that in some sense, all stories can be considered didactic in nature, in that they are intended to teach or convey something to the listener” i.e. stories are a vehicle through which experiences and events are communicated amongst people.

This study commits itself to the narrative inquiry in order to investigate the extent to which identity formation influences Zimbabwean A-level female students’ perceptions of and participation in physics. I used Sfard and Prusak’s (2005) notion of telling stories as identities.
Narrative researchers assert that the sharing of stories of experience actually create psychological and social realities in people’s lives (Clandinin & Connelly, 2000; Elliot, 2005). A story is used to “bring the texture, depth, and complexity,” of the lived experiences of students into view (Clandinin & Connelly, 2000, p. 122).

On the other hand, Appiah (2005, p. 68) says “it is through our narratives that we construct and express our identities” with a particular social and cultural plotting. The understandings of knowledge through our stories are linked to our identity which is shaped by our situational contexts. Soreide (2007, p. 529) refers to the stories we tell to construct and negotiate our identity as “ontological narratives.” We tell ontological narratives in an effort to make sense of how we experience ourselves and how we would like to be understood. The construction of ontological narratives should thus be understood as narrative positioning in the identity discourse. This happens through identification with or rejection of accessible subject positions (ibid.). Sfard and Prusak (2005b, p. 18) also claim that a narrative holds together “multiple experiences of an individual”, allowing for a sense of coherence. As such, narratives reflect actual and designated identities. Actual identity refers to the sense of identity that one may claim to have now, while designated identity refers to an expected identity in the future (ibid.). It is important to note that the self, like all other things, is signified and culturally constructed (King & Horrocks, 2010, p. 216).

Ontological narratives are pertinent to my study. The stories that female participants narrated during interviews are the ontological narratives. Since reality is multiple, each of the nine female students had her own reality from her experiences. The students were describing their actual identities (how they perceive themselves) and designated identities (expected identity in future) in relation to physics.

As a qualitative research design, narrative inquiry enabled me (as the researcher) to understand the experiences of female students which influenced their identity formation rather than to “formulate a logical or scientific explanation” (Chase, 2005, p. 656; Kramp, 2004, p. 104). Kramp (2004) explains that the story is the unit of analysis and that the object of narrative inquiry therefore understands the outcome of interpretation rather than explanation. Kramp, (2004, p.104) argues that a narrative is “a vital human activity” that structures experience and gives it the means to gather data, and the discourse or form for the data gathered. Historically, qualitative researchers have assigned value to context (ibid). Narrative researchers understand that behaviours, events, and actions are meaningful as embedded in context. Being social
constructions, narratives cannot be independent of their contexts. The contexts include, culture, parents, siblings, peers, the school the community etc. Narrative researchers situate individual stories with participants’ personal experiences (their home) their culture (racial or ethnic) and their historical contexts (time and place) (Creswell, 2013). Storylines arise out of, are associated with, and locate narratives within, specific cultural and social milieu (Connelly & Clandinin, 2006).

Contexts enabled me to make meaning where previously there was no meaning. I interviewed and observed the female students in their natural native surroundings. The participants’ use of the term context connected and situated their experiences so that they could cohere and structure life as experienced. The narrative inquiry approach is appropriate for this study because narrative stories are gathered through many different data gathering techniques, such as through interviews, observations, pictures and other sources of qualitative data (Creswell, 2007; 2013).

4.6 POPULATION AND SAMPLING

Sampling refers to the process used to select a portion of the population for the study (Nieuwenhuis, 2007, p. 79). Since Gweru district has sixteen high schools, I purposively selected four schools which I assumed had the appropriate data I wanted (Creswell, 2013). Of the four schools one was from a rural impoverished region, with a population of two female students who were studying mathematics, one was from the high density urban schools which comprised my sample (low income) with a population of three students studying physics twenty-five mathematics and the other one was from low density urban schools (middle income). Ten female students were studying physics and fifty mathematics. All three of these schools are coeducational. The fourth school was a low density boarding school for girls only and a total of fifty female students were studying physics and one hundred and seven mathematics. The participants were drawn from a population of A-level female science students at these selected schools.

Female adolescents aged 18 years and above doing Advanced Level (A-level) in lower 6 (form 5) or in upper 6 (form 6) were chosen as the participants of this study. Purposive sampling was used to select prospective participants from a population of female science students from the four different schools. A sampling questionnaire was designed and self-administered to all female students doing A-level sciences. This served to purposively identify participants who
met the inclusion criterion of age limit of eighteen years and above. The inclusion criteria also considered participants whose subjects were either mathematics with physics or mathematics without physics. Parents or guardians had an average monthly income of US $200 or less in the rural school, an income between $201 to $400 in the high density school and an income of above $401 in low density schools.

Purposive sampling entails that the inquirer selects individuals and sites for a study because they can suitably inform an understanding of the research problem and the central phenomenon being studied (Creswell 2007, p. 125; 2013, p. 124). I focused on two groups of female students (with different stand points). Those who were studying physics and mathematics as a combination and those doing only mathematics to enable me to find the extent to which identity formation influences Zimbabwean A-level female students’ perceptions of and participation in physics. Students studying mathematics only, are potential students to study physics but they had not opted to study the subject. It was significant that their perceptions and the way they perceive themselves would shed more light to low female participation in physics.

Based on the criteria employed in the purposive sampling, I chose nine students to participate in the study. From the low density school, two female students were selected, one doing mathematics and physics, and the second one doing mathematics without physics. Three female students were chosen from the high density urban school, one doing mathematics and physics, one doing mathematics without physics and the third student doing physics without mathematics. Traditionally, students at A-level enrol for both physics and mathematics as a combination of subjects to pursue a career in physics or in engineering. Her inclusion therefore would enrich the generated data. Two students were selected from the low density all-girls school, one doing mathematics and physics and the second student doing mathematics without physics. All rural schools did not offer physics because they did not have laboratory facilities, materials and equipment and therefore offered only mathematics. The rural school that was chosen had only two female A-level students doing mathematics hence both students became part of the sample.

4.7 DATA GENERATING INSTRUMENTS

This study is situated within the narrative inquiry approach for data generation. The techniques of generation were semi-structured interviews which were audio taped, Draw- A- Scientist (DAST) and classroom observations (which were videotaped). The observations were carried
out to reveal the interaction patterns displayed when the female students were doing theory and practical lessons in their physics CoP. The data generating instruments are explained in more detail in the sections that follow.

4.7.1 **Semi-structured interview Guide**

Denzin and Lincoln (1994) claim that the interview is the favourite methodological tool of qualitative research. The interview conversation is the art of asking questions and listening. It is not a neutral tool, for the interviewer creates the reality of the interview situation. Thus the interview produces situated understandings grounded in specific interactional episodes (ibid). An interview is a face-to-face verbal interchange, in which the interviewer attempts to elicit information from another person or persons (Jennings, 2005). It is a specialised pattern of verbal interaction initiated for a specific purpose. Semi-structured interviews are often used in qualitative studies. The nine participants were interviewed individually and the interview sessions which were audio-taped were thirty minutes to an hour each. The purpose of the individual interviews was to allow the students to unfold their narratives about their experiences with science in general and physics in particular. The setting allowed the students to articulate themselves without interruptions. As a researcher, I had room to explore participant responses by asking for clarification or additional information. I also had the freedom to be more friendly and sociable. As Huysamen (2001, p. 8) argues, semi-structured interviews allow the interviewer to use probes with a view to cleaning up vague responses or to ask for incomplete answers to be elaborated on. I used such probes which varied from ‘why?’ to ‘could you tell me more about this’ or ‘could you elaborate on this.’

Semi-structured interviews are most useful when one is investigating a topic that is very personal to participants as was the case with this study. Benefits include the ability to gain rapport, participants’ trust, as well as a deeper understanding of the responses. Data sets obtained using these styles are larger than with structured interviews (Creswell, 2013; 2007). They also enable participants (be they interviewers or interviewees) to discuss their interpretations of the world in which they live in, and to express how they regard situations from their own point of view (ibid). The semi-structured interview can be referred to as a narrative interview, therefore there is a need to explain narratives in more detail.
Narratives

Narrative descriptions exhibit human activity as purposeful engagement in the world and draw together diverse events, happenings and actions of human lives into a thematically unified goal-directed process (Polkinghorne, 1995, p. 5). The author further explains that narrative configuration refers to the process by which happenings are drawn together into a temporarily organised whole and that this “configurative process employs a thematic thread (plot) to lay out happenings as parts of an unfolding movement that culminates into an outcome.” The term narrative in this study is used to refer specifically to texts (stories) that are “thematically organised by plots” (ibid.). A plot is a type of “conceptual scheme by which a contextual meaning of individual events can be displayed” (Polkinghorne, 1995, p. 7). A storied narrative is the linguistic form that preserves the complexity of human action with its interrelationship of temporal sequence, human motivation, chance happenings and changing interpersonal and environmental contexts (Polkinghorne, 1995).

Stories, according to Polkinghorne (1995), are concerned with human attempts to progress to a solution, clarification, or unravelling of an incomplete situation. “People do not deal with the world event by event or with text sentence by sentence. They frame events and sentences in larger structures” (Bruner, 1990, p. 64). Plot, therefore, is the narrative structure through which people understand and describe the relationship among the events and choices of their lives. Plots function to compose or configure events into a story by:

- delimiting a temporal range which marks the beginning and end of the story
- providing criteria for the selection of events to be included in the story
- temporarily ordering events into an unfolding movement culminating in a conclusion and
- clarifying or making explicit the meaning events have as contributors to the story as a unified whole (Polkinghorne, 1995, p. 7).

Plots also function to select from a myriad of happenings those that are direct contributors to the terminal situation of the story. Narrative is the most common in everyday discourse and our lives are told and represented through narratives (Avraamidou & Osborne, 2009). A narrative can be referred to as an in-depth type of interview since, in one-to-one situations, participants are asked to tell their stories in a variety of ways, for example, by responding to “more or less structured interview questions or by engaging in conversation or dialogue” (Connelly & Clandinin, 2006, p. 380). A narrative may be oral or written and be elicited or heard during an interview or naturally occurring conversation (Stake, 2005). Bruner (1996), cited in
Avraamidou and Osborne (2009), states that the way humans order experience is narrative and it deals with the creation of stories. Narrative then becomes part of how people understand the world they live in and they serve as a way of “communicating that understanding to others” (Connelly & Clandinin, 2006, p. 377). Humans are storytelling organisms who, individually and socially, lead storied lives (ibid.).

The narrative interviews began with the researcher interviewing or having conversations with the selected female students who told stories of their experiences with regard to the extent to which identity formation influences Zimbabwean A-level female students’ perceptions of and participation in physics. Their narratives explained how they perceived, experienced and made sense of their world. Participants had to “journey back to recollect lived past experiences which shaped their lives” (Olivier, Wood, & De Lange, 2007, p. 18).

Narratives are stories and as “one is telling stories, one is telling identities” (Sfard & Prusak, 2005, p. 14). One’s path to effective learning is through knowing oneself. Students talked most of the time about their storied life, a story to live by or their identity. These stories to live by were shaped in places and lived in places (Clandinin & Huber, 2002). The narrator or female students constructed a story by structuring and framing relationships in a CoP.

4.7.3 Classroom Observation Guide

Observation is a systematic process of recording the behaviour and patterns of participation without necessarily questioning or communicating with the participants (Nieuwenhuis, 2007). It is an everyday activity where senses (seeing, hearing, touching, smelling and tasting) are used to generate data (ibid.). As a qualitative data generating technique, observation is used to enable the researcher to gain a deeper understanding of the phenomenon being observed (Nieuwenhuis, 2007). The risk is that observation by its very nature is highly selective and subjective since researchers focus on specific events or objects within the whole thereby cutting them off from the whole (Creswell, 2007; Nieuwenhuis, 2007). The risk of observation was minimised by formulating an observational schedule which was then used during the data generation process. Female students were observed doing their theory and practical lessons in physics. These lessons were video-taped to enable me to extract the participation and interaction patterns (teacher-pupil and pupil-pupil). It is a naturalistic technique in the interpretive paradigm where female students were observed in their natural environment (ibid.).
Observation provided me with an insider perspective of the group dynamics and behaviours in different settings. Observation allowed me to hear, see, to begin to experience (observation) and reflect on (which is part of the interim data analysis) how setting is socially constructed in terms of “power, communication lines, discourse and language” (Nieuwenhuis, 2007, p. 84).

To minimise the Hawthorne effect, I observed three lessons without collecting any data to enable the students to get used to my presence. This enabled me as a researcher to build a relationship with the participants in their setting. The observation data was used to inform interviews with the students. A total of three theory and three practical lessons were observed, one of each from the schools that were offering physics as a subject.

4.7.4 Drawing some of the main highlights of their life which they could relate to their aspirations to study physics

Visual data have become a prominent approach in qualitative research in general and qualitative researchers are now using images to enhance their understanding of the human condition (Knoblauch, Baer, Laurier, Petschke, & Schnettler, 2008). The use of visual data encompasses a wide range of visual forms, including films, videos, photographs, drawing, cartoons, graffiti, maps, diagrams, cyber graphics, signs and symbols (Weber, 2005). The visual images present a powerful collection of techniques to access and gain insight into people’s lives and environments. Drawing can be used as a form of expression, reflection and therapy (Stuart, 2007). They allow for the communication of both physical and emotional worlds and can “promote social action contributing to social change” (Galvaan, 2007, p. 153).

Use of drawings within visual methodologies is economical, requiring minimal supplies and it is highly generative and provides rich data. It also encourages free imagination (Barnes & Kelly, 2007). Mitchell, Theron, Smith, and Stuart (2011, p. 230) argue that they like drawings as a method because of “their simplicity (need paper and pencil or pen) and their tangibility, their concreteness take us inside the mind of the participants.” Drawing can be used as a tool to access perceptions and thus prove useful in addressing identity related issues in a number of ways. But perceptions, as we know, can change, and changing perceptions can bring about changes in the behaviour of individuals and groups in society (Stuart, 2007). Drawings can communicate complex messages in simple but rich ways. They are “lasting artefacts that can be used to give voice to participants’ messages” (Mitchell et al., 2011, p. 5), making it a suitable method to my study.
Mitchell et al., (2011) believe that the use of drawing is also appropriate for getting at the memories, thoughts and feeling of students. Despite the fact that drawings have “procedural, ethical and interpretive challenges, these cannot corrode the rich persuasive evidence embedded in the apparent simplicity of drawings” (Mitchell et al., 2011, p. 5). The female participants in this study were asked to draw some of the main highlights of their lives which they could relate to their aspirations to study physics. The justification for this was to gain an insight into the origins of their expressed interest in physics since the data gathered may possibly provide some clues towards the female students’ natural enthusiasm towards science (Bodzin & Gehringer, 2001). This was followed by ‘Tell me about your picture (s)’ (Mitchell et al., 2011). A discussion of what the drawing means and clarification or explanation, often propelled further relevant data generation. This shared analysis encouraged richer, researcher understanding of the phenomenon in question (Mitchell et al., 2011). Drawings, therefore, enabled the four female students doing physics not only to access their experiences but also to reveal these experiences and perspectives to others. The female students explored their perceptions as well as experiences of themselves towards physics and explained how their perceptions influenced their participation in physics. The Draw-A-Scientist Test is considered next.

4.7.5 Draw-A-Scientist Test

The Draw-A-Scientist Test (DAST) has been widely used for decades to examine, analyse, and evaluate students’ and teachers’ perceptions of scientists (Finson, 2002; Finson & Pedersen, 2009). All the female participants studying physics were asked to draw a picture of an imaginary scientist based on the model of Draw-A-Scientist Test (DAST) suggested by Chambers (1983). The rationale for using DAST was to explore female students’ mental images of scientists in an effort to discern their perceptions towards science in general and physics in particular. They were asked to provide a name, age, nationality and gender for the scientist they had drawn. One of the research questions of my study was to find how female students’ perceptions of physics influenced their participation in the subject, making DAST relevant to my study.

The female participants were also asked to write the names of other scientists they knew or had heard of (Weber, 2005). The purpose was to find out whether these students perceived scientists as ordinary people who are involved in the world around them or in their societies, for example,
laboratory technicians, nurses, doctors etc. or only as famous ground-breaking people they encounter in their science text books.

4.8 TRIANGULATION

Triangulation is defined as the use of two or more methods of data generation in the study of some aspect of human behaviour (Cohen, Manion & Morrison, 2011). It has been generally considered as a process of using multiple perceptions to clarify meaning, verifying the repeatability of an observational interpretation (Stake, 2005). Triangulation of data sources according to Stake (2005) means comparing and cross-checking the consistence of information derived at different times and by different means for example semi-structured interviews and observation which can capture different things during the research process. Triangulation, according to Stake (2005) also serves to clarify meaning by identifying different ways in which the phenomenon under study is being seen in order to identify different realities. The use of multiple methods, or triangulation, reflects an attempt to secure an in-depth understanding of the phenomenon in question. No single method can grasp the subtle variations in ongoing human experiences (Denzin & Lincoln 2003).

The researcher tries to explain more vividly, the richness and complexity of human behaviour by studying it from more than one stand point. It is a powerful way of demonstrating concurrent validity in qualitative research. Exclusive reliance on one method may give a bias or distortion to the researcher’s picture of a particular slice of reality that is being investigated. The researcher needed to be confident that the data generated are not simply artefacts of one specific method of generation. Such confidence can be achieved when different methods of data generation yield same results. The more the methods contrast the greater the researcher’s confidence in the findings. The other advantage is that the use of triangular techniques will help to overcome the problem of method boundness (Cohen, Manion & Morrison. 2011, p. 196). It is intended as a check on data. I triangulated data from female participants’ narratives during the semi-structured interviews with the data from the observation schedule and the Draw-A-Scientist Test. The rationale was to check on the consistency of the information derived at different times by different means.

4.9 DATA ANALYSIS

Creswell (2007) defines the concept of analysis as a reasoning strategy with the objective of taking the complex whole and dividing it into its parts. Creswell (2013, p. 179) claims that the
process of data analysis involves “coding and organising themes, representing the data and forming an interpretation of them.” The steps are interconnected and form a spiral of activities, all related to the analysis and representation of data. Data analysis in research mainly consists of preparing and organising data (i.e. text data as in transcripts, or image data as in drawings or photographs) for analysis, then reducing the data into themes through a process of coding and condensing the codes, and finally representing the data in figures, tables or in a discussion (Creswell, 2007).

There is no one way of analysing data, a process that begins during the data-gathering process (Creswell, 2007). Data analysis is making sense of data in terms of the participants’ definitions of the situation, noting patterns, themes, categories and regularities (Creswell, 2007; Nieuwenhuis, 2007). It rests heavily on interpretation and one has to note that there are frequently multiple interpretations to be made of qualitative data. In abiding by the principle of fitness or purpose, the researcher must be clear on what he or she wants the data analysis to do as this determines the kind of analysis that is undertaken (ibid.). Qualitative data analysis, therefore, tends to be an ongoing and iterative process, implying that “data generation, processing, analysis and reporting are intertwined” and not merely a number of successive steps (Nieuwenhuis, 2007, p. 100).

The goal in analysing qualitative data was to summarise what I had seen and heard in terms of common words, phrases, themes or patterns that aided my understanding of that which was emerging (Creswell, 2007; Nieuwenhuis, 2007). I kept in mind that qualitative data consist of words and observation and hence my aim was to make sense of what was in the data (ibid.). After patterns and themes emerging from the collective drawing and the participants’ interpretations were identified, the researcher returned to the participants to ask their opinions on the emergent findings (Mitchell et al., 2011). In this context, the participants were acknowledged as knowledge producers and respected as the experts. Stuart (2007) encourages collaborative meaning-making and allowing the drawer to give voice to what the drawing was intended to convey. Valid knowledge production occurs when the analysis is shared in this way (Mitchell et al., 2011). In other words, once the drawing was completed, it was vital to ask the participants to describe and interpret the image, including what meaning the participant attached to the colour (if colour was used) (ibid.).

While remaining aware that the story I heard was constructed, as a researcher using narrative inquiry, I accepted the story “as told.” The story as told, as it was constructed, became the
object of analysis in narrative inquiry. As a qualitative researcher, I understood that “there is no telling it like it is, for in the telling there is making. The task of the researcher was to do justice to the situation and yet recognised that all stories, including those in the natural sciences, are fabrications - things made” (Eisner, 1991, p. 191). Narratives were then organized thematically before they were analysed. To make sure there had been no major changes in the content of the refined narratives, they were compared with the original transcript and the tapes from the interviews (Søreide, 2007).

4.9.1 Analysis of Narrative

Analysis of narratives has become increasingly popular when examining adolescent and adult identity developments (Kroger, 2007). According to Kroger (2007, p. 23), biographies are studied as life stories in an attempt to understand “how people make sense of their lives, and give meaning and coherence to them”. Nieuwenhuis (2007, p. 102) claims that the word “narrative” is generally associated with terms such as ‘tale’ or ‘story’ especially a story told in the first person.

There are two types of analyses namely analysis of narratives which employs paradigmatic reasoning and narrative analysis which uses narrative reasoning (Polkinghorne, 1995). The analysis of narratives is a method for identifying, analysing and reporting patterns (themes) within the data (Braun & Clarke, 2006). Paradigmatic reasoning, according to Polkinghorne (1995), results in descriptions of themes that hold across the stories researchers collect of the descriptions of events and happenings and configure them by means of a plot into a story. Therefore, analysis of narratives moves from stories to common elements. Narrative analysis on the other hand, refers to a variety of procedures for interpreting or making meaning of the narrative generated in research (Nieuwenhuis, 2007). It moves from elements to stories as the outcome of the research.

I used analysis of narratives in this study, which seeks to locate common themes among the collected stories. Paradigmatic analysis provides a method to expose the commonalities that exist across the stories that make up the study’s database. This enabled me to interrogate what was said by the female students in order to obtain explanations of the extent to which identity formation influences Zimbabwean A-level female students’ perceptions of and participation in physics.
At the data preparation phase in this study, the orally generated stories were transcribed and transformed into written texts for analysis i.e. all the narrative data that had been recorded in audio and video form was transcribed verbatim in English, the language in which the data generation procedure had been conducted. The transcripts were compared with the recorded data to ensure that every word had been captured in the transcripts. During the transcription, all the names of the participants were replaced with pseudonyms or labels such as S1, S2 etc. The data emanating from the drawings contained the captions and the explanations of each drawing. The data was then coded to obtain categories and themes that best described the influence of identity formation on female students’ perception and participation in Physics. A summary of the analysis of thematic process is given (Table 4.1).

**Table 4.1 The process of the thematic analysis** (Braun & Clarke, 2006, p. 87; Holmegaard, Madsen, & Ulriksen, 2014, p. 195).

<table>
<thead>
<tr>
<th>Phase</th>
<th>Description of process</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Getting familiar with the data</td>
<td>In this phase, I first transcribed the data and then reading and re-reading the interviews while noting down initial ideas bearing the research questions in mind.</td>
</tr>
<tr>
<td>2. Generating themes</td>
<td>Constructed several themes i.e. coding interesting features of the data in a systematic fashion across the entire data set, collating data relevant to each code. Systematising of the data across the entire data set, and relevant quotes from each interview were gathered under each theme.</td>
</tr>
<tr>
<td>3. Searching the data</td>
<td>In this phase, I understood the patterns within the themes in a more comprehensive context of meaning according to my theoretical framework. This part of the process is about recontextualising the meaning within the students’ narratives by using Sfard and Prusak (2005) and Wengers’ CoP as the lenses.</td>
</tr>
<tr>
<td>4. Understanding the themes with the theoretical framework</td>
<td>Reviewing the themes by re-reading the transcripts to check if themes and theoretical interpretations work in relation to the entire data set</td>
</tr>
<tr>
<td>Phase</td>
<td>Description of process</td>
</tr>
<tr>
<td>-------</td>
<td>------------------------</td>
</tr>
<tr>
<td>5.</td>
<td>Reviewing themes</td>
</tr>
<tr>
<td></td>
<td>Defining the analysis heading towards a thick description of the data, moving across the data set but also looking deeper into some specific interviews or narratives. Picking out quotes illustrating points and patterns in the themes. In short, it is selection of vivid, compelling extract examples, final analysis of selected extracts, relating back of the analysis to the research question and literature, producing a scholarly report of the analysis.</td>
</tr>
<tr>
<td>6.</td>
<td>Producing the text</td>
</tr>
</tbody>
</table>

It is my contention that the stories told by the participants during the data-generation process represent what Clandinin and Huber (2002, p. 163) refer to in the three-dimensional narrative inquiry metaphorical space as the "wholeness" of their lives. Clandinin and Huber (2002, p. 163) assert that the “wholeness of life” is constituted by personal and social aspects and a continuity that is embedded in the notion of past, present and future, and in the notion of situatedness.

The data were analysed in two stages. The first stage is vertical analysis (Hunter, 2010; Kelchtermans, 1993) or “within-case” (Miles & Huberman, 1994). The second stage is the horizontal analysis (Hunter, 2010; Kelchtermans, 1993) or “cross-case” (Miles & Huberman, 1994). The data were analysed and discussed through the support of relevant literature using Wenger’s (1998) notion of learning in communities of practice, Sfard and Prusak’s (2005) notion of telling identities as stories and through the Feminist Standpoint Theory.

### 4.9.2 Techniques used to find common themes

Babbie (2001) defines content analysis or thematic analysis as “the study of recorded human communications.” It is a method for “identifying, analysing and reporting patterns (themes) within data” (Braun & Clarke, 2006, p. 79). According to Riley and Hawe (2005), thematic analysis may be done in two ways; either themes are generated deductively by the researcher’s a priori interests or inductively deriving them from the data itself i.e. the open coding of data by looking for patterns in the data or the building of a set of themes to describe a phenomenon.

Emphasis, according to Riessman (2006, p. 186), should be put on the content of the text, that is on the “what” is said rather than the “how” it is said. The thematic analyses should reflect both the ideas researchers bring to the data set beforehand (from the research questions) as well as being open to ‘new’ themes in the data. Zhang and Wildemuth (2009) argue that sometimes
a compromise between the two methods of generating the themes is possible and this is what I did in this study. As I made a compromise between inductive and deductive approaches, I was guided by Ryan and Bernard (2003, p. 94) who cautioned that on one hand, a strict theoretical perspective may lead the researcher “to find only what they are looking for” while on the other hand “assiduous theory avoidance… brings the risk of not making the connections between the data and important research questions.” Finding common elements across the participants’ stories is important because it can be useful in elaborating a developing theory.

From the interpretive perspective, making explicit the techniques I used for discovering themes is important because without thematic categories, investigators have “nothing to describe, nothing to compare, and nothing to explain” (Ryan & Bernard 2003, p. 86) and it allows consumers of qualitative data to assess methodological choices. Being guided by Ryan and Bernard (2003, pp. 88-93) and Love (1994, p. 2), I extracted techniques that I used to identify common themes across the nine female participants:

- **Repetitions**: This was the easiest way because I was looking for topics or elements that recurred in their stories.
- **Similarities and differences**: These are usually found by making a systematic search for them across units of data beginning either with a line-by-line analysis and asking questions such as, what is this sentence about? How is it similar to or different from the preceding or following statements? This kept me focused on the data rather than on theoretical aspects. I also compared either pairs of expressions or pairs of whole text for similarities and differences and asking, how is one expression different from or similar to the other? The abstract similarities and differences that this question generated were the themes.
- **Historical explanations, descriptions and interpretations**: These were stories of the past that were used to explain and justify present behaviours as well as meaning.

I used these techniques to search for themes from the data. This process of qualitative content or thematic analysis began during the early stages of data generation phase and it helped me to move back and forth between concept development and data generation and helped me to direct subsequent data generation towards addressing the research questions (Miles & Huberman, 1994). I was able to identify twelve themes from the data. Although it is common practice to use typical quotations to justify conclusions (Schilling, 2006), I also incorporated other options for data display such as graphs (Miles & Huberman, 1994) to show under-representation of female students in physics in the sampled schools. I strove for a balance between description and interpretation (Zhang & Wildemuth, 2009). As mentioned earlier, qualitative research is fundamentally interpretive, and interpretation represents my personal and theoretical understanding of the phenomenon under study.
4.10 **RESEARCHER ROLE**

The researcher was the primary tool or main instrument of generating and analysing data. Being a native Zimbabwean, the researcher’s familiarity with the culture and indigenous languages of her country assisted in placing issues and perspectives into context. As a human instrument of data generation, I interacted with participants and data during data generation and analysis respectively.

4.11 **VALIDITY AND RELIABILITY**

According to Creswell and Plano (2007), determining validity is an essential step in the research process. Golafshani (2003, p. 599) suggests that validity involves the answering of the following questions: *How truthful are the results? Does the research truly measure that which it was intended or claimed to measure?* In this study, the intention has always been to answer the research questions. Trustworthiness of the findings is the qualitative complement of validity and reliability (Jones, 2002). Triangulation is a validity procedure where investigators search for convergence among multiple and different sources of information to form themes or categories in a study (Creswell & Miller, 2010). The more sources tapped for understanding, the more believable the findings will be. Using multiple sources of data assisted in having this study address a broad range of “historical, attitudinal, perceptual and behaviour and process issues” (Creswell & Miller, 2010, p. 126). This has contributed to the trustworthiness of the data in that it provided a means of confirming or cross-checking the accuracy of emerging findings which is an issue of validity in this study.

Verbatim notation from interviews with participants is evidence that featured in the researcher’s analysis, backing up the interpretations that I made. It is impossible for research to be 100% valid. In qualitative data, the subjectivity of the respondents, their opinions, attitudes and perspectives together contribute to a degree of bias (Cohen, Manion, & Morrison, 2011). The validity of the study hinged on the assurance that the students had the same understanding of identity formation as the researcher, and that they differentiated between identity formation and physics participation in the same way as the researcher. The data generating instruments were pilot tested in high schools that were not part of the schools selected for the study but that were believed to share the same characteristics. It was subsequently established that the students had the same understanding of identity formation and physics participation as the researcher.
With member checking, the validity procedure shifts from the researchers to participants in the study. Lincoln and Guba (1985, p. 314) describe member checks as “the most crucial technique for establishing credibility” in a study. It consists of taking data and interpretations back to the participants in the study so that they can confirm the credibility of the information and narrative account and it contributed to the trustworthiness of the data in that it provided a means of confirming or cross-checking the accuracy of emerging findings. With the lens focused on participants, the researchers systematically check the data and the narrative account (Creswell & Miller, 2010). I allowed the participants to view the raw data (e.g., transcriptions or observational field notes) and comment on their accuracy and to sign as a way of agreeing that the data were correct. In turn, I incorporated participants’ comments into the final narrative. In this way, the participants added credibility to the qualitative study by having a chance to react to both the data and the final narrative (Creswell & Miller, 2010).

Reliability has to do with the consistency of the measurement or “the degree to which an instrument measures the same way each time it is used under the same circumstances with the same subjects” (Golafshani, 2003, p. 598). The focus here is on the replicability and repeatability of results. The narrative or semi-structured interview schedule, drawing and observation schedule in this study were designed in such a way that they could be replicated in similar situations with similar subjects under the same conditions.

4.12 ETHICAL MEASURES

Researchers have a duty and obligation to abide by the code of conduct that governs most professions (Babbie, 2007, p. 62). Ethics offer rules and behavioural expectations about the most correct conduct towards participants of a study. My commitment to uphold the ethics of research began by obtaining ethical clearance (H13-EDU-ERE-008) from the official Ethics Committee (REC-H) of Nelson Mandela Metropolitan University. Christians (2005, pp. 144-145) provides four principles of ethical practice in social research. These principles are informed consent, deception, privacy and confidentiality, and accuracy.

An ethical obligation rests with the researcher to protect subjects against any form of physical discomfort that may emerge. Respondents were informed beforehand about the potential impact of the investigation. Such information offered the respondents the opportunity to withdraw from the investigation if they so wished. Participants were protected from unwarranted physical or mental discomfort, distress, harm, danger or deprivation.
Obtaining informed consent implied that all possible or adequate information regarding the goal of the investigation, as well as possible advantages and disadvantages of participating, were made available to the research participants as accurately and as completely as possible (Strydom, 2002). Consequently, the participants were able to make a voluntary and thoroughly reasoned decision about their possible participation (ibid.). The participants’ informed consent was obtained after they had been briefed on the aim, procedures, possible risks and benefits of the research. They were made aware that they had the liberty to withdraw from the investigation at any time. Consent was obtained to use aspects of the drawings and the participants’ verbalisations during the discussion of the data. The participants were made aware that a final copy of the dissertation would be made available in the university library after the completion of the study. They were subsequently asked to give consent to voluntarily participate in the research process through filling in the appropriate form after all the relevant information had been given.

Deception of subjects refers to deliberately misrepresenting facts in order to make another person believe what is not true, violating the respect to which every person is entitled (Strydom, 2002). It involves withholding information or offering incorrect information in order to ensure participation of subjects when they would otherwise possibly have refused it (ibid.). This also included the handling of the participants’ identity, as well as being honest about one’s own identity as a researcher (Babbie, 2007).

The principle of privacy and confidentiality insists on safeguards to protect the identity of participants in a research study (Christians 2005). Privacy is defined as that which normally is not intended for others to observe or analyse or to have agreements between persons that limit others’ access to private information (Strydom 2002). Confidentiality on the other hand, can be viewed as being anonymous (ibid.). In an effort to uphold the principle of privacy in this study, the participants were assured that their actual names would not be used, particularly during the data analysis and discussion of the narrative data. The privacy and confidentiality of the participants in the recorded data was also ensured by assuring them of good storage of the recorded data and the transcribed data. The participants were also assured of confidentiality, as well as the anonymity of names and sensitive information that might emanate from the research process. Researchers are obligated to present information that is accurate. The principle of accuracy requires that aspects that imply fraudulent material and fabrication,
omissions, and contrivances be avoided in the analysis, reporting, and discussion of the data (Christians 2005).

4.13 SUMMARY

This chapter focused on the research design, the research paradigm, the data-generation methods, data analysis as well as a declaration of my ethical considerations. The study situated itself within the interpretive paradigm, underpinned by the conviction that an interpretive lens afforded me the opportunity to understand and investigate the extent to which identity formation influences Zimbabwean A-level female students’ perceptions of and participation in physics. A thematic approach to data analysis was chosen since it afforded me an understanding of the wholeness of identity, as related by the participants in their stories, and its influence on students’ perceptions and in turn the effects on their participation in A-level physics. The next chapter focuses on the presentation, analysis and discussion of findings.
CHAPTER 5
DATA PRESENTATION, ANALYSIS AND DISCUSSION OF FINDINGS

5.1 INTRODUCTION

“What is to be expected of an illiterate woman who is forced into subservience and into silence against the abuse of a man called my father? But my mother saw hope in us, her children... three daughters and two sons. She would educate us for her dreams were to move us outside this kind of life in which she had suffered. My eldest sister succumbed to what could be expected for young girls that live in a rural context. Morning chores, taking care of us when my mom was working and being responsible for many duties resulted in her failing at primary school. I always say, that it was my mother’s dream, my sister’s sacrifice and the abuse I saw my mother endure, that stirred in me a courage...a courage to achieve despite the obstacles. I had to make it through school, I must be educated...my family’s existence and well-being depends on it. Somehow, my mother convinced her brother to loan her money for my education. Onslaughts from the community did not spare us for my uncle became a laughing stock, chastised for supporting an in-law’s daughter who is highly likely to fall pregnant...a bad return on his investment they said. In seeing all of this I was determined to do well, to become something, to get an education. When I passed my O-levels with distinction I was elated to have proven those rumour-mongers wrong. I was ready to go on to do A-levels with physics and mathematics as my subjects of choice. No-one was going to stop me...no-one...I was driven by zeal, tenacity and confidence. I told myself that no road was too bumpy or too rough to deter me. Success was one milestone away...yet it was at school, through the attitude of a teacher that my dreams were shattered. I finally passed A-levels and it was an excellent pass, and I still became a beacon of hope for my family, but I did so without personal fulfilment...” (Journal Entry, September 2014)

I see myself in the many of the participants who chose to be a part of this study. So much of what they so generously shared of their lives has a deep connection to mine; yet my story is almost 40 years old. Could time have stood still? Has nothing changed?

Since this study sought to address the extent to which identity formation influences female students’ perceptions of and participation in physics an overview of the context, enrolment trends in different school contexts, a brief biography of the participants, descriptions of the main themes that emerged from participant narratives14 and an integration with literature findings is provided in the section below.

14 Narrative stories were gathered through semi structured interviews
5.2 ENROLMENT TRENDS IN DIFFERENT SCHOOL CONTEXTS

The Zimbabwean government, through the Education Act of 2004, made it clear that schools fall into two broad categories as outlined below.

Schools in Zimbabwe are classified-

- as either Government schools or non-Government schools; and
- in such other categories as the Minister may determine, taking into account the social and economic standards of the communities in which the schools concerned are situated (Education Act, 2004, p. 621).

For the purpose of this study, nine participants were purposively sampled from the two broad categories and invited to participate. The four schools selected for this study from the two broad categories could further be classified based on the contexts of the schools. Three were co-education government schools categorised as rural, low and high density (taking into account the social and economic standards of the communities in which the schools are situated) and one was an all-girls non-government school categorised as low density. Low density schools are situated in an educated community of middle income (above $400-$999) earners. Generally, these schools are well resourced with adequate laboratory facilities (usually 3 laboratories for senior and 2 for junior students) and well-qualified science teachers. The all-girls school was a low density school as well with six laboratories, three for junior and three for senior students. Generally high density schools are not well resourced having only two laboratories one for the senior and one for the junior students. Most people in the community where high density schools are located are not usually formally educated and can be categorised as low income (between $201- $400) earners. Rural schools are poorly resourced with no laboratories. The impoverished community is not formally educated and living on less than $200 per month.

Figures 5.1 and 5.2 show the enrolment patterns of female and male students who were doing either the physics and mathematics combination or mathematics only in the co-educational school contexts for the last six years. As seen in Figure 5.1 and Figure 5.2, the trend appears to be that more students take mathematics only rather than the usual combination of physics and mathematics whether it is males or females. More male students were doing either physics and mathematics combination or only mathematics than female students. There is a substantial difference in the number of female and male students taking either of the two combinations.
However, the difference in the number of female students taking the physics and mathematics combination and mathematics only is more than in male students.

**Figure 5.1:** Female students enrolled for physics and mathematics or mathematics only in the co-educational schools

**Figure 5.2:** Male students enrolled for physics and mathematics or mathematics only in the co-educational schools

The number of male students doing mathematics is lowest in rural school compared with the low and high density schools. This may be due to the more deeply rooted cultural perception
that mathematics is a hard subject. It must be noted that the rural school participating in the study did not offer physics as a subject since the school did not have adequate laboratory facilities, materials and equipment. However, the rural school was included to justify the extent to which cultural norms within the rural communities influence the identity formation of female students doing mathematics and not physics as well. It is interesting to note that only two female students opted to study mathematics in the rural school for the past six years i.e. one in 2014 and in 2013. This may be due to the cultural perception (as alluded to previously) and gender stereotypes. From this perspective, it becomes necessary to compare the data regarding rural female students doing only mathematics with that of the female students in the low and high density schools. The most important point to note is that far less female students do either the physics or mathematics combination or only mathematics compared to male students. This indicates a low participation by females in physics, and this is significant to this study. The biographical details discussed below may illuminate some of the reasons for the subject choices of the female participants.

5.3 BIOGRAPHICAL DETAILS OF PARTICIPANTS

Table 5.1 summarises the biographical details of the nine female participants in this study. They are labelled S1 to S9 in order to protect their identities. The biographical details collected include the educational level of parents, their economic status, the school category and any sibling influences on their A-level subject choices. These factors according to Gudyanga (2014) were considered as having an influence on female students when making their subject choices.

As can be seen from Table 5.1, S1, S2 and S8 enrolled for both physics and mathematics, while S3 was enrolled for physics only. S3 is an anomaly as students are generally not allowed to study physics without mathematics. The other five students (S4, S5, S6, S7 and S9) had all enrolled for mathematics only. Female students who enrolled for mathematics only were included in this study as they had the potential to study physics as well at A-level. Furthermore, it was considered that their narratives could provide insights into the reasons why they (as females) did not choose to do physics.
<table>
<thead>
<tr>
<th>Category</th>
<th>S1</th>
<th>S8</th>
<th>S2</th>
<th>S3</th>
<th>S4</th>
<th>S9</th>
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<td>Age</td>
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<td>A-level subjects</td>
<td>Physics &amp; Maths</td>
<td>Physics &amp; Maths</td>
<td>Physics</td>
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<td>Maths</td>
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<tr>
<td>Siblings</td>
<td>4Males+1Female</td>
<td>2Males+2Females</td>
<td>3Males+2Females</td>
<td>1Male+1Female</td>
<td>2Males+2Females</td>
<td>3Males+3Females</td>
<td>3Males+2Females</td>
<td>1Male+2Females</td>
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<tr>
<td>Parental Education</td>
<td>Both academically educated</td>
<td>Both academically educated</td>
<td>Both not formally educated</td>
<td>Both academically educated</td>
<td>Both academically educated</td>
<td>Both academically educated</td>
<td>Both no formal education</td>
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<td>Socio-economic status</td>
<td>Middle income - $401-$999 USD per month</td>
<td>Middle income - $401-$999 USD per month</td>
<td>Low income - between $201-$400</td>
<td>Middle income - between $201-$400</td>
<td>High income - Above $1000 USD per month</td>
<td>Middle income - $401-$999 USD per month</td>
<td>Low income of between $201-$400</td>
<td>Impoverished - below $200 per month</td>
<td>Impoverished - below $200 per month</td>
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<tr>
<td>School category</td>
<td>Low Density - Educated community, well-resourced (3 senior labs + 2 junior labs)</td>
<td>Low Density - Educated community, well-resourced with 6 laboratories</td>
<td>High Density - Most people have non-formal education not well</td>
<td>High Density - Most people have non-formal education not well resourced, two labs</td>
<td>Low Density - Educated community; school itself was well-resourced (3 senior labs + 2 junior labs)</td>
<td>Low Density - Educated community; school itself was well-resourced with 6 laboratories</td>
<td>High Density - Most people had no formal education; school itself was poorly resourced</td>
<td>Rural school community had no formal education; school itself was poorly resourced</td>
<td>Rural school community had no formal education; school itself was poorly resourced with no</td>
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<td>Category</td>
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<td>Any Other</td>
<td>4 Male cousins and brothers doing engineering</td>
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<td>Only child doing A-level</td>
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<td>Sister studying Pharmacy and Father teacher</td>
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<td>Both parents were teachers; brother doing Honours at the university</td>
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<td>Other siblings did not do A-level</td>
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<td>Currently staying with grandmother; parents emigrated; no mathematics at A-level; and was at a private school</td>
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<td>On government assistance, father died and walks 10 km to and from School</td>
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<td>Both brothers studied maths &amp; not physics; both parents had a science background</td>
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The biographical backgrounds of S1 and S8 were similar in the sense that the parents of both these students hold tertiary academic degrees and are categorised as middle to high income earners. Hence, of all participants, it is likely that the parents of S1 and S8 could afford good schools for their children. It is thus not surprising that both these students were doing their A-level at low density schools. In the homes of academically educated parents in a middle to high income economic status, parental attitudes toward education tend to be more positive and parents are better able to support their children’s choices by providing additional resources that their children may need (Gudyanga, 2014).

S1 and S8 both had siblings attending university and they appeared to have played a positive role in influencing these female students’ aspirations to do maths and physics at A-level. This is evident when S1 stated: *I grew up in a family of four brothers and four male cousins who are engineers by profession. I have a passion for physics and hence I was also being motivated by the family role models.* The fact that all four of S1’s brothers had done physics at A-level and were engineers could possibly have influenced her choice to do physics and mathematics. Although the brother of S8 had done mathematics and not physics at A-level, her passion for physics influenced her to choose physics and mathematics.

Of the three female students doing both physics and mathematics, the choice made by S2 can be regarded as unusual in the sense that her parents were not formally educated and were low income earners, living in a high density area. S2 was doing her A-level at a high density school that was not well-resourced. None of S2’s siblings had done A-levels, therefore, her aspiration to do A-level with physics and mathematics was a personal choice. S2’s determination to do physics and mathematics against all odds appears to resemble what Marcia describes as reaching an “achievement status” when a person demonstrates self-defined commitment to a specific choice and develops well-defined personal values and self-concepts (Marcia, 2002).

Being academically educated and earning a good income, the parents of S3 could send their daughter to a well-resourced school. Initially, S3 was enrolled at a very good, well-resourced private school. However, both her parents had to leave Zimbabwe to work in another country, five months after S3 started her A-level studies. This resulted in S3 being transferred to a high density school as she went to stay with her grandmother. Being the first-born in a family of two children (one girl and one boy), S3 did not have a sibling as a role model to influence her decision to do physics. S3’s choice to study physics only can be regarded as an anomaly, because it is unusual for a school to enrol a student for physics without mathematics as these
two subjects are often a required combination. The motivation for S3 to enrol for physics without mathematics was mainly based on the fact that she wanted to study chemical engineering where one can substitute mathematics for physics.

S3 commented: “...for chemical engineering, the required subjects are usually biology, chemistry and mathematics or physics. So, I have no passion for mathematics and I am not very good at mathematics, but I am very, very good at physics and that’s why I opted for to do physics, and in chemical engineering, if you are not good in mathematics, you can substitute mathematics for physics...”

The reason for including her in this study was to probe how her determination in going against the norm impacted on developing a physics identity. S3 clearly demonstrated independent thinking and a high level of confidence, making definite commitments and decisions with respect to the choice of subjects at A-level. Similar to the behaviour of S2 in making choices, S3 also demonstrates the highest level of Marcia’s stages of identity formation namely identity achievement status (Marcia, 2002). It is at this stage that the late adolescent students arrive at self-defined commitment on their own, have a strong sense of “ego identity” (Zimmermann & Becker-Stoll, 2002, p. 111) and are committed to pursuing the choices that one has made.

Having looked at the female students doing physics and mathematics, the following section considers female students who were doing only mathematics without physics. The parents of S4 and S9 were also academically educated and, therefore, could afford to send their children to well-resourced schools. Both S4 and S9 were attending low density schools. Although the parents of S4 had a science background, she did not opt to study both physics and mathematics, but only mathematics, because of the influence of her siblings. Her reason to do only mathematics is evident when she says:

S4: Both my elder brothers did mathematics at A-level and not physics and I felt that maybe I would be the odd one out had I studied physics.

Therefore, it is possible that she could have chosen her brothers as role models and hence, S4 decided to take mathematics and not physics at A-level. S9 had an elder sister who had done A-level physics and was studying pharmacy at university. However, S9 wanted to be an economist and, therefore, physics was irrelevant to her choice of a future career. Barnes, McInerney and Marsh (2005) and Tai, Liu, Maltese, and Fan (2006) also found that career aspiration is an important factor that influences students’ decisions when it comes to science (physics) enrolment.
The parents of S5, S6 and S7 were not formally educated and can be categorised as low income earners. Because of their low socio-economic background, these parents could not afford to send their children to well-resourced schools. None of the siblings of S5, S6 and S7 had done A-level and hence could not have been an influence on these female students in choosing mathematics.

The biographical details described above show that there tends to be a link between the level of parental education, economic status and choice of school for their children. On one hand, the more educated parents tend to earn more and hence send their children to well-resourced, low density schools, while on the other hand, parents of low socio-economic status are not formally educated and can only afford to send their children to high density or rural schools. The data indicated that the influence of siblings was another factor that seems to have an impact on identity formation of female students and subsequently their choices regarding A-level subjects. The female students appear to choose their siblings as role models in the sense that they opted to study either physics and mathematics or mathematics only because their brothers were either engineers by profession or pursuing a higher degree in mathematics at the university. The third factor that seems to have an influence on female students’ choice of subjects at A-level is their career ambition and subsequent study at university.

Having given a summary of the participants’ biographical information, the following section considers the main themes that emerged from vertical and horizontal analyses of the narrative data generated from interviews with the nine participants of the study. The themes provide insight into the research questions that guided this study and are discussed in detail in the sections below.

5.4 CONTEXTUAL INFLUENCES ON IDENTITY FORMATION

The contextual factors which contribute towards the development of identity with regard to the female students’ perceptions of physics that emerged from the data are: family, cultural norms (community), O-level experience, teacher attitude, classroom experience, laboratory practice and peer influence. Most of these factors listed (except cultural norms and O-level experience) are the same as those revealed in the studies of (Angell et al., 2004; Kubeka, 2014; Murphy & Whitelegg, 2006b) which sought to explore elements that influence female students’ perceptions of physics as a subject of choice.
5.4.1 Family Influences (Parental and Siblings)

The family is the most naturally occurring group or community of practice (CoP) in any society, as it is the most important and primary socialising agent, especially during the first years of life (Scabini & Manzi, 2011). For the purpose of this study, family influences refer to the roles played by parents and siblings of the female participants in their education. The parents of the participating students appeared to have had varying influences on the subject choice of their children. For example, the parents of S3 and S8 encouraged their daughters’ choice of studying physics by providing material and moral support. The motivation of S3 to study physics can partially be attributed to the role her father played by asking her to explain phenomena concerning how things worked in the physical world. This was evident in the comment by S3:

My father is in the habit of asking me to explain how this or that comes about or works. This in a way, really shows me that he supports me, because now it drives me to want to learn more, because sooner or later, someone is going to want an answer from me.

Similarly, the parents of S8 sent her to vacation school for additional support in learning physics. When referring to female participation in physics careers, it should be noted that “students rated parents as having the greatest influence on their decisions on enrolment choices” (Lyons, 2006, p. 298). This shows that parents play a critical role in supporting their children learning physics, both at home and in school. As outlined in the biographical details, S3 was the first-born and hence had no sibling influence in her choice of A-level subjects, while the sibling of S8, who had studied mathematics at A-level, appeared to have influenced her choice of mathematics as a subject.

Unlike the parents of S3 and S8, the parents of both S1 and S2 did not initially support their daughters’ choice of studying physics, because they thought that their daughters were not intelligent enough to do physics, despite the fact that both had achieved Grade A in O-level physics. When referring to female participation in a physics career, Pey-Tee and Subramaniam (2013, p. 113) speculate that “this discouraging attitude of parents could be one of the reasons that contribute to the low intention among students to pursue a physics-based career...”. The other reason which also seems to have influenced the parents of S1 and S2 was the cultural beliefs that females would not cope with physics because it was considered that only male students can succeed in physics. For example, S1’s parents expected her to choose biology instead, believing that biology would be more useful to her as a mother. However, S1 went against her parents’ wishes and decided to study physics as she explained below:
S1: I chose physics myself. My family was actually astounded - like they were shocked - why I wanted physics, because mostly they wanted me to do biology, but I chose physics myself because I just loved it from a very young age.

S1 negotiated her choice of subjects with her parents. It seems that because of their level of academic education, they changed their initial position and became more supportive of her choice. Consequently, they provided her with material and moral support. The siblings of S1 acted as role models, and she could either Skype or Google talk with one of her brothers when doing homework. Growing up with her brothers and playing with her brothers’ toys appeared to have helped S1 to shape her identity, helping her not to feel intimidated in a male dominated classroom.

Being the only child in the family to have done A-level, S2 had to ask her O and A-level physics teachers to talk to her parents who were adamant in their belief and had informed her that they were going to withdraw payment of her tuition fees had she continued to study physics. They eventually and grudgingly accepted her choice, constantly reminding her of the need to work hard and not to relax in order to achieve her goals. It is worth noting that some students go against the cultural norms and become independent thinkers.

From my experience as a mother, children are supposed to obey their parents in the Zimbabwean tradition. This means that the female students are not really ‘free’ from the influence of their parents to explore alternatives as individuals. Their choices are generally negotiated with their parents, who are highly influential in the choices they make (Scabini & Manzi, 2011). They have to adopt what is grounded in the fabric of the community’s culture. In this respect, S2 is similar to S1 in that she also went against the cultural norms and opted to study physics, thus reflecting independent thinking. The two students according to the FST, had a different stand point from their parents which influenced them to shape an identity more attuned to studying physics and hence defied the cultural expectations.

The determination of S1 and S2 to study physics and mathematics against the wishes of their parents, appears to be contrary to the claims made by Bleeker and Jacobs (2004), namely that parental beliefs about their children’s abilities have a strong influence on children’s own beliefs about their academic abilities. It is worth noting that, according to Marcia’s Identity Status Model, S1 and S2 can be described as late adolescents, and appear to resemble identity achievement status. This is because these female students could think abstractly and critically in order to attain self-defined commitment (Moshman, 2005).
What is evident from the findings above is that the parents, who were more educated, supported the subject choices of their daughters from the beginning. These parents came from economically advantaged backgrounds and could provide active support by encouraging their daughters to explore the natural world or by sending them to get support from subject experts. While the parents of S1 were academically educated, the parents of S2 were not formally educated. However, both sets of parents did not initially support their daughters’ choice of studying physics and mathematics. It could indicate that factors other than education played a role, e.g. the cultural perception of society, which considers physics to be a masculine subject. Education seems to have played a part, because although initially reluctant, S1’s parents were more amenable to support their daughter’s preference than S2’s parents. The parents were socialised that physics must be done by male students while female students are also being socialised at school that students can choose to study any subject at A-level resulting in different standpoints (Smith, 1987). Women, as a result of their “different lived experiences, have a distinct standpoint” (Roychoudhury et al., 1995, p. 898) for example parents of S1 and S2 and their daughters. Because of their different standpoints, S1 and S2 had to negotiate with their parents, reshaping their parents’ perception in the process. The female participants’ positive identity in relation to physics influenced formation of positive perception of the subject which motivated them to study physics.

Having given a summary of parental influence on female students doing physics and mathematics, the following section considers parental influence on female students doing only mathematics as a subject of choice. The parents of both S4 and S9 were academically educated and could be categorised as middle to high income earners. The parents of S4 supported their daughter’s choice of studying mathematics without physics from the onset and provided her with all the resources that she needed. Although the parents of S4 had a science background, they did not encourage her to take physics along with mathematics. However, she chose her siblings, who had done mathematics at A-level, as role models and hence did not opt to do physics but only mathematics. In spite of the parents of S9 wanting her to study physics because of the prestige that it would bring to the family, they supported their daughter’s choice of doing only mathematics. Her decision to do only mathematics was primarily due to her career choice in the field of economics and her career ambition is expressed as follows:

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15 social reality being a gender construction
S9: No-one discouraged me from doing physics, because my big sister did physics, chemistry and mathematics and is now doing pharmacy. Basically, my passion for being an economist prevented me from being a physics student, as I have seen that Zimbabwe’s economy is basically not well, so I’m thrilled and I thrive to make Zimbabwe economy okay. My parents supported the subject choices that I made and are buying me the resources that I am using.

The parents of S5, S6 and S7 were not formally educated with a low to impoverished economic status. They did not initially support their daughters’ choices of studying mathematics as part of a subject combination. The parents’ failure to support their daughters’ choices from the beginning could have been influenced by cultural perceptions, which perceive mathematics as being a masculine subject and hence not suitable for female students. They feared that their daughters were not intelligent enough to master mathematical concepts. However, after a lot of negotiation, the parents eventually accepted their daughters’ choices. In addition, because most parents in rural areas are very poor it may appear that they do not value the importance of female students doing A-levels, which may also be a way of conserving the meagre resources that they have. Students S5, S6 and S7 were the only children in their families to have done A-level and therefore had no sibling influence on their subject choices. Their ambitions to become accountants, influenced these female students’ decision to do only mathematics.

In summary, all the parents who did not have any formal education failed to support their daughters’ choice of A-level subjects from the outset, whereas all the educated parents, except those of S1, supported their children’s choices from the outset. The more academically educated the parents, the more amenable they were to accepting their daughters’ choices; the less educated the parents were, the more resistant they were to accommodate their daughters’ choices of subjects. This finding is supported by Gudyanga (2014, p. 45) who claims that:

Parents of higher socio economic status [and] higher level of education encourage their sons and daughters to learn sciences [e. g. physics and mathematics]. They value sciences [e.g. physics and mathematics] by virtue of their academic enlightenment…

Because of their level of education, parents of S5, S6 and S7 appeared to have been resistant to support their daughters’ preferred subjects from the beginning. Smyth and Hanna (2006, p. 307) claim that “participation in advanced science and maths courses has been found to be greater among those with more highly educated parents and/or from higher social classes.” Unlike parents without formal education, educated parents are in a better position to question the cultural beliefs and to encourage their daughters (e.g. S3 and S8) to defy the norm by supporting their choices to study physics and mathematics. The cultural perception that physics and mathematics are masculine appeared to influence their failure to support their children
opting to go against the norm. In the event that parents do not support the subject preferences, female students are persuaded by sibling role models. Career ambition also seems to play a significant role in influencing female students’ choice of A-level subject. Two out of five participants who were studying only mathematics chose not to do physics, purely because of career ambition. This is in line with Barnes et al. (2005) and Tai et al. (2006), who also found that career aspiration is an important factor that influences students’ decisions when it comes to science (physics) enrolment. Community perspective as one of the contextual factors is considered next.

5.4.2 Community Perspectives (Cultural perceptions)

Aguila and Krasny (2011, p. 219) note that a community is “a place of learning where practice is developed and pursued, meaning and enterprise are negotiated among members, and membership roles are developed through various forms of engagement and participation.” All nine female participants, who were interviewed individually on different days, concurred that society confers a high status on physics and mathematics. In addition, female students are not considered to be intelligent enough to study these subjects and they are viewed as not as hard-working as male students. They also stated that the Zimbabwean community in the Midlands Province considered physics to be a masculine subject and not a suitable choice for female students, who should rather study biology instead. This sentiment was expressed by all participants during the interviews:

S1: Most families believe that physics is just for boys and if you are a girl, going to do sciences, you have to do biology and be a doctor. They don’t really see a girl being an engineer or something better. I am very courageous to go against cultural expectations, which perceive physics as masculine.

S2: Due to the cultural socialization, people in my society view girls who do physics as crazy or something. They see me as someone who is just not normal, passing comments like “This girl was meant to be a boy [in shona] - “murume chaiye” (she is a man).

S3: The general idea that physics is hard and also... that it’s supposed to be a male subject not to be studied by females, so most people tend to shun away from studying physics.

S8: Well, the people in our society at home see us, the students, doing physics as not very normal, going against what society deems appropriate, hence they think that we are acting against nature.

S4: Our culture is against girls who do physics and I felt uncomfortable to choose it as one of my subjects.
S9: Basically, it’s due to the socio-cultural factors for mathematics and physics are said to be masculine. Only boys are seen to possess the intelligence to do them. People from my culture that I come from, believe that guys are more superior to girls and we girls are inferior. Hence, only the hard or the hardest subjects should be done by the guys who are said to be more intelligent and hardworking are to do those subjects so that’s the thing that pulls away girl children from participating in physics in their large numbers.

S5: Our culture says that it is not good for girls to do physics. If anyone in our culture finds out that a girl is doing physics they say a-a-a! - like it’s kind of weird. Because of the way society is, the boy should take physics and the girl should take other subjects, because physics is considered to be a masculine subject. In other words, the community views physics as a male subject and they think that the female students are not that intelligent.

S6: Our culture, also especially in rural areas, discourages girls from doing science subjects. Mathematics and physics are considered to be boys’ subjects. ... People in this rural society mock me due to their ignorance and they are very demotivating... They do not take education seriously; going to study Advanced level to them is a waste of time, especially for the girl child.

S7: Culture forbids that girls do maths and physics, but should do biology, languages and arts subjects. Female students therefore perceive the maths and physics as boys’ subjects, as a result of what society says... Society is also saying that I am behaving as a boy by doing mathematics, which they consider to be a masculine subject as well ... People in this rural community say that it is a waste of time to send a girl child to high school.

The quotes from the participants explicitly indicate that female students were culturally socialised to believe that the choice of physics as a subject at school is for only males since females are not intelligent enough to learn physics. Those female students who chose to study either physics and/or mathematics were described as behaving like males for the reason that they were going against Zimbabwean cultural expectations. The deeply entrenched cultural views of physics as being a “masculine” subject may prevent female students from participating in physics in larger numbers as their choices could be highly influenced by the social environment. Hence, the more the community confirms physics as masculine, the less likely girls will be attracted to it. The cultural perceptions of physics as a subject for only males is further illustrated when Hannam (2008) reports that parents may discourage their daughters from studying physics as it is stereotyped to be masculine. In addition, Matope and Makotose (2007) carried out a study into the factors that influence female engineering students’ career choice in Mutare, Zimbabwe. During the interview with the parents of the participants, these authors discovered that parents in general seemed to be discouraging female students from venturing into the engineering profession by telling the female students that engineering was not for girls but for males. Since parents are the early socialisers of the female children, they strongly hinder potential female engineers from being groomed (ibid.). These authors further argued that this may be the reason why few females were courageous enough to choose
engineering as a profession. However, they noted that parents who were in the engineering field positively influenced their children to pursue a career in engineering “… If the cultures of child-rearing practices are gender-stereotyped, then boys and girls will be brought up very differently from each other” (Van Leuvan, 2004, p. 249). People in the community are deeply rooted in their cultural beliefs and engage in practices which reflect gender stereotyping and gender-based role expectations. According to Social Cognitive Theory, communities encourage and coerce female students to fit in with social expectations advocated by their societies (Lips, 2008). Thus, gender stereotyping and gender role expectations seem to discourage female students from participating in subjects such as physics and mathematics at A-level. Furthermore, according to the Gender Schematic Theory these female students form organised knowledge structures (schemas16), which are gender-related conceptions of themselves and others. These schemas influence the thinking and the behaviour of female students (Martin & Ruble, 2004).

From the sentiments outlined above, the parental resistance to female students choosing to study physics and mathematics or only mathematics seems to be culturally rooted in the fabric of society. Culture is “a system of shared beliefs, values, customs, behaviours and artefacts that the members of society use to cope with their world and with one another… the collective programming of the mind that distinguishes the members of one group or category of people from others” (Hofstede, 2011, p.3). In this context, Zimbabwe, being a gendered society (schematic) culture and traditional values, described by Mwamwenda (2005, pp.374-375) as “inheritable from their parents” seem to play an important role in shaping the identity of female students. Generally, the differences observed amongst people (diversity) are the result of differences in culture. Furthermore, Bala et al. (2012) argue that people’s lives are strongly influenced and shaped by prevailing cultural norms, which give identity to a group of people as they are passed down from generation to generation through learning. Against this background the decision by the female participants in this study to do physics and mathematics reflects a measure of courage and determination in shaping their identity.

In addition, the data gathered from the sampled schools show that all the teachers teaching physics at A-level were males, reinforcing a masculine perception of the subject, indicating that the female students did not have any female role models who could possibly inform their

16 A schema is a mental structure or cognitive repertoire, which contains general expectation and knowledge of the world.
subject choices. Interestingly, it is also the masculine perception of physics and the power associated with this subject (Danielsson, 2009; Walker, 2001) that encouraged S1, S2, S3 and S8 to defy the ‘cultural norm’ and to pursue physics. Some measure of courage was required by these female students who chose to study physics and/or mathematics against this norm.

For example, S1 and S2 commented that:

S1: As I grew up, I always loved challenges in life so I said why not study physics, since it has always been my passion? I also wanted to prove that I was capable of doing physics just as boys. I grew up in a family of four brothers four male cousins and I think growing up around boys also helped me because I’ve never been intimidated by boys but am happy being in their company and this encouraged me to go against the cultural norms.

S2: Society is just used to the males being more intelligent and hence they study physics and mathematics in their large numbers, but I don’t think that keeps me from doing physics also. I became strong enough to stand up to the dominance of men in the physics section and I am determined to produce better results than males. I feel motivated and encouraged to be in a male dominated area. In other words, it is just the excitement of wanting to venture more into a male domain—physics—that pushes me to study it more. Actually, I am excited to be in a male domain.

Therefore, from these comments, it appears that the female students doing physics and mathematics liked the challenge of being in the male domain which is considered prestigious by society, as stated above by Danielsson (2009).

To sum up the above discussion, all the nine female participants of the study explicitly refer to the cultural perceptions as playing a major role in discouraging female participation. Physics and mathematics are perceived as being masculine and engagement with these subjects require high levels of intelligence which according to the community, the female students apparently do not possess. As discussed above with reference to parental influence, there is a re-affirmation that parental resistance to females doing physics and mathematics is grounded in the cultural perception of these subjects. The influence of prevailing cultural norms is mediated via the parents in influencing identity of the female participants. All the female students doing physics and mathematics or only mathematics displayed a tendency of defying the established cultural view of females doing these subjects. Hence, they were shaping a positive identity towards physics and/or mathematics in their communities of practice. It is worth noting that the socialisation of girls emanates from the cultural views. Courage is one of the facets of identity formation considered to be of significance by female students in relation to physics. The participants needed courage to go against cultural gender stereotyping and gender role expectations that seem to discourage female students from participating in subjects such as
physics and mathematics at A-level. The impact of O-level experience is discussed in the section below.

5.4.3 Impact of the O-levels experience

Teachers serve as important role models since they communicate information about their own abilities and skills (Meece et al., 2006). The implicit and explicit actions of teachers as role models play a crucial role on female students’ identity formation with regard to their perceptions of physics as a subject of choice. It is highly likely that the classroom experiences that teachers provide can shape female students’ perceptions with regard to their roles in the CoP (Murphy & Whitelegg, 2006a; Zohar & Bronshtein, 2005). For example, all the female students who chose to study physics (S1, S2, S3 and S8) described a positive learning experience of the subject in their O-level years as explained below.

S3 said: The way I was taught influenced me to do physics. What really pushed me to study physics was my O-level teacher. He taught me in such a way that at that time, I took physics as any other subject but the way he taught and encouraged me made me come to a point where I realised that I had the capacity to do well in that subject, and I actually began to enjoy physics. I enjoyed learning O-level physics because I was able to apply most of what I learnt and it helped me to understand a lot about what is happening around me and how things work together in my society.

Her enjoyment of physics at O-level seemed to result in her shaping a physics identity that motivated S3 in choosing physics at A-level. S3 added that:

My A-level physics teacher is in the habit of making sure I do my work, I participate in class even if sometimes I’m not too sure or discouraged, and he always makes sure I do something.

In addition, the O-level physics teachers were passionate about the subject and could explain concepts very well e.g.

S8: My ordinary level teacher was very good. He taught physical science in an interesting and practical manner that one could tell the importance of physics. He was encouraging us female students to take up physics at A-level... Well the attitude of our teacher is really encouraging, he is really motivating; he keeps on telling us that it’s not in gender and I have confidence in you. Your work is encouraging, am happy with your performance, keep up the good work, it shouldn’t end here but you should go on to do the physics at tertiary level, he actually encouraged us to not to fear and he gave us all the support; he really encouraged us as female students.

Their physics learning experiences in the classroom relating to how the subject was taught may have resulted in the female students studying physics and mathematics, shaping their identity in favour of physics. The conducive learning environments (as described above) created by the
physics teachers appeared to have been a key deciding factor in influencing these female students’ choice of studying physics as a subject. In this context, Hazari et al. (2010) have shown that students can modify their behaviour in order to form an identity they want to be recognised through in adult life. Thus, teachers could be important sources of information that children draw on to form their identity and could provide and encourage different recreational and learning activities that could support the development of specific skills and interests (Meece et al., 2006). A teacher’s attitude and ability to teach may seem to have a positive influence on the female students to choose physics as a subject of choice as they interact in their respective CoP.

Mead (1934, p. 135) proposed that the “self is not initially there, at birth” but it arises in the process of social experience and activity, developing in the individual as a result of his/her relations to this process.” For example, the O-level experiences of S3 and S8 with their teachers may have resulted in them reshaping their identities since personal identity is never a finished product, but it is continually evolving as suggested by Wenger (1998). The new experiences, new insights of oneself, social changes, exposure to other world views and deeper reflection lead to regular revisions of one’s personal identity (Parekh, 2009). Personal identity, therefore, provides a vantage point from which one can view one’s past and construct meaningful narratives of one’s life (ibid.) which connects to one’s social identity. In addition, Jenkins (2004, p. 4) argued that all human identities are essentially “social identities.”

In the same vein, S1 and S2’s experiences with their parents who initially did not support their choices may have resulted in them having to negotiate with all that was happening at home and in the classroom if they were not going to be outcasts with reference to cultural expectations. This negotiation had a significant influence on S1 and S2’s identity formation, thus affecting their decision making process on physics as a subject of choice (Angell et al., 2004; Kubeka, 2014; Moshman, 2005). Hence, we learn our unique selves through socialisation with significant others (e.g. teachers, parents and siblings) in our society (Kubeka, 2014).

According to the Feminist Standpoint Theory (FST), the female students who were studying physics and mathematics (S1, S2 and S8), S3 (only physics) and those who opted for only mathematics (S4, S5, S6, S7 and S9) had different stand points which involved commitments that occur as a result of the socialisation process during learning. We define who we are by the ways we experience ourselves through participation as well as by the ways we and others reify ourselves i.e. we reflect our shared experience around which we organize our participation.
Meaningful learning in social contexts requires both participation and reification in interplay (Wenger, 2010). All the female students doing physics had positive perceptions, attitudes and motivations, towards the subject. The way these female students perceived themselves (their identity) was influenced by good science teaching at O-level and consequently they began to construct and to reshape positive physics identities. The female students (S1, S2, S3 and S8) were all recognised by their teachers as having the potential to pass their advanced level physics. This is in line with the comments by Carlone and Webb (2006) that one cannot claim an identity all by oneself; being somebody requires the participation of others. Furthermore, the way the female students doing physics engaged in their O-level physics was influenced by how the students viewed themselves and whether they perceived themselves as the kind of people who could engage in physics at A-level (Brickhouse, Lowery, & Schultz, 2000). It is, therefore, crucial to understand students’ identities and how this interacts with their school science identities.

On the other hand, all the female students who were studying mathematics only and not in conjunction with physics (S4, S5, S6, S7 and S9) had negative O-level physics experiences in the classroom. The way physics was taught at O-level seems to have discouraged them from choosing physics and according to the FST, the students formed a different standpoint of not opting to study physics.

Male teachers, as described by S4 and S5, were gender biased and gender insensitive in favour of male students. For example, S4 explained:

*From their comments, physics teachers at this school portray the image that girls are not welcome to do physics since they would be encouraging boys to do better and telling us girls that we are not capable to master concepts in physics.*

This negative physics classroom experience appears to have resulted in them shaping a negative physics identity. The low participation of females in O-level physics also discouraged S4 from opting to study physics at A-level. There were 32 males and only six female students (15.85%) in the class.

*Boys are more in number than the girls in physics classrooms, approximately boys were thirty-two and girls were only six. I lacked confidence in male dominated classrooms and therefore choosing physics at A-level would make me feel more uncomfortable since the number of females is far less that this could be one or two, if not zero ... At this school, there are less lab apparatus and we are group when doing experiments. Because boys rush for the apparatus and they will be doing the experiments while girls are leaning on the benches looking on.*
There was also passive exclusion of female students on gender basis due to the shortage of apparatus. The male students had the hands on experience of carrying out the practical experiments while the female students were mere observers. In this context Cheryan, Siy, Vichayapai, Drury, and Kim (2011) reported that male dominated fields can be unwelcoming to women on two dimensions:

- The first is gender ratio, or the extent to which there are more men than women in a field. A skewed gender ratio can activate negative stereotypes about women’s abilities and bring about underperformance among women who have identified those domains as important to them (e.g., STEM majors).
- The second dimension is the extent to which the field is assumed to embody stereotypes that are incongruous with the female gender role. Gender roles shape the way people see themselves and women report feeling dissimilar from people who fit STEM stereotypes which cause them to believe themselves less likely to possess traits that others have.

The way physics was taught also appeared to be a barrier (teacher barrier) to a female student’s participation in physics as she describes below:

**S5:** *Physics was taught in an uninteresting way which never aroused my curiosity and I also did not understand the way some of the concepts were explained.*

Conversely, male physics teachers for S6, S7 and S9 were very competent teachers who could explain the concepts well i.e. the physics learning experience in the classroom was positive. However, the relationship between the teachers and each of the female students was negative because of the undesirable comments directed at the female students that may have resulted in portraying the image that they were inferior. The comments raised laughter from the male students, making female students uncomfortable in class. For example,

**S9:** *Who helped you to do that assignment? Isn’t it your boyfriend from that other school who wrote that work for you? If not, then you worked very hard. Such a higher mark should have come from a boy because they are intelligent.*

The physics teacher for S9 perceived female students as inferior compared to male students. Higher marks by a female student signified a lot of hard work and not intelligence or that they got help from male students from other schools, but if it were male students getting a higher mark, then male students were perceived as very intelligent. This painted a picture that females are not intelligent enough to study physics. She subsequently transferred from this co-education school to an all-girls high school. Despite her achievement of grade A in physics at O-level, she did not opt to do physics at A-level, selecting mathematics only.
In addition, S6 and S7 who were learning O-level physics in different rural schools had teachers who very openly stated that these students were going to find physics hard. According to these male physics teachers, female students are not as intelligent regarding physics as the male students. It is evident in the remark below:

*S7: Physics is a hard subject for the boys because they are intelligent and not you girls. If you are to do A-level, it’s better to do biology because you will find physics very hard and you will fail.*

These female students (S6 and S7) were advised to do biology rather than physics. Their teachers created a hostile physics learning environment towards these students. Despite being immersed in this type of environment, S6 and S7 were motivated by their good O-level passes in physics to wish to study physics.

*S6: I was disappointed to note that physics, chemistry and biology were not being offered at this school although I had done O-level physics at my former school.*

*S7 said: physics is not being offered here, no physics teachers because there are no science laboratories at this high school.*

S6 and S7 lacked the opportunity to study physics because their parents could not afford to send them to schools that were offering physics. This resulted in these female students studying mathematics without physics.

From what has been described above, it is important to note that the sociocultural context of the school environment, especially prior experiences with O-level physics teachers at various schools (low, high and rural), that seem to have played a strong mediating role in shaping either positive or negative physics identity in female learners (Castro, Garcia, Cavazos Jr. & Castro, 2011). These authors maintain that often it is the people in the lives of female students who facilitate their eventual academic achievement in the chosen subjects. There are hostile environments not only at home but also at school. Therefore, teachers’ treatment of students is significant in determining students’ feelings about physics and their self-concept in relation to it (Murphy & Whitelegg, 2006b). Teachers’ behaviours in this case seemed to have marginalised the female students studying mathematics only, making teachers’ practices key to these students’ aversion to physics. Because female students’ identity is socially constructed, their actions become an expression of their social identities because it was their social identities that determined (Lloyd & Duveen, 1992) the kind of persons that they are and wish to be in as far as their participation in physics is
concerned. Hence, contextual factors such as the impact of their O-level experiences, appear to influence Zimbabwean female students’ identity formation, which inevitably seems to affect their participation in physics (Gudyanga, Adam & Kurup, 2015). All the O-level physics teachers of female students who selected mathematics and did not opt to do physics were not supportive of female students’ choice of studying physics at O-level, thus creating a hostile learning environment for them. These teachers contributed to the female students’ failure to choose physics as their subject of study. This is evidence that there are hostile environments not only at home but also at school.

Therefore, teachers’ treatment of students is significant in determining students’ feelings about physics and their self-concept in relation to it (Murphy & Whitelegg, 2006b). Teachers’ behaviours in this case seemed to have marginalised these female students, making teachers’ practice crucial to changes in physics, if we are to increase female students’ participation in the subject. As mentioned earlier, the context which influenced the way the Zimbabwean female students saw themselves was good science teaching as well as the kind of relationship they had with their physics teachers. This means that if Zimbabwe is to increase female participation in physics, then teachers are to create a conducive O-level environment that influences female students’ perception of and participation in physics.

The O-level physics classroom/laboratory environments of all female students who did not choose to study physics at A-level were not conducive for learning in a CoP. The gender insensitivity of the male physics teachers did not augur well for female students. Physics classrooms can be understood as communities of learners and learning occurring as individuals engage, imagine and align in and contribute to the practices of their communities. For female participants to feel a sense of belonging or membership, they must be able to engage mutually with the other students in a CoP (Wenger 1998). This was demonstrated by female students who were doing physics and mathematics. Female students’ sense of belonging to a community helps create an understanding of how differences in experiences and interests might combine to create barriers to some girls connecting meaningfully with others in the joint enterprise of physics activity (ibid.). This was the case with some female students (e.g. S4 and S5) who eventually opted to study only mathematics and not physics. The way they saw themselves was influenced by these teachers resulting in them constructing a negative physics identity.

Identity is personal and is influenced and shaped by the context in which we live. Identity cannot be viewed as separate from the social milieu in which it is located. When one behaves
in terms of a certain social identity, one is guided by the “norms, values and beliefs that define the relevant identity” (Reicher, 2004, p. 929). Identifying ourselves or others is a matter of meaning, and “meaning always involves interaction agreement and disagreement, convention and innovation, communication and negotiation” (Jenkins, 2004, p. 4). From this perspective, participation in a CoP shapes one’s identity as described above.

With regard to female teachers, S1 was the only student who had a female O-level teacher [see Table 5.1] and S1 referred to her as a “role model” as is reflected in her comments:

S1: *I enjoyed learning my Ordinary Level physics because I had a female ordinary level teacher who was my role model. She encouraged me a lot as a girl.*

Unlike the other female students, S3 developed a habit of reading biographies of women who excelled in physics (female role models) and this gave her the motivation to be like them. *Reading about the biographies of women studying in physics as a discipline really inspired me also to study physics.*

The biographies of females in physics and the female O-level physics teacher acted as role models and were a motivation to S3 and S1 respectively and this encouraged them to opt for physics at A-level. Lyons (2006) argued that a student is more likely to enrol in the physical sciences if the student’s science teachers advocate for the physical sciences. This affirmation helps the student to overcome his/her fear of the subject as well as its relevance (Lyons, 2006).

Lockwood (2006, p. 44) proposes that female role models may be especially beneficial for women for a variety of reasons:

- Outstanding women can function as inspirational examples of success, illustrating the kinds of achievements that are possible for women around them.
- Successful women demonstrate that it is possible to overcome traditional gender barriers, indicating to other women that high levels of success are indeed attainable.
- Female role models can also serve as proxies, guides to the potential accomplishments for which other women can strive.
- Finally, by demonstrating their competence in traditionally male occupations, highly successful women may undermine traditional gender stereotypes about women, thus reducing the damaging potential of stereotype threat effects.

This author further explained that among women who perceive themselves to be in a minority group for their profession (such as the Zimbabwean female students studying physics) the success of another woman in that career group may have a positive impact on their self-perceptions. In other words, role models play important functions when it comes to
encouraging young women, especially when it involves choosing non-traditional career pathways such as physics. This is supported by Lockwood (2006, p. 38) who maintains that “if women believe that gender-related barriers to success exist in their chosen occupation, then they may be especially inspired by an outstanding female role model, who suggests that similar success may be possible for other women in spite of these barriers.” Hence, use of female role models may be an effective way of inspiring female students to participate in physics in their large numbers.

As has been noted above, a conducive O-level learning environment on one hand, facilitated female students studying physics and mathematics to form positive perceptions of physics which seem to have helped them to develop positive identities of physics motivating them to choose physics at A-level. On the other hand, a hostile O-level learning environment experienced by female students appeared to have developed negative perceptions of physics which resulted in them choosing only mathematics and not physics at A-level. In particular, the way the O-level physics teachers interacted with female students seems to be a major factor in influencing them whether or not to opt to study physics at A-level. Female physics teachers also appear to have played a significant influence as role models in encouraging female students to participate in physics. Identity and identity formation are shaped by a variety of contextual factors with strong linkages to gender categories. A pertinent finding was that the impact of O-level experiences largely contributes to perceptions of the self (identity) and the choices one makes.

Having discussed the impact of O-level experiences on identity formation of female learners, including the influence of role models, the next section highlights teacher attitude and classroom and laboratory experiences of female students who studied physics and mathematics or only physics without mathematics at A-level.

5.4.4 A-level Physics teachers’ attitudes

In all the four schools participating in this study, physics at A-level was taught by male teachers only. Surprisingly, it is worth noting that even in the all-girls high school, both A-level physics teachers were males. Taking the feminist and masculinist science ideas into the classroom, Rosser (1989) argues that the science classroom is also heavily gendered and the masculine nature of science classes contributes to lack of women in science. This indicates that, generally, female students who were doing advanced level physics in the sampled schools did not have
female teachers/mentors as role models to encourage the students to participate in physics in large numbers. Lockwood (2006, p. 36) argued that “by identifying with an outstanding role model, individuals can become inspired to pursue similar achievements.” For example, a female astrophysicist will encourage young women to pursue non-traditional careers in science. Students need to know that someone like themselves are able to achieve success, and can strive for similar accomplishments. As role models play an important function in the identity formation of female students, an area of concern revolves around the lack of female leadership in the field of physics (Angell et al., 2004; Lockwood, 2006; Lyons, 2006; Owen et al., 2008). This may mean that the examples and applications used in teaching are frequently from a masculine perspective, and that classroom interactions encourage male dominance as a norm, even the assessments may be gender biased (McCullough, 2004; Murphy & Whitelegg, 2006b).

It is likely that women would feel excluded in science classes when their emotional and connected ways of knowing are not nurtured or their experiences are marginalised (Roychoudhury et al., 1995, p. 899).

The A-level physics teachers of S1, S 2, S3 and S8 were good, very supportive and continued to inspire them to keep on working hard for a higher grade. Although the A-level physics teacher of S3 gave her academic support, he could not effectively control the behaviour of male students towards her as she indicated below.

S3: *I was very intimidated because the boys in my class were very open about not wanting me to be part of the class. So sometimes we would be having a lesson and they wouldn’t tell me, I was new and they would just go and attend the lesson or sometimes we would be given an assignment and they wouldn’t want to share that assignment, I would have to come and talk to the teacher and ask him for the assignment but that the students I was learning with, were not willing to share information...I ask questions most of the time. But lately, it’s been hard asking questions because of the way the male students respond. So what I do now is that I am learning to write my questions in a note book and ask my teacher later, which sometimes makes learning difficult because even when you do not understand something, they kind of jest about the questions you have asked*

As illustrated above, the teacher of S3 failed to control the behaviour of male students when she asked questions in class. This may be because male teachers identify with male students and often may exhibit differential expectations for males and females (Blakemore, Berenbaum, & Liben, 2009). This teacher failed to instil in male students the concept of sharing homework questions and accommodating S3 as a person with the right to study physics without any intimidation. Despite this hostile behaviour from the male students, she continued to study physics. S3 was determined and she was able to study physics which is stereotyped as
masculine. This positive perception of physics may have resulted in her forming a positive physics identity in a CoP.

In brief, the fact that physics was taught at the senior level only by male teachers, reinforced the masculine perception of the subject. Thus, female students did not have any female role models who could possible inspire them to keep on creating positive physics identity since identities are developed in bits and pieces as decisions are continually made in this life long identity development process (Santrock, 2006). The gender of the teacher is significant in determining students’ perceptions towards physics and their self-concept in relation to it. Teachers have always been seen as having tremendous influence over students (Gazin, 2004) and that their gender-based perceptions may continue to influence their interactions with students in a CoP (Schwendenman, 2012). This may mean that the female students may feel alienated because they come to school with a sense of their own sexual identity (Cohen, 2008). Teachers’ behaviours can marginalise or empower students, making teachers’ practice key to increasing female participation in physics. Classroom experience is discussed in the next section.

5.4.5 Classroom and Laboratory Experience

The data gathered from classroom observation indicate that the O’ and A-level physics classrooms/laboratory environments of female students doing physics were conducive for learning in a CoP. This is because female students were encouraged to ask questions, read more, take apparatus first before distributing to male students and the male students were asked to share when there is a shortage of equipment. They were also urged to work harder and this, in a way may have aided these female students to construct a positive physics identity. However, asking them to read more and to work harder may indicate the teacher’s perception that the female students were not intelligent enough to study physics. During classroom observation, when students were being taught one theory lesson and one practical work, I observed that the teacher had more or less same interaction time with both male and female students. They treated the male and female students equally well without showing any favouritism with the exception of the S3 teacher. All the students were asked to find information on given topics so that they could come to present to the whole class. There was good rapport between the female students doing physics and their teachers. There was teacher-student as well as student-student interaction in this physics community. The teachers were asking thought-provoking high order questions. What must be known is that physics is a social
construct which is informed by students’ lived experiences and social interaction as mentioned previously. As students develop knowledge and competence and meaning from these interactions, they begin to construct their identities in terms of who they wish to be in relation to their communities. Hence, one’s self-concept shapes one’s attitude to physics and is a predictor of students’ decisions to continue to study physics.

The female participants were observed during the practical and theory lessons. Specific examples of S1, S2, S3 and S8 that I observed by way of the interaction between these students and their teachers are worth noting. For example, the male physics teacher of S1 reprimanded male students for laughing at female students during lessons. S1 always took a seat in front of the class and during the theory lesson she remained in the laboratory to ask the teacher pertinent questions. She was competing well with male students in terms of tests. This female student was comfortable in handling apparatus and was also very comfortable both in the laboratory and in the classroom. She actively participated in both theory and practical experiments. S1 voluntarily paired with a male student and not with the other female student as they were doing the practical experiment in pairs demonstrating shared practice in a CoP. They were investigating how the motion of a pendulum bob is affected by the height above the bench. She was actually doing the experiment and the male partner was recording the time the bob took for each complete swing. There was an enabling classroom environment with respect to resources and promoting learning in CoP.

S1 had gone against the cultural norm by opting to study physics. She came from a family of four brothers and four cousins who had all done physics and were engineers by profession. S1’s voluntary pairing with a male student may indicate that the rapport between the two students was good and that she was confident and courageously creating an identity for herself.

S2 was competing well with male students in terms of tests and class exercises. As was the case with S1, she also paired with a male student and not with the other female student during the practical work. S2 had stated during interviews that she was excited to be in a male dominated classroom. This may suggest that she was interacting well with the male students and that she was determined and confidently creating a physics identity for herself. They were investigating the extension of springs supporting a load as the load was varied. They ended by drawing a graph individually as was required in presenting the data collected during the experimental activity. The whole group was working well. All the students were able to complete their task within the given time. During the theory lesson, S2 made a presentation to
the whole group on electro-magnetic induction demonstrating understanding and meaning making. She was very confident in explaining to the whole class the factors that affect electromagnetic induction. It shows that the opportunities and support provided by the male physics teachers of S1 and S2 resulted in these female students gaining confidence and taking a leadership role to become active participants in the learning community.

S3 always took a seat in front of the class. She was comfortable handling the apparatus when they were carrying out the experiments in the laboratory. Because the teacher had requested that they work in pairs showing shared practice in a CoP. S3 had no option but to pair with a male student since she was the only female in that class. These were the male students who were subjecting her to immense peer pressure. As outlined in the previous sections, S3 used to ask questions but of late she was no longer comfortable asking questions during lessons. This was because of the behaviour of male students toward her, in particular, the comments they passed during the lessons and during their study period, which implied that she was inferior compared to them. She wrote her questions down and would then ask the teacher later or ask other female students who were in the final year of A-level. S3 usually performed better than male students in class tests, demonstrating that she was exerting a lot of pressure on the male students by outperforming them as she was constructing a positive physics identity for herself in this CoP.

S8 on the other hand was learning at an all-girls school. This school was well resourced and as a result, the female students did not work in pairs but carried out the experiments individually in the laboratory. The male physics teacher was creating an enabling classroom or laboratory environment where female students were expressing their identity during classroom engagements. The teacher of S8 had more or less the same interaction time with all the female students; S8 was competing very well with other female students doing physics in terms of performance in tests.

Although the teacher of S3 could not fully control the behaviour of male students, he did, however, try to give her support as a student who was studying physics without mathematics. He made sure that S3 participated in class as she came from a different level. Opportunities and support were also provided by the male physics teachers of S1, S2, S3 and S8. This caused them to gain confidence to participate in a physics CoP.
As has been explained above, when I observed S1, S2, S3 and S8 in the laboratories doing practical and theory work, I noted that they engaged or participated fully and effectively in learning physics within an enabling CoP. This is in line with Murphy and Whitelegg (2006) who explained that social theories of learning emphasise that learning occurs as individuals engage in and contribute to the practices of their communities. From this perspective, physics classrooms can be understood as communities of learners. Female participants must be able to engage mutually with the other participants to feel a sense of belonging or membership (Wenger 1998). To engage, they have to draw on what they do and what they know.

Generally, the teachers provided these female students with an opportunity to express and evolve their identities by helping them to actively participate in practical and theory work. The female students were all very confident in carrying out practical work and in presenting the assigned topic to the other students in a class, without any stage fright. They belonged to a CoP where they were participating fully as members. According to Wenger (2010), there is a profound connection between identity and practice. Developing a practice requires the formation of a community whose members can engage with one another and thus, acknowledge each other as participants. As a consequence, practice entails the negotiation of ways of being a person in that context. The formation of a community of practice is also the negotiation of identities (ibid.). Identity in this case can be defined as negotiated experience. We define who we are by the way we experience ourselves through participation as well as by the ways we and others reify ourselves (Wenger, 2010). Identity includes not only our knowledge and experiences, but also our perceptions of ourselves, others’ perceptions of us, and our perceptions of others’ perceptions of us that develop as we participate in communities with one another (Van Zoest & Bohl, 2008). As such, our identities do not exist only within ourselves, but rather are strung between us and the others with whom we interact. In a sense, then, our identities (Van Zoest & Bohl, 2008, p. 320) are the “vehicles from within which we participate with others in community - vehicles that provide both potentials for and limitations to our participation, and that are modified as we learn and grow through mutual participation in joint enterprises with others.” Thus, a person’s own and others’ perceptions of his/her location and trajectory within a community are key aspects of that person’s identity in practice. Therefore, it is from observing others in a CoP that one forms an idea of how new behaviour should be performed and later this coded information serves as a guide for action in their CoPs.

17 i.e. our values, beliefs, desires, motivations, and self-identifications
author stresses that students are active participants and learners in many different CoPs, in which they have formal and informal apprenticeship opportunities to learn the common language, conventions, rituals, stories and histories valued within each community.

Wenger (1998) explains that participation in collaborative activities is closely intertwined with reification and that reifications are representations of practice which give form to experience and provide a focus for participation. This implies that meaning grows out of an interweaving of participation and reification and that without participation and practice, reifications are abstract and inert. Practice without reification leaves little to reflect upon. Physics identities therefore require negotiation and construction as female students engage positively with traditionally masculine areas of study after having developed the confidence to relate to and meaningfully interact with male peers during mutual engagement as was demonstrated when these students’ behaviour was observed during classroom engagement.

In brief, identity is a powerful construct for understanding student learning because identities are constructed through practice. The female students’ experiences determine the way they form their identities, behave in class, interact within the group and with the teacher and the way they interpret the knowledge presented. This means that the schema which individuals develop about the process of identity formation might be a product of self-construction as well as social construction. The way female students are socialised affects the way they interact within their communities of practice and hence the way they form their identities. Prusak (2003) argued that sociocultural context affects individual learning; hence in the case of this study it may directly affect the participation of female students in physics.

5.4.6 Drawing a scientist

All the female participants studying physics (S1, S2, S3 and S8) were asked to draw a picture of an imaginary scientist based on the model of Draw-A-Scientist Test (DAST) suggested by Chambers (1983). The rationale for using DAST was to explore female students’ mental images of scientists in an effort to discern their perceptions towards science in general and physics in particular. They were asked to provide a name, age, nationality and gender for the scientist they had drawn. In addition, the female students were also asked to write the names of a few other scientists. The purpose was to find out whether these students perceived scientists as ordinary people who are involved in the world around them or in their societies, for example, laboratory technicians, nurses, doctors etc. or only as famous ground-breaking people they
encounter in their science text books (see other sections of the thesis). Finally, the female participants were asked to draw some of the main highlights of their life which they could relate to their aspirations to study physics. The justification for this was to gain an insight into the origins of their expressed interest in physics since the data gathered may possibly provide some clues towards the female students’ natural enthusiasm towards science (Bodzin & Gehringer, 2001).

A preliminary analysis of the diagrams drawn by the four students and subsequent discussions with them showed that S1 and S2 had similar conceptions of a scientist, i.e. a scientist as a male from a Eurocentric background while S2 and S3 visualised a scientist to be a female in an African cultural setting. Therefore, the analysis of the diagrams drawn for a scientist and related activities of S1 and S2 are presented first before discussing the data for the same activities gathered from S2 and S3. The diagrams drawn by the different students are shown below.

![Figure 5.3: The scientist drawn by S1](image)

The scientist drawn by S1 was given the names of two physicists, namely, Albert Einstein and Isaac Newton as indicated in Fig 5.3 above. During the interview she was asked to explain why she gave two names to one diagram. Her response was that the two names of these two
scientists came to her mind first and she wrote them down before doing the drawing. S1 was also familiar with Newton’s first law of motion as she wrote it alongside her diagram as indicated in Figure 5.3. Newton’s laws are not taught at A-level and it seems that it was learnt by rote from a science text book when doing O-level physics. This seems to indicate that her O-level experience might have had a positive influence on her decision to study physics. She further described the scientist as having a funny hairstyle, mature (over 50 years old) and that he might not have been happy as he was by himself carrying out experiments in a laboratory. Albert Einstein was correctly described as a male American physicist who was born in Germany. She added that due to the nature of their work, for example using microscopes, scientists may suffer from eye strain necessitating the wearing of spectacles.

The second participant (S2) also drew a male scientist, Mendeleev as shown in Figure 5.4 below. The scientist named by S2 was not a physicist but a chemist who was famous for the invention of the periodic table which is not taught at A-level as well. This suggests that S2 also might have been influenced by her O-level science experience.

![Figure 5.4: Scientist drawn by S2](image)

S2 stated that the scientist she had drawn was a Russian male who was 49 years old. During interviews she further described that scientists always worked as individuals in a laboratory.

S1 listed other scientists as shown in Fig 5.5 below. The seven scientists that she named were all male physicists except for Mendel, Raoult and Bunsen.
Similarly, S2 also listed mostly male physicists as shown in Figure 5.6 despite having drawn the image of a scientist who was a chemist.
S1 and S2, as outlined above, gave male names to their drawn scientists and their choice of listed male names from a European background (figures 5.5 and 5.6 respectively) seemed to indicate that they had a stereotype male image of scientists who are usually depicted in their textbooks. As Türkmen (2008) suggests, the image of a scientist among students is affected by male physics teachers and science textbooks. S1 and S2’s perceptions of scientists are in line with Paechter (2003) who found that most female students attribute a masculine perspective to physics which could have its origins in the cultural socialisation of females as suggested by McCullough (2004) and (Farland-Smith, 2009) which portray the perception that all scientists are males. Female students may be reluctant to participate (or engage) in science, especially physics, because they often perceive the identities of scientists as inconsistent with their own (Brotman & Moore, 2008). This could lead to more female students excluding themselves from the physics educational and professional opportunities as a result of their low participation in the subject.

It is also worth noting that neither of the two students named a single female scientist although the pictures of female scientists, for example Marie Curie, are shown in some physics textbooks and discussed during science lessons. The listing of male scientists by S1 and S2 may suggest that, because female students’ identities are socially constructed in relation to their classroom experience, their actions then become an expression of this social identity. From the ages they gave to the drawn scientists, both S1 and S2 seemed to hold the perception that scientists are mature people who always work in the laboratory.

Drawings often assist people in their journey back to recollect and represent highlights of their lived past experiences (Oliver, Wood, & De Lange, 2007). Drawings are therefore an effective way of encouraging people to express what they are thinking, feeling, longing for or even their good or bad experiences. As mentioned earlier, the female students doing physics were asked to draw pictures of events in their lives that they would consider as important in developing an affinity for physics.

The following are the diagrams that S1 drew showing herself playing with toy cars and toy cell phones (Figure 5.7). She refused to play with the dolls that her mother bought her. This may be due to the influence of male siblings, which eventually resulted in her choosing to study physics, thus creating an identity more attuned to a physics related career such as engineering.
The diagrams that S2 drew of the main highlights of her life that could be related to her aspirations to study physics are shown in Figure 5.8 below.

S2 indicated to me during the interview that she wished to become a medical doctor from as early as grade three. She chose physics, which is a requirement, in order to enable her to pursue studies in medicine. As shown in Figure 5.8, S2 imagined herself practising as a doctor, using a laser to cut a growth from the skin of her patient as illustrated above. A lot physics is applied in the use of this device. Laser (an acronym for light amplification by stimulated emission) is a device that transforms various forms of energy into electromagnetic radiation. It emits narrow beams of intense electromagnetic radiation (light) based on the stimulated emission of photons.
and the principle behind the laser goes back to the world’s most famous physicist, Albert Einstein, who in 1917 proposed a theory of stimulated light emission (Al-Azzawi, 2007). S2 described further that a laser can be used in information technology telecommunication, medicine, manufacturing, measurement and analysis, scientific research, metrology, microscopy etc. The use of the laser is an indication that S2 was aware that a lot of physics is involved in the construction and use of the laser in a variety of fields. This is a clear indication that she already started developing a physics identity which eventually influenced her to study physics.

The diagrams and lists of scientists provided by S3 and S8 are shown in Figures 5.9A and 5.9 B and figures 5.10A and B respectively. Both S3 and S8 drew female scientists and each provided an African name, specifically Zimbabwean names. The interesting point to note is that S3 drew herself as the scientist and wrote her name, aged 19 and of Zimbabwean nationality. During the interview, she identified herself as a physicist. This is significant because she perceived herself as a young African scientist implying that she was aware that scientists can also be very young.
On the other hand, S8 perceived a scientist to be mature because she stated the age 40 as shown in figure 5.9.B. In the same figure above, S8 showed the scientist wearing a laboratory coat and corrective spectacles. This is significant that S8 seems to have paid more attention to personal safety equipment like the laboratory coat. A study conducted by Demirbas (2009) produced similar results in that students imagined scientists as wearing spectacles and a laboratory coat.

The names of scientists listed by both S3 and S8 are shown in figures 5.10 A and 5.10 B below. Both these female participants listed male and female scientists. S3 wrote her name first on the list of scientists (fig 5.10 A) which I obliterated for ethical reasons. During the interview S3 said that she was an avid reader of the biographies of successful women in physics which indicates her interest in the subject and developing an identity for herself as a physicist. Furthermore, it points to the influence of female role models in shaping the identities of female students in their aspirations to become a scientist.

S8 was studying at an all-girls high school and this environment could have influenced her to include Marie Curie, a female physicist among her scientists. Although her physics teacher was a male, all her peers being females could have contributed towards her developing a self-concept that females are intelligent and are able to achieve success in physics. The list of scientists that S8 provided (Figure 5.10 B) consisted mostly of physicists similar to the list supplied by S3. This seems to indicate that both S3 and S8, though studying in different school settings, had developed positive perceptions of physics.
The lists written by both S3 and S8 are significant in the sense that both these students seemed to be aware that scientists can be either male or female, despite the prevailing cultural perception that scientists are males. The list of scientists supplied by S3 and S8 may indicate a Eurocentric perception of a scientist. However, their drawings of African female scientists appear to suggest that they also had an Afrocentric perception of a scientist. This was important because neither perceived a scientist to be only Eurocentric as was the case with S1 and S2. Figures 5.11A and 5.11B show some of the main highlights of S3 and S8’s lives which they could relate to their aspirations to study physics. S3 explained that she foresaw herself being awarded a certificate of merit in physics at the university. This implies that she was determined to pursue a career in physics, suggesting that nothing would prevent her from achieving her goals.
S8 drew her experiences when she was at a family party as illustrated in figure 5.11B. During interview S8 said that when she was at a family gathering, a glass bowl was overloaded with fruits as shown by figure 5.11B. She was doing O-level at the time and wondered why the bowl fell off. She could apply the principles of physics related to the centre of mass she learnt at O-level to explain why the structure had no balance and caused it to fall over. She seemed to link physics to daily life, demonstrating her interest in studying the subject. This might imply that S8’s passion might have developed a natural enthusiasm towards science.

It is important to note that S1 and S2 had the same standpoint that scientists are European males while S3 and S8 had a different stand point that scientists can be either male or female and that they can also be African or European. Women, as a result of their “different lived experiences, have a distinct standpoint” (Roychoudhury et al., 1995, p. 898). The premise of Feminist Standpoint Theory is that it is the difference in the social experiences of men and women that give them different ways of looking at life and interpreting events and hence different standpoints. However, Smith (1987) notes that science is developed primarily from the perspective of one group, namely, a male Eurocentric view.

In summary, the images of scientists held by Zimbabwean female high school students resemble the images held by students from other countries across the world. Two out of four female students drew stereotypical image of a male scientist and listed Eurocentric names of male scientists because their mental schemas are affected by cultural models to which students
are exposed (Gardner, 1980). The diagrams of scientists drawn by female participants may represent a perceived public stereotype and not a personal belief or perception (Symington & Spurling, 1990). Historically, images of male scientists dominate mass media as indicated by Steinke et al. (2007) and were the ones presented to them in almost all of their school encounters with science. “[The] widespread images of ordinary scientists as white men effectively discourage many talented young women … from exploring physics as an option” (Ong, 2005, p. 596). In other words, if certain subjects (or careers) are generally perceived (by the dominant view) to be occupied by people of certain traits (e.g. gender, physique, social class, etc.), then students who do not wish to be associated, or who do not have the advertised characteristics, may opt for other subjects (or careers) that are more consistent with their self-identity.

The other two female students gave African names to the scientists that they drew, indicating a deviation from the usual perceptions of a scientist as being a European. This may suggest that scientists are not only Eurocentric but can also be Afrocentric and, more specifically, Zimbabwean. In other words, their drawings and names of scientists reflect their self-belief that Africans can also be scientists, indicating a positive physics identity. Furthermore, the female students seemed to visualise scientists as ordinary people from their daily life experiences and not only as famous scientists depicted in the textbooks. Their diagrams might denote a positive physics perception which may have resulted in the construction of a positive identity formation regarding physics. The positive physics identity in turn may indicate that the female participants were more attuned to continue studying physics. The influence of peers in shaping or re-shaping identities is considered in the next section.

5.4.7 Peers

Peer groups play a crucial role in the secondary socialization of the adolescent students (Kubeka, 2014) in that they may offer them a bridge for the gradual attainment of ‘independence’ from the parents (Gouws et al., 2008). Children who conform to gender stereotypes are accepted by their peers more readily than those who do not conform (Rudman & Glick, 2008). Consequently, girls are motivated to conform to prescriptions of femininity and boys to prescriptions of masculinity.

The data suggest that female students who were doing physics experienced a lot of peer pressure at school from both male and female students, particularly at the beginning of their
engagement as a CoP. The general perception of males towards females doing physics is illustrated in the following comments made by S1, S2 and S3 during interviews:

S1: you can face challenges from boys that you are a girl doing physics it’s kind of in their manner to discourage girls. They think it’s not right, they just think girls must do biology that’s where you are supposed be and they actually say you are in the wrong place...so you really feel maybe you are in the wrong place. My male class mates right now are my friends. My teacher banned the system of male students laughing at you if you don’t know something and hence, now they just leave you to ask whatever you feel like asking.

S2: Some male students do not believe that I am going to pass physics and they also say ‘we don’t think she’s going to make it’. I feel like they are pulling me down but since I’m already doing physics, this indicates that I have the confidence and I am courageous to be in this class, so I can still overcome and be the best...

S3: The early days when I started to learn here, I was very intimidated because if I got a higher mark than the male students, they wouldn’t think that I got that because I studied but somehow because I copied or somehow cheated. Boys treat me in a way that I am inferior to them, which makes learning sometimes difficult. Most of them were expecting me to quit physics, now the attitude is, she is not going to quit but definitely she is not going to get an A. They have this element of thinking they are superior or something like that. So they are expecting me somehow to fail or to drop out.

The narratives of the three female students (S1, S2 and S3) display certain common features with respect to their male peers’ perceptions of them doing physics. Irrespective of whether the learners come from disparate socio-economic background (low income to middle/ high income socio-economic groups) or from different school categories (low density to high density/rural schools), the male peers seem to exhibit a negative attitude towards the females learning physics. As the data indicate the negative perceptions are particularly strong at the beginning of the academic year with the male students appearing to hold the belief that the female students are expected to be doing biology and, therefore, are in the wrong course or are not intelligent enough to study physics or to pass in physics. Brooks (2003) report that peer influence is significant in that it develops an individual’s sense of ability and as shown by the female participants’ motivation to perform well. The origins of physics being viewed as a ‘masculine’ subject could be a reflection of culturally rooted perceptions (Hannam, 2008; Matope & Makotose, 2007).

However, as time goes on and through sheer determination and hard work the female students try to achieve higher levels of performance in physics and the male students seem to be more tolerant towards them, as illustrated in the comment by S1 that “My male class mates right now are my friends.” The resilience of the female students to do well in physics and thereby gain a
measure of confidence and peer acceptance illustrates that they are constructing a new identity for themselves in their CoP. Their determination to do physics and mathematics against all odds reflects a measure of courage in shaping their identity. As mentioned previously, personal identity is never a finished product, but it is continually evolving as suggested by Wenger (1998). It is worth noting that, according to Marcia’s Identity Status Model, S1, S2 and S3 appear to be progressing towards identity achievement status when a person demonstrates self-defined commitment to a specific choice and develops well-defined personal values and self-concepts (Marcia, 2002). In this context, Hazari et al. (2010) have shown that students, for example, the female participants in this study can modify their behaviour in order to form an identity they want to be recognised with in their adult lives.

S8, being the only participant in this study from an all-girls school, encountered male peer pressure when she attended extra lessons in physics with male students at another school during school holidays. The male students refused to be in the same group with the female students. The main reason for this behaviour was that the males did not consider the female students to be intelligent enough to study physics and therefore would not add value to the discussions. This clearly indicates that the female students are prejudiced against doing physics when they begin to engage in learning communities with male counterparts.

The behaviour of the male students may be due to the way they were socialised from birth since they seem to regard themselves as more intelligent and hence more capable to learn physics than the female students. This is in line with Bala et al. (2012) who argue that people’s lives are strongly influenced and shaped by prevailing cultural norms, which give identity to a group of people as they are passed down from generation to generation through learning.

In summary, being a minority in a class full of male students (excluding S8 who was in an all-girls school), all the female students studying physics and mathematics encountered peer pressure both in the low and high density schools. Despite this peer pressure, female students actively resisted exclusion and were able to develop a positive physics identity.

5.4.8 Other Factors

An awareness of the role and relevance of physics in the modern technological world appeared to have motivated the female students in this study to choose physics at A-level. All the female students studying physics could explain the relevance of physics in their daily lives as illustrated below:
S1: physics is the subject to do, nowadays we are moving in an era, whereby in our generation there is nothing that is without physics; hence basically physics is now one of the most important subjects in our generation of technology.

S2: Physics is very important; almost every gadget we are using nowadays makes use of physics e.g. alarms, anything that has an operational amplifier, mobile phones, computers, etc.

S3: Physics comes into play in every single thing that we use, if we talk about stoves, if we talk about cell phones, if we talk about televisions, and the electron microscope which uses a beam of electrons.

S8: Physics is generally applied everywhere, the technology, the communication that we use, cell phones and its application its physics right, even the transport that we use is physics, machinery everything is just physics based. Maybe if we look at the cell phones they have got the chip or the line that uses the network, the wireless network that’s physics that is actually coordinated from one place to one place through a centre, the electronics of that cell phone is a modification of the physics...even spectacles or the lenses that converge or diverge light rays, is physics etc.

The data indicate that physics was not perceived an abstract subject to these female students. They were aware of the application of physics to common appliances such as stoves, operational amplifier, computers mobile phones, television, electron microscopes etc. This awareness and extensive knowledge in relation to the application of physics in the modern technological world appeared to have played a significant role in motivating the participants in choosing to study physics.

The sheer determination of the female students to succeed in physics is evident when they decided to form study groups on their own after their physics theory and practical lessons. They worked as a team when doing homework or when studying. They either searched for information on internet, discussed questions in their study groups. It was good for female students to form discussion groups where they were sharing ideas and learning from each other. The homework groups showed all three elements of coherence of communities of practice (Wenger, 1998): they worked together showing mutual engagement; wanted to prove to the males and other students that they could do the homework showing joint enterprise; and, in the process they gained a shared repertoire of valuable physics competencies. There is a clear sociocultural element of learning as participation in the practices of a CoP (Wenger, 1998). Their joint enterprise was to ensure that the homework was correctly done; their shared repertoire was the skills of answering questions they developed in the process. The female students developed confidence in themselves and their self-perception in relation to identity formation also seemed to have improved.
In brief, the awareness of the role and relevance of physics appeared to have motivated the female students to study the subject. Formation of study groups also may have made a significant contribution in improving female participants’ confidence and self-perception which might have influenced the formation of a positive physics identity. Having discussed the contextual factors which contribute towards the development of a positive or negative physics identity, the next section highlights the facets of identity formation considered to be of significance by female students.

5.5 FACETS OF IDENTITY FORMATION CONSIDERED TO BE OF SIGNIFICANCE BY FEMALE STUDENTS IN RELATION TO PHYSICS

The term identity is defined differently by the various theorists who attempt to explain it (Reay, 2003). For example, McKeon and Harrison (2010, p. 10) argue that “identity is used by individuals to justify, explain and make sense of themselves in relation to others and to the situations in which they operate” while Polman and Miller, (2010, p. 884), consider it to be “the story that each one of us is creating for ourselves.” Our identity is something that we uniquely possess and it is what distinguishes us from other people. Our identity can fundamentally shape our life experiences, how we are treated, who we meet and become friends with, what kind of education and jobs we get, where we live, what opportunities we are afforded, and what kind of inequities we may face (Gouws et al., 2008). Identity is also personal and the “manner in which we live is shaped by our sense of who we are,” (Shi & Babrow, 2007, p. 316). Identity implies the ability of an individual to be aware of the different meanings that he/she associates with himself/herself and the meanings that others assign to him/her through their interactions. It is a socially and historically constructed concept (Wenger, 1998).

We learn about our own identity and the identity of others through interactions with family, peers, school, media and other connections we make in our everyday life. The experience people acquire throughout life leads to continuous modifications of one’s identity in life because identity is not a finished product. It exists in past, present and future time frames (Horowitz, 2012), implying that individuals have multiple identities that are socially constructed through relationships with others. Identity is one’s definition of self and answers the question ‘who am I?’

Identity formation, which is part of the natural process of adolescence, is seen as the development of their self-concept. Identity is the major component of one’s self-concept and
the self has been used as an organising construct for understanding the identity (Leary & Tangney, 2003). The values transmitted to female students through the socialisation process become internalised and represent an important aspect of the self-concept (Knight, Bernal, Garza, & Cota, 1993). Subsequently, these internalised values become guides for behaviour. Thus, female students’ self-concept mediates the relation between socialisation experiences and their behaviour (ibid.). Self-concept refers to a set of abilities, opinions and thoughts by which we define and categorise ourselves (Gouws et al., 2008). Self-concept is, therefore, composed of multiple identities, hence it is multidimensional in nature (Knight et al., 1993). The self-concept is dynamic in the sense that it may change from time to time and from situation to situation. With respect to this study, the physics self-concept implies how students perceive themselves in relation to physics now and in the future (Horowitz, 2012).

Facets of identity formation are the self-descriptions of who the female students perceive themselves to be. According to Knight et al. (1993), identities may be conceptualised as memory structures composed of schemas and that these schemas are self-theories that guide information processing by structuring experiences that control behaviour. A schema can also be defined as a collection of inter-associated mental representations that function together as a unit (Horowitz, 2010). It is, therefore, a mental concept that informs female students about what concept from a variety of experiences are then stored in memory (Leary & Tangney, 2003). Our brains create and use schemas as a short cut to make future encounters with similar situations easier to navigate. In relation to my study, schemas enable female students to form an identity or self-concept with respect to physics. The self-descriptions made by female students holistically contribute towards developing and eventually achieving a physics identity. These self-descriptions are the facets or units of thought expressed in words. In other words, the facets are symbolic expressions on one’s self-concept in relation to physics and they contribute to the motivation towards physics. Table 5.2 below summarises female participants’ facets of identity formation that they consider to be of significance with respect to physics. As shown in Table 5.2, all nine female participants doing physics and/or mathematics described themselves as being intelligent and hard working. These facets support the development of an identity that would enable the female students to compete well in physics or mathematics that are culturally stereotyped as being masculine and perceived as difficult subjects. In Zimbabwe, female students are perceived by the community as being less intelligent than male students and are, therefore, expected to study biology and not physics. This implies that they needed to be hard workers if they were to register a pass in the subject.
An examination of the list of facets of identity described in Table 5.2 and interview data indicate three categories of students. The first category is those who were doing physics (S1, S2, S8 and S3), displaying a measure of confidence in the subject. The second category are those who were doing only mathematics (S4 and S5) despite having the potential to do physics but lacking in courage. The last category is those who were doing mathematics only (S6, S7 and S9) but did not do physics because of a lack of laboratory resources at school or due to a career interest not related to physics. The self-descriptions common to the first category of participants doing physics (see Table 5.2) are listed as:

Confident, determined, courageous, fearless, like challenges, likes physics, not intimidated by boys, and determined to prove that girls can study physics.

These facets that the participants perceived themselves to possess, spurred them into defying the cultural expectations when they opted to study physics. These facets enabled the female students to go against the prevailing cultural norms in the sense that they seemed to contribute towards developing a physics identity. For example, the fact that females stated that they like physics might imply that they were displaying positive attitudes towards the subject. It might also imply that they were creating a positive identity that motivated them to keep on studying the subject since they liked challenges as well. The participants’ desire to prove that they were just as able to study and pass physics as male students could result in the achievement of a science identity in general and a physics identity in particular. The category of students who chose to do physics was not intimidated by male students. S2 explained that she was excited being in a male domain and, hence, she was not afraid to be amongst the male students.
### Table 5.2: The facets of identity formation considered to be of significance by female students in relation to physics

<table>
<thead>
<tr>
<th>S1</th>
<th>S2</th>
<th>S8</th>
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<th>S4</th>
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<th>S6</th>
<th>S7</th>
<th>S9</th>
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<tbody>
<tr>
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<td>Doing physics and maths</td>
<td>Doing physics and maths</td>
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<td>Doing maths only</td>
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**SELF-DESCRIPTIONS OF FEMALE STUDENTS IN RELATION TO PHYSICS**

- **Intelligent**
- **Confident**
- **Determined**
- **Courageous**
- **Fearless**
- **Hard worker**
- **Likes challenges**
- **Likes physics**
- **Not intimidated by boys**
- **Determined to prove that girls can do physics**

- **Intelligent**
- **Confident**
- **Determined**
- **Courageous**
- **Fearless**
- **Hard worker**
- **Likes challenges**
- **Likes physics**
- **Excited being in a male domain**
- **Not afraid amongst boys**
- **Determined to prove that girls can pass physics**

- **Very intelligent**
- **Confident**
- **Determined**
- **Courageous**
- **Fearless**
- **Hard worker**
- **Likes both challenges and physics**
- **Have zeal to know inquisitive**
- **Very bold, Not intimidated by boys**
- **To prove that girls can study physics**

- **Very intelligent**
- **Confident**
- **Determined**
- **Courageous**
- **Fearless**
- **Hard worker**
- **Likes physics**
- **Doing physics at all odds**
- **Doing better than boys in physics. Determined to prove that girls study physics**

- **Very intelligent**
- **Fear of failure in physics**
- **Not courageous**
- **Lacked confidence**
- **Hard worker**
- **Do not like physics**
- **Physics was irrelevant to career aspirations**
- **Did not choose it**

- **Intelligent**
- **Courageous**
- **Determined**
- **Fearless of physics if given the opportunity**
- **Hard worker able to tackle challenges I like physics**
- **To prove that girls can do physics if given the opportunity**

- **Intelligent**
- **Courageous**
- **Determined**
- **Fearless of physics if given the opportunity**
- **Hard worker I like physics but intends to be an economist**
- **Did not choose it**
- **Physics was irrelevant to career aspirations**
The biographic data in Table 5.1 shows that all the female students doing physics were in families where they grew up with male siblings, for example, S1 had four brothers and four male cousins, S2 had three brothers and S8 had two brothers and hence they may have been very comfortable in a male-dominated classroom environment. The female students considered themselves capable of studying physics and, hence, they participated fully in the subject. For example, S8 highlighted that she was an inquisitive student who asked a lot of questions, especially during lessons, demonstrating her passion in participating in this CoP. All the facets that the female students outlined were also noted during the classroom observations, implying that the students were creating a physics identity for themselves. How students engage in school science is influenced by how students view themselves and whether they see themselves as the kind of people who could engage in science, specifically in physics (Brickhouse et al., 2000). It is therefore crucial to understand students’ identities and how their identities interact with school science identities which impact on their participation in physics.

As opposed to the first category of students studying physics, the second category of students, S4 and S5, enrolled for mathematics despite the fact that the schools they attended offered physics at A-level. In spite of the fact that they said they were intelligent and hardworking, they also expressed facets which did not seem to motivate them to study physics. These were:

*Fear of failure in physics, not courageous, lacked confidence, do not like physics and that physics was irrelevant to their career aspirations.*

These facets did not seem to create a self-concept that would allow the female participants to cross the cultural boundaries expected of them. For example, fear of failure in physics and not being courageous enough to take on the challenge indicate that the identity that these female students may have created might not have allowed them to aspire to study physics. S4 and S5 appeared to have succumbed to cultural pressure. In this context culture, which is “the collective programming of the mind that distinguishes the members of one group or category of people from others” (Hofstede, 2011, p.3) was at work in these female students. Although these students described themselves as being intelligent, cultural socialisation from a young age prevented them from studying physics, indicating the stranglehold of cultural views on an individual. Bala et al. (2012) argued that people’s lives are strongly influenced and shaped by prevailing cultural norms that, as
they are passed down from generation to generation through learning, give identity to a group of people.

The third category of female students studying mathematics (S6, S7 and S9) is considered next. S6 and S7 were studying at an under-resourced rural school with no laboratory facilities while S9 was at a well-resourced all-girls school. These three participants described themselves as:

*Courageous, determined, confident, fearless if given the opportunity/fearless, likes physics*

By stating that they liked the physics, the female participants were displaying positive attitudes for the subject as previously alluded to. This indicates that the participants may have developed a self-concept that may have influenced the creation of a positive physics identity. These self-descriptions were also a clear indication that S6 and S7 specifically, had the ability to study physics. For example, they stated that they were fearless if given the opportunity, indicating that they might have developed positive self-concepts that encouraged them to be courageous and determined to prove that girls can study physics in an environment with deep rooted cultural practices. S9 on the other hand, had the opportunity to study physics, but because she was aspiring to be an economist, believed that physics was irrelevant. She had a family role model i.e. her elder sister who had done physics at A-level and was studying pharmacy at a university, as she explains:

*S9: Basically no one discouraged me from doing physics because my big sister did physics, chemistry and maths and is now doing pharmacy.*

Despite having a role model and her parents encouraging her to study physics, S9 did not opt to study physics. This indicates that career prospects can influence the subjects one may opt to do.

To sum up, it was evident that the female students doing physics were stronger personalities who could steer away from peer pressure and sociocultural expectations. They were more assertive about what they wanted to do in life. I may, therefore, describe these female participants as having formed a positive physics identity which might have encouraged them to engage or participate fully in this CoP. In a sense then, our identities are the vehicles from which we participate with others in community i.e. “vehicles that provide both potentials for and limitations to our participation, and that are modified as we learn and grow through mutual participation in joint enterprises with others” (Van Zoest & Bohl, 2008, p. 320). As highlighted above, the facets of
identity formation considered to influence female students’ participation in physics include confidence, being courageous, determined, fearless, and intelligent, being a hard worker and liking challenging situations. On the other hand, female students who had the potential to study physics but were studying only mathematics stated that fear of failing physics, not being courageous, lacking confidence and that physics was irrelevant to their career choice were significant in influencing their non-participation in physics. These facets or self-descriptions of how the female students perceive themselves may influence their self-concepts that may have enabled female students to form an identity that contributed towards their motivation for participation or lack of it in physics. The next section discusses how, as a result of their identity, female students’ perceptions of physics influence their participation in the subject.

5.6. FEMALE STUDENTS’ PERCEPTIONS OF PHYSICS AND THEIR PARTICIPATION IN THE SUBJECT

Traditionally students at A-level enrol for both physics and mathematics as a combination of subjects to pursue a career in physics or in engineering. However, an analysis of female students’ enrolments at A-level in these two subjects in Zimbabwe indicates a different picture in the sense that more female students register for only mathematics (except the rural school which has very low numbers) and seem to avoid taking the combination of physics and mathematics as subjects of choice. Figure 5.12 below shows the number of female students doing either physics and mathematics or only mathematics at A-level in the four participating schools from 2009 to 2014. These enrolment figures of the female students participating in this study over the past six years indicate certain trends as described below.

Firstly, there are far more female students doing only mathematics compared to those doing physics, and this distinction is particularly prominent in 2010 and 2014. The reason could be that Zimbabwe introduced the use of multi-currency halfway through the year 2009 as a way of lowering high inflation. Before 2009 a large number of parents could not send their children to schools because of the financial turmoil in the country. Since the introduction of the United States Dollar as a viable currency in Zimbabwe, considerable number of families started returning from the diaspora which resulted in large numbers of students who had previously dropped out of school re-entering the school system. This gave rise to the increased student numbers at A-level in 2010.
Secondly, the total number of females doing either mathematics only or physics and mathematics appear to be greater in the all-girls school compared to the other three categories of schools. This is mainly because this school is well resourced with science laboratory facilities and quality teachers which tend to attract more students into the maths and science stream at the school. In addition, being an all-girls school, the female students are not exposed to negative perceptions towards them in doing maths and physics from male students as is the case in the coeducation schools. Thirdly, the number of female students registered for these two subjects is relatively low in the high density and rural schools compared to the other types of schools. The high density school is under-resourced in terms of laboratory facilities, materials and equipment. There is a high teacher turnover as these schools cannot retain experienced teachers who seek employment in institutions giving school based incentives.

![Chart showing the number of female students doing physics and mathematics in the four schools](image-url)

**Fig 5.12 Female students doing physics and maths in the four schools**
Lastly, the rural school does not offer physics because it does not have well-equipped science laboratory facilities. It is interesting to note that at this rural school, from 2009 to 2014, only two female students enrolled to do mathematics i.e. one in 2014 and another one in 2013 and none in 2009 to 2012 as shown in Figure 5.12 below. This may be due to the fact that the rural school is considerably under-resourced with poor teacher capacity and, hence, the female students are not well nurtured. Female students may find it more difficult to go against deeply rooted cultural perception that females are not capable enough to do mathematics, and this results in fewer female students opting to study mathematics. The cultural view that mathematics is not a suitable subject to be studied by female students seems to be stronger in the school located in the rural community compared to other school categories. During the interviews, the participants stated that female students were discouraged from studying mathematics by the community. This is an indication that only the strong-willed would be courageous enough to opt to study mathematics in a rural school. Figure 5.12 above shows the enrolment numbers of students for the physics and mathematics combination and those doing only mathematics.

As shown in Table 5.3 below, all nine female participants in this study perceived physics as a masculine subject. This may be due the socialisation they experienced from birth that physics is culturally stereotyped as being masculine and thus not a suitable subject to be studied by females, but is suitable for male students only. Many scholars of gender issues (Kelly, 1985; Rosser, 1998) have claimed that the inherent masculinity of science is the prime reason for female students’ avoidance of science. In this context it is interesting to note that physics is taught by only male teachers in all the participating schools. This is very pertinent in that the female participants do not have female role models to function as inspirational examples to help them realise that females are able to overcome traditional gender barriers and achieve high levels of success in physics (Lockwood, 2006).

The students doing only mathematics largely have the potential to study physics as well but they do not, as alluded to previously. An analysis of female students in the four participating schools indicates three distinct categories of students based on their subject choices and are summarised in Table 5.3 below.
Table 5.3: Female Students’ perceptions towards physics

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**FEMALE STUDENTS’ PERCEPTIONS OF PHYSICS**

- **Masculine**
  - It’s taught by male teachers
  - It’s hard
  - Very involving
  - Very interesting
  - It’s very important

- **It’s taught by male teachers**
  - It’s taught by male teachers
  - A bit hard
  - Not involving
  - Very interesting
  - Physics is very important

- **Masculine**
  - It’s taught by male teachers
  - It’s kind of hard
  - Requires a lot of concentration
  - Very interesting
  - Very important

- **Masculine**
  - It’s taught by male teachers
  - It’s kind of hard
  - Complicated and abstract
  - Very boring
  - Have negative perception of physics

- **Masculine**
  - It’s taught by male teachers
  - A very difficult
  - Very boring
  - Have negative perceptions of physics
  - Lacked female role models

- **Masculine**
  - It’s taught by male teachers
  - Must be very interesting
  - I am told it is hard
  - Irrelevant to my career aspirations
  - It’s Challenging

- **Masculine**
  - It’s taught by male teachers
  - Must be very interesting
  - I am told it is hard
  - Irrelevant to my career aspirations
  - It’s Challenging

- **Masculine**
  - It’s taught by male teachers
  - Very hard
  - Very boring
  - Have negative perceptions of physics
  - No female role models

- **Masculine**
  - It’s taught by male teachers
  - A bit hard
  - Very involving
  - Very interesting
  - Physics is very important

- **Masculine**
  - It’s taught by male teachers
  - It’s kind of hard
  - Requires a lot of concentration
  - Very interesting
  - Very important

- **Masculine**
  - It’s taught by male teachers
  - It’s kind of hard
  - Complicated and abstract
  - Very boring
  - Have negative perception of physics

- **Masculine**
  - It’s taught by male teachers
  - A very difficult
  - Very boring
  - Have negative perceptions of physics
  - Lacked female role models

- **Masculine**
  - It’s taught by male teachers
  - Must be very interesting
  - I am told it is hard
  - Irrelevant to my career aspirations
  - It’s Challenging

- **Masculine**
  - It’s taught by male teachers
  - Very hard
  - Very boring
  - Have negative perceptions of physics
  - No female role models
<table>
<thead>
<tr>
<th>Relevant to daily life</th>
<th>Physics is practical to daily life</th>
<th>Practical</th>
<th>Applicable to daily life</th>
<th>Irrelevant to my career choice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Am to work harder</td>
<td>Has to work hard</td>
<td>Working very hard</td>
<td>Physics is the love of my life and hence I am working hard.</td>
<td>Irrelevant to my career aspirations</td>
</tr>
</tbody>
</table>
The first category relates to students doing physics as one of their subjects. These female students perceive physics as:

A hard/challenging; too involving or demanding; requiring logical reasoning; but very interesting; very important and can practically be applied to daily life.

Despite the fact that these students perceived physics as a challenging subject, they liked the challenge and were determined to work hard to show that they could match the performance of their male counterparts in the subject. An additional motivating factor could have been that their male physics teachers always reminded them to work harder since they perceived them as less intelligent compared to the male students.

The female students’ perceptions of physics as interesting, important and very relevant to daily life is an indication that they had developed positive perceptions of the subject which might have influenced them to study physics. S1, S2, S3, and S8’s positive perceptions of physics influenced their participation in the subject, thereby creating a positive identity with regard to physics. They were comfortable in handling laboratory equipment when they were observed carrying out practical experiments in pairs. It is, therefore, a positive identity formation which might have influenced the female students’ active participation in the subject.

S4 and S5 form the second category of students who chose to do only mathematics and not physics, despite the fact that the schools they were at offered physics as a subject at A-level. Their perceptions of physics as being very hard, abstract, complicated and very boring could have been key factors which inhibited them from choosing this subject. In addition, the two students highlighted the lack of female physics teachers as role models as another reason to opt out of physics. The negative perceptions of the subject might have influenced the development of a negative identity in relation to physics resulting in them in choosing a career path where physics was irrelevant.

The third category of students (S6, S7 and S9) chose only mathematics for different reasons. S6 and S7 were studying at a rural school. These students lacked the opportunity to study physics mainly because the school did not offer physics since there were no laboratory facilities, materials and equipment. These two female participants found the subject to be interesting based on their O-level experience and were actually disappointed to note that physics was not being offered at this
rural school as it was a requirement to their career aspirations. S9 was at a well-resourced school and had the potential and opportunity to do physics. Although she was interested in physics she chose only mathematics because her career ambition to be an economist did not require physics as a subject at A-level.

The findings of this study are not in any way peculiar to Zimbabwe. Other researchers (Angell et al., 2004; Checkley, 2010; Lyons, 2006) produced similar results in that physics is perceived as interesting, but difficult and work-intensive or boring and uninteresting. This intimidating reputation of physics (that it is a difficult subject) may be creating a barrier for bright minds to participate in the subject. Further, Angell et al. (2004) claimed that the perception of physics as being difficult tends to result in the development of a general negative attitude towards the subject. However, the female participants studying physics who perceived it as interesting were motivated to pursue careers in the fields of physics and engineering. This was reflected in their active participation in laboratory work as well as a leading role they assumed in giving presentations to the whole class on different topics in physics.

In summary, female students who hold negative perceptions towards physics chose to do only mathematics at A-level while those with positive perceptions of physics displayed enthusiasm and commitment to achieve high levels of performance in the subject. The female students, having positive perceptions, actively participated in their physics community of practice. Having looked at the influence of female students’ perceptions of physics on their participation, the next section considers factors of identity formation considered as contributing to developing an orientation to physics by female students.

5.7 FACTORS OF IDENTITY FORMATION CONSIDERED AS CONTRIBUTING TO DEVELOPING AN ORIENTATION TO PHYSICS BY FEMALE STUDENTS

It has long been argued that science education is a male domain and a masculine culture (Murphy & Whitelegg, 2006a). In this context, the historical positioning of girls in the Zimbabwean society would suggest that, for many female students, making a decision to study physics requires considerable commitment and determination as a result of the cultural perception of the subject. Despite the inception of the gender policy in Zimbabwe in 2004, the participation of female students in physics is significantly low. It is therefore important to recognize that, although
educational policy may change, what students, their parents and their teachers have come to understand as appropriate ways for girls and boys to be, to know and to behave, will continue to reflect the historic masculine culture (Murphy & Whitelegg, 2006a). This is what is meant when people refer to inheriting a gender culture. As Davies (2003, p. 12) comments, “New discourses do not simply replace the old as on a clean sheet. They generally interrupt one another, though they may also exist in parallel undermining each other perhaps, but in an unexamined way.” Wenger (1998) explains that shared histories are fundamental to learning and identity formation within a community of practice:

We are connected to our histories through …our experience of participation as our identities are formed, inherited, rejected, interlocked, and transformed through mutual engagement in practice from generation to generation (Wenger, 1998, p. 89).

History cannot be divorced from the culture of a people. Hence, the identity formation of female students who were or were not studying physics may have been shaped or influenced by their history of being an African in a patriarchal Zimbabwean society which is marked by the supremacy of the father in a clan or family i.e. fathers hold authority over women and children resulting in the legal dependence of wives and children. Zimbabweans practice patrilineal\textsuperscript{18} inheritance and the least powerful roles are carried out by women in the domestic sphere or reproductive toil, such as bearing of and caring for children, food preparation and housekeeping. These activities are all time-consuming as well as labour-intensive.

Identity is the concept of ‘who we are’ that develops in our own minds and in relation to the concept of others about us as we interact with them (Wenger, 1998), developed in these participants influenced their participation in physics. In a sense, then, our identities are the vehicles from within which we participate with others in a community i.e. “vehicles that provide both potentials for and limitations to our participation, and that are modified as we learn and grow through mutual participation in joint enterprises with others” (Van Zoest & Bohl 2008, p. 320). Thus, our identity is shaped by our communities (Wenger, 2000), since identity is a socially and historically constructed concept. We define who we are by the ways we experience ourselves

\textsuperscript{18} Power, authority and possession are passed on from father to son.
through participation as well as by the ways we and others reify ourselves (Wenger, 2010). A female scientist who would have a strong science identity is one who is competent, demonstrating meaningful knowledge and understanding of science content and is motivated to understand the physical world scientifically (Carlone & Johnson, 2007). From this definition, the female students who were doing physics could be said to have achieved a science identity because they articulated themselves when they described the application of physics to daily life, thus demonstrating their knowledge and understanding of physics.

What then are the factors of identity formation considered as contributing to developing an orientation to physics by female students? These are described below. Factors are conditions or circumstances that contribute positively or negatively to the participation of female students in physics. During the interviews, the female students outlined the factors they believed had an inclination to developing an orientation or a preference to physics. They outlined several factors that would encourage or motivate them to opt to study physics. In other words, these are the elements or circumstances that would increase the formation of positive perceptions towards physics. These in turn would result in the creation of positive self-concept or identity in relation to physics. Once female students have a positive identity, they would opt to choose physics at A-level, resulting in an increased participation of females in the subject. All the female participants listed similar factors and these are summarised in table 5.4 below.

Amongst other factors they highlighted that they need female physics role models, who can encourage O-level female students to take up physics being motivated by good O-level teaching.

The need for female role models appears to be a key factor which is supported by Lockwood (2006, p. 38) who maintains that “if women believe that gender-related barriers to success exist in their chosen occupation, then they may be especially inspired by an outstanding female role model, who suggests that similar success may be possible for other women in spite of these barriers.”

Good O-level teaching is another critical factor in the sense that it is at this point that students begin to make decisions on whether or not to study physics. They also begin to create an identity in relation to physics based on their performance, which is improved if concepts are well explained with examples during the interaction process. Poor teaching would mean, concepts are not developed, no understanding, poor performance and poor construction of self-concept, hence a
negative identity resulting in non-participation in the subject. A physics identity, according to Carlone and Johnson (2007), is accessible as a result of an individual’s competence and performance. In addition, a study by Newman and Newman (2012), found that personal experiences influence identity development.
Table 5.4: Factors of identity formation contributing towards an orientation to physics.

<table>
<thead>
<tr>
<th>S1</th>
<th>S2</th>
<th>S3</th>
<th>S4</th>
<th>S5</th>
<th>S6</th>
<th>S7</th>
<th>S8</th>
<th>S9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Doing physics and mathematics</td>
<td>Doing physics and mathematics</td>
<td>Doing physics without mathematics</td>
<td>Doing mathematics only</td>
<td>Doing mathematics only</td>
<td>Doing mathematics only</td>
<td>Doing mathematics only</td>
<td>Doing mathematics and mathematics</td>
<td>Doing mathematics only</td>
</tr>
</tbody>
</table>

**FACTORS OF IDENTITY FORMATION CONTRIBUTING TOWARDS AN ORIENTATION TO PHYSICS.**

- Need for female role models
- Encouragement of female students by Good O-level teaching
- Teach gender sensitivity to male teacher and high self-esteem
- Educate community against gender stereotyping
- Female to have high self-confidence and high self-esteem

- Need for male role models
- Encouragement of female students by Good O-level teaching
- Teach gender sensitivity to female students and high self-esteem
- Educate community against gender stereotyping
- Female to have high self-confidence and high self-esteem

- Need for female role models
- Encouragement of female students by Good O-level teaching
- Teach gender sensitivity to physics and high self-esteem
- Educate community against gender stereotyping
- Female to have high self-confidence and high self-esteem

- Need for female role models
- Encouragement of female students by Good O-level teaching
- Lack of self-confidence and self-esteem
- Teach gender sensitivity to physics
- Educate community against gender stereotyping
- Teach girls relevance and importance of physics
- Educate community against gender stereotyping
- Teach girls relevance and importance of physics

- Need for female role models
- Encouragement of female students by Good O-level teaching
- Career aspirations
- Educate community against gender stereotyping
- Teach girls relevance and importance of physics
- Educate community against gender stereotyping
- Teach girls relevance and importance of physics

- Need for female role models
- Encouragement of female students by Good O-level teaching
- Career aspirations
- Educate community against gender stereotyping
- Teach girls relevance and importance of physics
- Educate community against gender stereotyping
- Teach girls relevance and importance of physics

- Need for female role models
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- Educate community against gender stereotyping
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- Teach girls relevance and importance of physics
As outlined previously, the school environment, especially prior experiences with O-level physical science teachers at various schools, may have played a strong mediating role in shaping a positive physics identity formation in female learners (Castro, Garcia, Cavazos Jr., & Castro, 2011). They maintain that, often it is the people in the lives of female students who were doing physics who facilitated their eventual academic achievement in their chosen subjects. Hence, good science teaching by the physics teachers influenced the way S1, S2, S3 and S8 perceived themselves. They began to construct a positive physics identity, which enabled them to opt to study physics.

Teachers can also encourage female O-level students to study physics by telling participants not to look down upon themselves and reinforcing the need for positive thinking by female students studying physics that build a strong science concept. During the interviews, female students explained that they need reassurance of good success by teachers during the learning encounters. This is because identity formation, and science identity in particular, is a continuous process (R. Ryan & Deci, 2012) and a lifelong journey.

The female participants outlined high self-confidence and high self-esteem as factors of identity formation they believed contributed to developing an orientation to physics. Identity, which is one’s sense of self, has two key aspects which are self-concept and self-esteem (McNeely & Blachard, 2009). The authors argue that self-concept or what a person believes about him or herself is determined by a person’s perceptions about his or her talents, goals and qualities. For example, as shown in table 5.4 above, female students who were studying physics mentioned high self-esteem and high self-confidence and this may have influenced them to select physics as their subject of choice, while S4 and S5 stated lack of self-esteem and lack of self-confidence that might have caused them to not study physics. Self-esteem, on the other hand, which refers to how people feel about their self-concept, is affected by approval from parents and other adults, the level of support received from friends and family, and personal success (McNeely & Blachard, 2009).

The child’s first place of contact with the world is the family. The family being the first and major agency of socialisation has a great influence and bearing on the development of the child (Threlfall, Seay, & Kohl, 2013 ). Parents, teachers, students and their peers live in a cultural milieu. The surrounding cultural imperatives help shape the parents’ perceptions towards physics and mathematics as well as what they expect from their daughters and this culture in turn also shapes
the female student's perceptions of physics. *Parental support and encouragement* were factors identified by both groups of students whether doing physics or only doing mathematics. We learn about our own identity and the identity of others through interactions with family, peers, organizations, institutions, media and other connections we make in our everyday life (Kail & Cavanaugh, 2000).

Three female participants (S4, S5 and S9) mentioned *career aspirations* as an important factor of identity formation that they considered as contributing to developing an orientation to physics. This may imply that if one has no intention of pursuing a science related career, then one is not motivated to develop a science identity. These findings are in line with the studies carried out by researchers (Barnes et al., 2005; Tai et al., 2006) who found career aspiration as another important factor that influences students’ decision when it comes to science enrolment.

All nine female participants stated that male physics teachers must be taught to be gender sensitive in their classroom interactions, teaching male students not to harass female students doing physics and educating the community against gender stereotyping. Gender insensitivity, male peer harassment and gender stereotyping are, therefore, factors in identity formation considered as inhibiting the development of an orientation to physics by female students. These negative factors may not motivate the female students to develop a science identity which would then discourage participation in physics. Lastly, female students who were not studying physics but were studying mathematics only (S4, S5, S6, S7, and S9) stated that there is a need to teach girls the importance and relevance of physics. If female students in general think that physics is abstract, irrelevant and not important to daily life they might not be influenced to develop a positive identity that may encourage participation in physics. These factors are also in line with the findings of researchers (Angell et al., 2004; Lyons, 2006; Murphy & Whitelegg, 2006a) who suggested as contributing to the low participation of female students in physics.

In summary, some of the factors of identity formation considered as contributing positively to developing an orientation towards physics by female students include the need for female physics role models, who can encourage O-level female students to take up physics being motivated by good O-level teaching; high self-confidence; high self-esteem; parental support and encouragement; career aspirations and the need to teach girls the importance and relevance of
physics. If female students in general think that physics is abstract, irrelevant and not important to daily life they might not be influenced to develop a positive identity that may encourage participation in physics. Gender insensitivity, male peer harassment and gender stereotyping are factors in identity formation considered as inhibiting the development of an orientation to physics by female students. These negative factors as mentioned previously may not motivate the female students to develop a science identity which would then discourage participation in physics.

5.8 CHAPTER SUMMARY:

The following contexts including parental education and their socio-economic status, masculine nature of physics, socialisation afforded to female students, impact of O-level experiences, the interaction of teachers with students and peers appear to have a significant influence on female students in shaping their identity formation which enabled them to make decisions about their subject choices at A-level. These contexts influenced the identity formation of female students with regard to their perceptions of physics as a subject of choice. Prusak (2003) argues that sociocultural context affects individual learning; hence, in the case of this study it directly affected the participation of female students in physics. Formation of a positive physics identity enables female students to have a positive perception of the subject, resulting in them opting to study it as a subject of choice. The way we are socialised affects the way we interact within our communities of practice and, hence, the way we form our identities. Facets such as being courageous, determined and intelligent encourage more female participation in the subject since they encourage the development of positive self-concepts. Fear of failing physics, lack of confidence to study physics and a lack of self-esteem are some of the factors that female students perceived as contributing to developing a negative orientation towards physics. Female students who hold negative perceptions towards physics chose to do only mathematics at A-level, while those with positive perceptions of physics displayed enthusiasm and commitment to achieve high levels of performance in the subject. Some of the factors of identity formation considered as contributing positively to developing an orientation towards physics by female students include the need for female physics role models, high self-confidence, high self-esteem, parental support and encouragement, career aspirations and the need to teach girls the importance and relevance of physics. On the other hand, gender insensitivity, male peer harassment and gender stereotyping are factors in identity formation considered as inhibiting the development of an orientation to
physics by female students. The next chapter considers conclusions, limitations and recommendations.
CHAPTER 6

CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

6.1 INTRODUCTION

And if I want to know myself, to gain insight into the meaning of my own life, then, I too, must come to know my own story (McAdams, 1993, p. 11).

I had told myself that if driven with confidence, no road was rough and bumpy to deter me from achieving my goals as I was driven with total commitment, zeal and tenacity. I managed to change the perceptions of my community in relation to educating girl children. The number of female children accessing secondary education increased in my community because I was a role model. Will Zimbabwe be in a position to increase the number of female physics teachers in all school categories in order to inspire female students’ to participate in the subject in their large numbers?  (Journal Entry, June, 2015)

The study set out to determine the extent to which identity formation influences Zimbabwean A-level female students’ perceptions of and participation in physics and this is a theme from the primary research question. In order to answer the main research question, the following sub-questions were developed in relation to this study.

1. In what ways do contexts influence the identity formation of female students with regard to their perceptions of physics as a subject of choice?
2. Which facets of identity formation are considered to be of significance by female students in relation to physics?
3. How do female students’ perceptions of physics influence their participation in the subject?
4. What factors of identity formation could be considered as contributing to developing an orientation to physics by female students?

This study being situated within the field of sociocultural psychology which aims to study the influence of society on individual human behaviour (how we create our identities) focuses not only on the fact that our interactions with others in society affect our thought processes, but also our perceptions (Myers et al., 2010). Within this context, research questions were framed from an understanding that identity formation is embedded in a cultural context (Myers et al., 2010).
The qualitative narrative research design, used in this study, situated me in the world of the participants (Denzin & Lincoln, 2000) and, hence, according to Babbie and Mouton (2001), the research process took an insider perspective. Qualitative researchers according to Denzin and Lincoln (2003, p. 13) are guided by a set of principles that emphasise the “socially constructed nature of reality, the personal relationship between the researcher and what is being inquired, and the situational constraints that shape the inquiry.” Qualitative inquiry is, therefore, a method of investigation that is “systematic and interactive,” and is employed to give an exposition of the life experiences of the participants and also to give meaning to these experiences (Mouton, 2002, p.161). As such this method grounded in an interpretive paradigm enables one to gain an in-depth understanding of the human perspectives at the individual level.

Considering the various socio-cultural and gender-related factors that influence identity, it becomes apparent that the shaping of identity largely occurs in learning communities. Therefore, a hybrid of three theoretical frameworks, namely, Wenger’s Social Learning Theory (SLT), Sfard and Prusak’s notion of telling identities as stories and Feminist Standpoint Theory (FST) was considered appropriate for the purpose of this study. Gender and Identity Formation have been considered to be nested within a hybrid of three theoretical frameworks. These frameworks are Feminist Standpoint Theory characterised by different standpoints, Sfard and Prusak’s (2005) notion of “telling” identities in a socio-cultural setting (CoP) as espoused by Wenger’s (1998) Social Learning Theory. This framework was used as an analytical toolkit in this study to elucidate the meanings within the stories of female students, with the aim of showing the extent to which identity formation influences Zimbabwean A-level female students’ perceptions of and participation in physics. The common features in the three theoretical frameworks include the following:

- that all the three frameworks are sociocultural in nature
- that human beings are social beings
- that learning is considered to be an experience, doing, belonging and becoming
- that interactional patterns are gender-linked
- that there is active construction of identity within a specific culture
- that context is a central space in which identity is constructed
All the features outlined above were pertinent to this study.

Wenger’s SLT is built on four assumptions about what matters in learning and these are: *humans are social beings* and this assumption is a central aspect of learning; that *knowledge* is a matter of competence with respect to valued enterprises; *knowing* is a matter of active engagement in the world; and *meaning* is our ability to experience the world and to engage with it in a meaningful way (Wenger, 1998, p. 4). These four assumptions conceptualise learning as an inter-play of four components mediated by social participation, namely: *meaning* (learning as experience), *practice* (learning as doing), *community* (learning as belonging) and *identity* (learning as becoming) (Wenger, 1998, p. 5). SLT was used as a lens to interpret the behaviour of female students in a learning environment and their attempts to author their identities in a CoP. Smit and Fritz (2008) argue that meaning is central to human behaviour in the sense that humans act toward people and things based on the meaning that they have attributed to those people or things. Learning in Wenger’s SLT is viewed as social participation and the development of one’s identity is closely integrated with the learning that takes place as a result of one’s participation in a CoP. Therefore, issues of identity are difficult to separate from those of learning. Lave and Wenger (1991, p. 13) argue that from a social perspective, learning should be conceived of as “a process of social participation rather than a matter of acquisition of knowledge and cognitive skills in the head” and therefore is intrinsically linked to the construction of identities.

During semi-structured interviews, the female participants narrated their stories or their identities as Sfard and Prusak (2005) contend that identities are stories that are told in a cultural setting. Lastly, Feminist Standpoint Theory recognises that gender cannot be understood in isolation from other social categories. The Feminist Standpoint Theory was used to select female students with different standpoints i.e. the students doing physics and mathematics combination and those doing only mathematics. Female students who enrolled for mathematics only were included in this study as they had the potential to study physics as well at A-level and, therefore, it was considered that their narratives could provide insights into the reasons why they did not choose to do physics.

This study took place in an educational context in Zimbabwe where, for decades, far fewer females have been enrolling for physics and mathematics compared to that of males. Three of the four schools purposively selected for the study were co-education government schools categorised as
rural, low and high density schools based on the social and economic standards of the communities in which the schools are situated. The fourth school was an all-girls non-government school categorised as a low density school. Low density schools are generally well resourced with adequate laboratory facilities (usually 3 laboratories for senior and 2 for junior students) and well-qualified science teachers. The all-girls school has six laboratories, three for junior and three for senior students. Generally, high density schools are not well resourced, having only two laboratories, one for the senior and one for the junior students. The three categories of schools selected for the study can be considered as representative of the types of schools in the broader Zimbabwean context. Therefore, it was important to determine if the interaction patterns which shape the identity formation of females would vary as the school setting changes.

6.2 CONCLUSIONS

The conclusions drawn based on the results described in the previous chapter are presented in the order of the sub-research questions, starting with contextual influences, facets of identity formation, female students’ perceptions of physics, and lastly, factors of identity formation considered as contributing to the development of an orientation towards physics by female students.

6.2.1 Influence of contextual factors on identity formation in relation to physics

The biographical details of the participants (Table 5.1) indicated a link between the level of education of the parents, their economic status and the category of the school they chose for their children. It was evident that the more educated parents being wealthier could afford to send their children to well-resourced, low density schools, while parents of low socio-economic status were generally not formally educated and, hence, could only afford to send their children to high density or rural schools. The findings of the study indicated that various contexts contributed towards the identity formation of female students with regard to their perceptions of physics as a subject of choice. The contextual factors include, community perspectives (cultural perceptions), the family (parents and siblings), the impact of the O-level experience, A-level Physics teachers’ attitudes, classroom and laboratory experience and male peer pressure.
It is important to note that our identities are the vehicles from within which we participate with others in the community i.e. “vehicles that provide both potentials for and limitations to our participation, and that are modified as we learn and grow through mutual participation in joint enterprises with others” (Van Zoest & Bohl 2008, p. 320). If identities according to Kail and Cavanaugh (2000) are socially and historically constructed, then they are not neutral.

We are connected to our histories. . .through our experience of participation as our identities are formed, inherited, rejected, interlocked, and transformed through mutual engagement in practice from generation to generation (Wenger, 1998, p. 89).

According to Wenger, history cannot be divorced from the culture of a people. Hence, the identity formation of female students may have been shaped and influenced by their history of being Africans in a patriarchal Zimbabwean society that is marked by supremacy of the father in a clan or family. Who one is, in the past, present and possible futures, is informed by the encounters one has as one addresses and responds to others (Holland & Lave, 2009).

Gudyanga et al. (2015) argue that identity is a powerful construct for understanding student learning because identities are constructed through practice. The authors point out that female students’ experiences determine the way they form their identities, behave in class and interact within the CoP, including their teachers and the way they interpret the knowledge presented. This means that the schema that individuals develop about the process of identity formation might be a product of self-construction as well as social construction. The way we are socialised affects the way we interact within our communities of practice and, hence, the way we form our identities. Sfard and Prusak (2005) argue that the sociocultural contexts affect individual learning and hence, in the case of this study, it directly affects the participation of female students in physics.

Firstly, one of the contextual factors that appeared to have had a strong influence on the identity formation of female students was the community perspectives (cultural perceptions) on the females doing physics and mathematics. Aguilar and Krasny (2011, p. 219) noted that a community is “a place of learning where practice is developed and pursued, meaning and enterprise are negotiated among members, and membership roles are developed through various forms of engagement and participation.” All nine female participants during interviews expressed the view that society confers a high status on physics and mathematics and that these subjects should not to be studied by female students but rather by males only. Biology is perceived as the subject suitable for
females. In addition, they stated that the community believes that engagement with physics and mathematics requires a high level of intelligence, which according to the community, the female students apparently do not possess. All participants in the study openly referred to the cultural perceptions as playing a major role as an inhibiting factor with regard to female participation in physics and/or mathematics. The female students who took only mathematics and not physics expressed the following: “our culture is against girls who do physics; physics is said to be masculine and should be done by the guys who are said to be more intelligent.” The quotes from the participants explicitly indicate that female students were culturally socialised to believe that the choice of physics as a subject at school is for only males. The female students who chose to study either physics and/or mathematics were described as behaving like males for the reason that they were going against Zimbabwean cultural expectations.

It is therefore worth noting that the socialisation of girls emanates from cultural perceptions. The deeply entrenched cultural views of physics as being a “masculine” subject may prevent female students from creating a positive physics identity. Hence, the more the community confirms physics as masculine, the less likely female students will be attracted to it.

Secondly, the family (parents and siblings) is another contextual factor that appeared to have influenced the identity formation of female students with regard to their perceptions of physics. Some parents supported their daughters’ choice to study physics and mathematics while others did not support them at the beginning but relented only after intense persuasion from their children. Parental resistance to female students choosing to study physics and/or mathematics seems to be culturally rooted in the fabric of society.

Since parents are the early socialisers of the female children, it is possible that they may discourage their daughters from studying physics or hinder potential female engineers from being groomed because of cultural perceptions (Hannam, 2008; Matope & Makotose, 2007). The authors further argue that this may be the reason why few females were courageous enough to choose physics or engineering as a profession. However, it was noted that parents who were in the physics or engineering fields positively influenced their children to pursue a career in engineering. “… If the cultures of child-rearing practices are gender-stereotyped, then boys and girls will be brought up very differently from each other” (Van Leuvan, 2004, p. 249). People in the community are deeply
rooted in their cultural beliefs and engage in practices which reflect gender stereotyping and gender-based role expectations. According to Social Cognitive Theory, communities encourage and coerce female students to fit in with social expectations advocated by their societies (Lips, 2008). Thus, gender stereotyping and gender role expectations seem to discourage female students from participating in subjects such as physics and mathematics at A-level. Furthermore, according to the Gender Schematic Theory, these female students form organised knowledge structures (schemas\textsuperscript{19}), which are gender-related conceptions of themselves and others. These schemas influence the thinking and the behaviour of female students (Martin & Ruble, 2004).

Siblings as role models and career ambition seem to play a significant role in influencing female students’ identity formations in favour of either physics and/or mathematics. The female participants who created an identity in favour of physics and/or mathematics were influenced by siblings who were engineers or pursuing a degree at university. Two out of five participants who were studying only mathematics chose not to do physics, purely because of career ambition. This is in line with Barnes et al., (2005) and Tai et al. (2006) who also found that career aspiration is an important factor that influences students’ decisions when it comes to science (physics) enrolment.

Thirdly, the impact of the O-level experience is another influential context on identity formation. A conducive O-level learning environment, on the one hand, facilitated some female students studying physics and mathematics, seem to have helped them to develop positive perceptions of physics which resulted in motivating them to choose physics at A-level. On the other hand, a hostile O-level learning environment experienced by other female students appeared to have created negative perceptions of physics, which eventually resulted in them choosing only mathematics and not physics at A-level. In particular, the way the O-level physics teachers interacted with female students seem to be a major factor in influencing them to opt for or against studying physics at A-level. A female O-level physics teacher who taught some of the female participants appears to have been a significant influence as role model in encouraging them to participate in physics. Identity and identity formation are shaped by a variety of contextual factors with strong linkages to gender categories. A pertinent finding was that the impact of the O-level experience largely contributed to perceptions of the self (identity) and the choices one makes. The

\textsuperscript{19} A schema is a mental structure or cognitive repertoire, which contains general expectation and knowledge of the world.
way physics was taught encouraged some students to study the subject and, on the other hand, it discouraged others from choosing physics as one of their subjects at A-level. If Zimbabwe is to increase female participation in physics, then teachers are to create a conducive O-level environment that influences female students’ creation of positive perceptions which motivate development of positive identities which increase their participation in physics. Therefore, the way physics was taught in some cases appeared to be a barrier (teacher barrier) to female student’s participation in physics.

The fact that physics at the senior level was taught only by male teachers reinforced the masculinity of the subject, thus female students did not have female role models who could possibly inform their choices. Taking the feminist and masculinist science ideas into the classroom, Rosser (1989) argues that the science classroom is also heavily gendered and the masculine nature of science classes contributes to lack of women in science. Interestingly, it is also the masculine perception of physics and the power associated with this subject (Danielsson, 2009; Walker, 2001) that encouraged some of the female participants doing physics to defy the ‘cultural norm’ and to pursue physics. The teachers’ treatment of students is significant in determining students’ perceptions towards physics and their self-concept in relation to it. Teachers’ behaviours can marginalise or empower students, making teachers’ practise key to increasing female participation in physics.

Fourthly, classroom and laboratory experience had an impact on female students’ identity formation. Identity, as alluded to previously, is a powerful construct for understanding student learning because identities are constructed through practice. The female participants who were doing physics expressed their views, thoughts and ideas as they interacted in their respective communities of practice. They participated fully in physics, associated freely and felt comfortable about who they were, where they came from, their gender and what they believed in, within their communities of practice. Male students’ perceptions towards female participants changed as time went on, and they accepted the females as part of the physics class. Having been accepted into the CoP, the female participants’ shaped and re-shaped their identities during the engagement process.

The female students studying physics were asked to draw a scientist and to provide a name, age, nationality and gender for the scientist they had drawn. The image of scientists held by
Zimbabwean female high school students resemble the images held by students from other countries across the world. Two out of four female students drew the stereotypical image of a male scientist and listed Eurocentric names of male scientists because their mental schemas appeared to be affected by the cultural models to which students these students were exposed as alluded to by Gardner (1980). The diagrams of scientists drawn by female participants may represent a perceived public stereotype and not a personal belief or perception (Symington & Spurling, 1990). Historically, images of male scientists dominate mass media as indicated by Steinke et al. (2007) and were the ones presented to them in almost all of their school encounters with science. “[The] widespread images of ordinary scientists as white men effectively discourage many talented young women … from exploring physics as an option” (Ong, 2005, p. 596). In other words, if certain subjects (or careers) are generally perceived (by the dominant view) to be occupied by people of certain traits (e.g. gender, physique, social class, etc.), then students who do not wish to be associated, or who do not have the advertised characteristics, may opt for other subjects (or careers) that are more consistent with their self-identity.

The other two female students gave African names to the scientists that they drew indicating a deviation from the usual perceptions of a scientist as being a European. Their drawings and names of scientists reflect their self-belief that Africans can also be scientists indicating a positive physics identity. Furthermore, the female students seemed to visualise scientists as ordinary people from their daily life experiences and not only as famous scientists depicted in the textbooks.

Being a minority in a class of male students (excluding the student who was in an all-girls school), all the female students studying physics and mathematics encountered male peer pressure, both in the low and high density schools. The male peer pressure made the environment in the various communities of practice not conducive for female students to learn. For example, some of them were no longer comfortable to ask questions in class but would rather ask the teacher later. Despite this peer pressure, female students actively resisted exclusion and developed a positive physics identity.

Lastly, other contextual factors such as the awareness of the role and relevance of physics motivated some of the female students to opt to study the subject. The role and relevance of physics created positive perceptions in the female participants. The positive perceptions of physics
encouraged them to choose to study physics at A-level. The formation of study groups by female participants doing physics, made a significant contribution in improving these female participants’ confidence and self-perception. The study groups also influenced the formation of a positive physics identity. There is a clear sociocultural element of learning as participation in the practices of a CoP (Wenger, 1998). Female students’ joint enterprise was to ensure that the homework was correctly done and their shared repertoire was the skills of answering questions they developed in the process. The female students developed confidence in themselves, their self-perception in relation to physics improved. Having discussed the contextual factors which contributed towards the development of a positive or negative physics identity, the next section highlights the facets of identity formation considered to be of significance by female students.

6.2.2 Facets of identity formation considered to be of significance by female students in relation to physics

Our identity is something that we uniquely possess and it is what distinguishes us from other people. Identity is the major component of one’s self-concept and the self has been used as an organising construct for understanding the identity (Leary & Tangney, 2003). As alluded to previously, self-concept refers to a set of abilities, opinions and thoughts by which we define and categorise ourselves (Gouws et al., 2008). Facets of identity formation are the self-descriptions or units of thought expressed in words of who the female students perceive themselves to be. In other words, the facets are symbolic expressions of one’s self-concept in relation to physics and contribute to the motivation towards physics. The self-descriptions made by female students doing physics holistically contributed towards developing and eventually achieving a physics identity. It was evident that the female students who were studying physics were stronger personalities who steered away from negative peer pressure and sociocultural perceptions. They were more assertive about what they wanted to do in life. I can, therefore, describe these female participants as having formed a positive physics identity that encouraged them to engage or participate fully in this CoP.

The facets of identity formation considered to influence female students’ participation in physics included confidence, being courageous, determined, fearless and intelligent and being a hard worker who likes challenging situations. The participants needed courage, determination, belief in one’s capability, agency etc. to go against cultural gender stereotyping and gender role
expectations that seem to discourage them from participating in physics and mathematics at A-level. These facets or self-descriptions of how the female students perceived themselves, positively influenced their self-concepts and enabled them to form an identity that contributed to their motivation towards participation or lack of it in physics. On the other hand, female students who had the potential to study physics but were studying only mathematics stated that the fear of failing physics, not being courageous, lacking confidence and that physics was boring and irrelevant to their career choice significantly influenced their non-participation in physics. The next section discusses how, as a result of their identity, female students’ perceptions of physics influence their participation in the subject.

6.2.3 How female students’ perceptions of physics influence their participation in the subject

Students who were studying physics perceived it as too involving or demanding; requiring logical reasoning; but very interesting; very important and can be practically applied to daily life. These positive perceptions of physics influenced them to create positive identities of the subject with regard to physics. The positive identity enabled the female participants to study physics. The female participants were observed during the practical and theory lessons. They were comfortable in handling apparatus and were also very comfortable in the classroom. Female participants actively carried out practical experiments which they completed within given time. During the theory lesson, some made presentations to the whole group on electro-magnetic induction demonstrating understanding and meaning making. They were very confident and engaged or participated fully and effectively in learning physics within their communities of practice.

The female students holding positive perceptions actively participated in their physics CoP, further shaping and re-shaping their identities in the process. Having looked at the influence female students’ perceptions of physics had on their participation, the next section considers factors of identity formation considered as contributing to developing an orientation towards physics by female students.
6.2.4 The factors of identity formation considered as contributing to developing an orientation towards physics by female students:

Identity, a concept of ‘who we are’ that develops in our own minds and in relation to the concept of others about us as we interact with them is shaped during interaction in our communities of practice (Wenger, 1998). Factors are conditions or circumstances that contribute positively or negatively to the participation of female students in physics and would increase the formation of either positive or negative perceptions towards physics. Female students outlined several factors which they perceived encouraged or motivated them to study physics. The factors of identity formation considered as contributing positively to developing an orientation towards physics by female students included the need for female physics role models who could encourage O-level female students to take up physics, being motivated by good O-level teaching, high self-confidence, high self-esteem, parental support and encouragement, career aspirations and the need to teach female students the importance and relevance of physics. If female students in general think that physics is abstract, irrelevant and not important to daily life, they might not be influenced to develop a positive identity that may encourage participation in physics. Gender insensitivity, male peer harassment, sociocultural perceptions as well as gender stereotyping were factors considered as inhibiting the development of an orientation towards physics by female students. The next section considers the researcher’s personal reflection of the research journey, implications and recommendations for further research.

6.3 REFLECTION OF THE RESEARCH JOURNEY AND IMPLICATIONS

The concept of female students’ identity formation in relation to physics is a relatively novel area in the discipline of physics education, especially in developing African countries. Identity, according to Sfard and Prusak (2005a), is most suited to answer questions about human beings in action and it serves as “the missing link” (p. 15) between learning and its sociocultural context. I used identity as an analytical tool in this study to understand the relationship between female students’ identity in relation to their participation in physics.

The qualitative narrative design grounded in an interpretive paradigm assisted me to have deep insights in order to understand the extent to which identity formation influences female students’ perceptions of and participation in physics with regards to the sociocultural and contextual
situations. The female participants were examined in their natural setting and from the perspective of the participants without imposing the researcher’s “outsider’s *a priori* understanding on the situation” (Orlikowski & Baroudi, 2001, p. 5). I realised that the research study is an iterative process in that I had to go back and forth, revisiting not only the chapters making sure that what I have written was relevant and novel, but also the interplay among research elements such as design, data generation, preliminary analysis and further data generation. The philosophy behind an iterative approach to research is that of flexibility and ongoing change that meets the needs of the research design, data requirements and methods of analysis in response to new information generated. The main strength of qualitative research is that it yields data that provides depth and detail to create an understanding of phenomena and experiences (Bowen, 2005, p. 209). Qualitative data analysis enabled me to uncover and understand what the participants really thought, felt or did in some situation or some point in time in order to see the richness of real social experiences.

### 6.3.1 Limitations of the study

The main weakness of interpretive research is that it does not seek to generalise settings to a broader population since sample sizes are usually small due to the extended in-depth interviewing. Inferences from this study are limited to the specific population in one geographic area of Gweru district in the Midlands province of Zimbabwe. Only nine female A-level students were involved in the study. A larger sample could have meant more female students involved in the study, providing more data in relation to the extent to which identity formation influences female students’ perceptions of and participation in physics. It is a strength in that “in-depth single cases highlight questions and provide insights that may be useful in other contexts” (Spillane, 2000, p. 30). Data were based on self-reports which, according to (Hong, 2010, p. 1533), “may result in recall bias such as decay of memory or oversimplification of experiences.” People do not have complete access to their experiences according to Polkinghorne (2005, p. 139), who maintains that “the capacity to be aware of or recollect one’s experiences is intrinsically limited.” Self-reported information may be general and not accurate. Therefore, the validity of the answers depended on the truthfulness of the female students. However, this study was also based on actual behaviour of the female students in their natural CoP, learning both theory and practical lessons in physics.

The findings have particular implications as outlined below:
6.3.2 Implications for the female student as she forms her identity in relation to physics.

The formation of a physics identity does not happen in isolation from other contextual identity influences such as the influence of parents and siblings, community, male peer harassment, impact of O-level experiences and female role models to mention a few. It became apparent that female students needed to be strong, determined and courageous to go against cultural stereotypes and participate in physics in their large numbers despite male peer harassment. Therefore, the need to empower the female students and help them to break away from the cultural perceptions and gender stereotypes is of critical importance if the goal of more female participation in physics is to be achieved. One’s positive self-concept influences the formation of a positive perception which would in turn encourage the formation of a positive identity in relation to physics (e.g. students can see the subject as very interesting; very important and that it can be applied practically in daily life). Positive perceptions would then impact on participation.

6.3.3 Implications for education in Zimbabwe

The study provided empirical evidence that contextual and other factors outlined above would influence female students’ participation in physics. The Zimbabwe school curriculum should be used as a tool for promoting gender inclusiveness. A gender inclusive curriculum is achieved by consciously selecting, reflecting upon, and addressing choices about classroom planning, implementation and evaluation (United Nations, 2007). During curriculum design and development, the Ministry of Primary and Secondary Education should translate the national gender policy in terms of school content into curriculum practices. This may play a major role in helping the adolescent female students pursue their personal goals, including their participation in physics. Gouws et al. (2008) admit that the emotional upheavals associated with adolescence often influence the teacher-student relationship and may consequently affect the self-concept of the female students if not well managed. The educator must be knowledgeable and require certain skills to handle these emotions with sensitivity. It is my belief that the findings may create the need in heads of schools to sensitise academic staff on the gender dimensions of teaching and learning, which is an important first step towards the transformation of cultural perceptions in order to enable female students to realise their full potential and can make meaningful contributions to the economic, social and cultural development in Zimbabwe. Teachers, as the chief curriculum
implementers, need to work hard to educate and encourage parents to treat male and female children equally.

The study also contributes to the strengthening of the need to involve key faculties, in particular male colleagues in re-conceptualising the curriculum in order to eliminate the prevailing cultural perception that physics is a masculine subject. Gender sensitive education needs to be introduced and enhanced so that those teachers will not perpetuate male dominance and female subordination in their lessons. This study revealed in particular that countrywide advocacy campaigns to eliminate negative societal and cultural attitudes that underpin the absence of women in the curricula need to be carried out. I agree with A Gudyanga et al. (2015) who recommended that female students need to be afforded a conducive social environment that enables them to form positive social perceptions of physics so that they can develop the self-esteem that is essential for decision making throughout life. The encouragement from both the home and school plays a crucial role in this process. Lastly, participation of female students may be increased especially if ways to incentivise them to participate in physics are sought by the government for example, offering bursaries for tertiary education in Zimbabwe.

6.3.4 Implications for educational research

A large number of western studies (Coyle, 2006; Murphy & Whitelegg, 2006a; Olorode, 2005) have reported on the reasons for the low uptake of physics by girls, with very few studies having been carried out in developing countries like Zimbabwe where cultural gender role patterns are distinct and pervasive. The focus of studies in western countries have been predominantly on school, classroom and student factors (Carlone & Johnson, 2007; Hazari et al., 2010; Hughes, 2001) with hardly any studies examining identity forming factors. There are no studies that focus on the relationship between female students’ identity and their participation in physics, the gap which this research study addressed.

My contention is that this study contributes to the scholarship of the extent to which identity formation influences Zimbabwean A-level female students’ perceptions of and participation in physics and the ways in which various contexts influence the identity formation of female students with regard to their perceptions of physics as a subject of choice. I managed to illuminate negative physics classroom experiences which resulted in female participants shaping a negative physics
identity, which discouraged their participation in physics. I also succeeded in outlining underlying facets of identity formation (self-descriptions) made by female students which holistically contributed towards developing and eventually achieving a physics identity. Lastly, the factors considered as inhibiting as well as those believed to be contributing positively to developing an orientation towards physics by female students were founded. Indeed, this study also contributed to the strengthening of educational research in Zimbabwe.

6.4 RECOMMENDATIONS FOR FURTHER RESEARCH

It is recommended that:

- A wider and more comprehensive study nationally is warranted to confirm the findings of this study.
- A broader range of cases could have strengthened the research evidence, with potentially wider acceptance and, hence, this could result in the formulation of more relevant policies.
- Developing this study into a longer term research programme may therefore be interesting.
- Further research to explore the reasons for the common perception that physics is a difficult school subject would be beneficial.


APPENDICES

APPENDIX 1: SAMPLE QUESTIONNAIRE

My name is Gudyanga Anna Mrs and I am a PhD student at the Nelson Mandela Metropolitan University in Port Elizabeth. The research I wish to conduct for my doctoral thesis is entitled: Participation of Zimbabwean female students in physics: Subject perception and identity formation. This project will be conducted under the supervision of Dr K. Adam (promoter) and Dr R. Kurup (co-promoter), of (NMMU, South Africa). It should take no longer than 10 minutes of your time. Although your response is of the utmost importance to us, your participation in this study is entirely voluntary. Please do not enter your name or contact details on the questionnaire. It remains anonymous. Information provided by you remains confidential and will be reported in summary format only.

This sample questionnaire should be filled in by all A-level female students doing mathematics with physics and A-level female students doing mathematics without physics. These questions are used for the selection of the female students who are to be participants in this study and only the biographical information of the participants will be used.

Should you have any queries or comments regarding this study, you are welcome to contact me on the following e-mail address gudyangaa@gmail.com

NB. Please do tick the option that you are choosing and fill in the spaces provided

1. Are you doing A ‘Level Science? Yes ☐ No ☐

2. Are you in lower six (form 5)? ☐ Or upper six (form 6)? ☐

3. What is your age?
   17 and below ☐
   18 years ☐
   19 years ☐
   Above 19 years ☐
4. List the subjects that you are doing……………………………………………………………

………………………………………………………………………………………………………..

5. Are your parents alive?    Mother □    Father □

6. I live with: Both my parents □    Mother & siblings □    my guardian □

7. What is the occupation of your father? .................................................................

8. What is the occupation of your mother? ..............................................................

9. Who is responsible for paying your fees?    Parents? □    Or Guardian? □

10. What is the average monthly salary of your parents or your guardian?

   Poor ($ 200 and below) □

   Low income ($201-$400) □

   Middle income ($401-$ 999) □

   High income ($ 1 000 and above) □
APPENDIX 2: INTERVIEW GUIDE 1 (Interview guide for students doing physics and mathematics)

Date: ………………………

Time of interview…………………………

Place………………………………………

Interviewee Code…………………………

Welcome…………………… (Participant’s name) to this interview session. Thank you for agreeing to be here today and for sharing your perspective and your experiences relating to the participation of Zimbabwean female students in physics: subject formation and identity formation. Before we begin, I would like to remind you that any information you impart to me during this interview is strictly confidential. You also have the right to refuse answering any question I ask. Please feel free to stop me at any time if you do not understand the question so that I can rephrase it. Identity is defined as the ability of the individual to be aware of the different meanings that she associates with herself and the meanings that others assign to her. Identity formation on the other hand is defined as the creation, establishment, organisation, development, genesis, and generation or coming into existence of oneself.

1. Did you enjoy learning O-level Science? Explain why or why not?

   If answer is yes, to give reason(s) and if no, still to give reason(s)

2. You are a student doing physics. What has influenced you to do it?

   An in depth explanation as to what led her to do physics

3. Fewer female students are doing physics, what reasons do you think might have contributed to this?

   An in depth explanation as to what reasons they think would have contributed to this?

5. What challenges have you experienced as a physics student?
   An in depth explanation as to what challenges the student has encountered.

6. Explain the relevance of physics in your day to day life e.g. in the technology that you use.

7. How do you perceive the attitude of male students doing physics in class towards you?

8. How do you get support with your homework?

9. What kind of support does your parents and or your guardians give you in your endeavour to study science?

10. Can you please describe the attitude of your teacher towards female students doing physics?
   How often do ask questions?
   - encouragement in class
   - motivation

11. What do you perceive yourself as a physics student among male physics students?
    - identity descriptions

12. How do you think your physics teacher perceives you in your physics class?

13. What programmes do you envisage to do at tertiary level after completing your A-level physics?
Welcome………………… (Participant’s name) to this interview session. Thank you for agreeing to be here today and for sharing your perspective and your experiences relating to the participation of Zimbabwean female students in physics: subject formation and identity formation. I would like to remind you that any information you impart to me during this interview is strictly confidential. You also have the right to refuse answering any question I ask. Please feel free to stop me at any time if you do not understand the question so that I can rephrase it. Identity is defined as the ability of the individual to be aware of the different meanings that she associates with herself and the meanings that others assign to her. Identity formation on the other hand is defined as the creation, establishment, organisation, development, genesis, and generation or coming into existence of oneself.

**Interview Questions**

1. You are a student capable of doing physics. What has prevented you from doing physics?
   - Reasons for not doing physics, when she has the potential of doing it.

2. What are your thoughts of physics as a subject?
   - The way she perceives physics.

3. In your opinion, why are fewer girls opting to do physics?

4. What stimulated you to do mathematics?

5. What are your future plans?
APPENDIX 4: OBSERVATION GUIDE

Date: ………………………

Practical Session  □  Theory Lesson  □

Time of observation…………………………

Place………………………………………

School Code…………………………

Type of School

Rural poor □
High-density low income □
Low-density middle income □

Which form?  Lower six (form 5) □  Or upper six (form 6) □

Teacher’s Gender?  Male □  or  Female □

No of students in a class…………  Gender Ratio: Girls □  Boys □

Description of learning environment

Where do the girls sit?

- in front
- back of class or
- well spread out.

Are girls comfortable in carrying out experiments, handling equipment etc. in the lab space?

Interaction Patterns

- How many times the teacher asks students questions (and their responses to boys or to girls).
- How many times students ask questions, (do girls ask questions in class?)
- Are they closed or open-ended questions?
• Interaction time with boys or girls? etc.

Rapport between teacher and students

• Freedom to ask questions
• Participation in experiments or discussions
• How comfortable are the girls in the classroom

After school or recess interactions

• Do Students like to hang around in the science lab or in the science teacher's classroom?
APPENDIX 5: DRAWING QUESTIONS [DRAW-A-SCIENTIST TEST (DAST)]

Date: .............................

Time of Drawing..........................

Place.................................

Participant Code........................

My name is Gudyanga Anna Mrs and I am a PhD student at the nelson Mandela Metropolitan University in Port Elizabeth. The research I wish to conduct for my doctoral thesis is entitled: Participation of Zimbabwean female students in physics: Subject perception and identity formation. Use the answer sheets provided to answer the following questions in about an hour. Although your response is of the utmost importance to us, your participation in this study is entirely voluntary. Please do not enter your name or contact details on the questionnaire. It remains anonymous. Information provided by you remains confidential and will be reported in summary format only.

Should you have any queries or comments regarding this study, you are welcome to contact me on the following e-mail address gudyangaa@gmail.com

Remember that what is important is not how well one draws but what new insights one can gain through the drawing process (Pithouse, 2011). You do not have to be an artist, simply draw.

1. Draw a scientist.

2. Name the scientist, provide a name, age, nationality and gender for the scientist that you draw.

3. List the names of other scientists that you know.

4. Look back from the time that you were young (as far as you can remember) to present and remember highlights of your life. Draw diagrams and or cartoons that reflect the following in relation to your learning physics:
• Family experiences
• School experiences
• Peer experience
PARTICIPATION OF ZIMBABWE FEMALE STUDENTS IN PHYSICS: SUBJECT PERCEPTION AND IDENTITY FORMATION.

Your above-entitled application for ethics approval was approved by the Faculty Research, Technology and Innovation Committee of Education (ERTIC) meeting on 4 March 2013.

We take pleasure in informing you that the application was approved by the Committee.

The ethics clearance reference number is H13-EDU-ERE-008.
We wish you well with the project. Please inform your co-investigators of the outcome, and convey our best wishes.

Yours sincerely

Ms J Elliott-Gentry

Secretary: ERTIC
APPENDIX 7: INFORMATION AND INFORMED CONSENT FORM

NELSON MANDELA METROPOLITAN UNIVERSITY

<table>
<thead>
<tr>
<th>RESEARCHER’S DETAILS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Title of the research project</strong></td>
</tr>
<tr>
<td><strong>Reference number</strong></td>
</tr>
<tr>
<td><strong>Principal investigator</strong></td>
</tr>
<tr>
<td><strong>Address</strong></td>
</tr>
<tr>
<td><strong>Postal Code</strong></td>
</tr>
<tr>
<td><strong>Contact telephone number (private numbers not advisable)</strong></td>
</tr>
</tbody>
</table>

A. DECLARATION BY OR ON BEHALF OF PARTICIPANT

<table>
<thead>
<tr>
<th>Initial</th>
</tr>
</thead>
</table>

I, the participant and the undersigned

<table>
<thead>
<tr>
<th>Initial</th>
</tr>
</thead>
</table>

ID number

<table>
<thead>
<tr>
<th>Initial</th>
</tr>
</thead>
</table>

Address (of participant)

<table>
<thead>
<tr>
<th>Initial</th>
</tr>
</thead>
</table>

A.1 HEREBY CONFIRM AS FOLLOWS:

I, the participant, was invited to participate in the above-mentioned research project

that is being undertaken by Gudyanga Anna Mrs

from Faculty of Education

Of the Nelson Mandela Metropolitan University.
**THE FOLLOWING ASPECTS HAVE BEEN EXPLAINED TO ME, THE PARTICIPANT:**

<table>
<thead>
<tr>
<th>2.1</th>
<th><strong>Aim:</strong></th>
<th>The investigator wants to find out the influence of identity formation on perceptions and participation of Zimbabwean female students in physics. The information will be used for purposes of study only.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.2</td>
<td><strong>Procedures:</strong></td>
<td>I understand that I will be audio-taped during one-hour interview sessions spanning over a period of four days, will take part in one hour drawings -visual methodology and video-taped during classroom observations (40 minutes if it is a theory lesson and one hour 20 minutes if it is a practical lesson)</td>
</tr>
<tr>
<td>2.3</td>
<td><strong>Risks:</strong></td>
<td>There are known or anticipated risks if you participate in this study.</td>
</tr>
<tr>
<td>2.4</td>
<td><strong>Possible benefits:</strong></td>
<td>As a result of their participation in this study, female students will be empowered to make informed choices of the science subjects as well being aware of the choices that are available to them. They will be enlightened in the way they behave, interact and see things from the cultural point of view.</td>
</tr>
<tr>
<td>2.5</td>
<td><strong>Confidentiality:</strong></td>
<td>My identity will not be revealed in any discussion, description or scientific publications by the investigators.</td>
</tr>
<tr>
<td>2.6</td>
<td><strong>Access to findings:</strong></td>
<td>Any new information or benefit that develops during the course of the study will be shared as follows: The final written report will be provided to the three participating schools. The report will be channeled through the gatekeeper of the relevant personnel. The copy can also be accessed on line from NMMU website when thesis is accepted</td>
</tr>
<tr>
<td>2.6</td>
<td><strong>Voluntary participation refusal discontinuation:</strong></td>
<td>My participation is voluntary YES NO My decision whether or not to participate will in no way affect my present or future care / employment / lifestyle TRUE FALSE</td>
</tr>
</tbody>
</table>
3. **THE INFORMATION ABOVE WAS EXPLAINED TO ME/THE PARTICIPANT BY:**

<table>
<thead>
<tr>
<th>Language</th>
<th>Afrikaans</th>
<th>English</th>
<th>Xhosa</th>
<th>Other</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Gudyanga Anna Mrs

And I am in command of this language.

I was given the opportunity to ask questions and all these questions were answered satisfactorily.

4. No pressure was exerted on me to consent to participation and I understand that I may withdraw at any stage without penalisation.

5. Participation in this study will not result in any additional cost to me.

**A.2 I HEREBY VOLUNTARILY CONSENT TO PARTICIPATE IN THE ABOVE-MENTIONED PROJECT:**

Signed/confirmed at

On 20

Signature of witness:

Signature or right thumb print of participant

Full name of witness:
### B. STATEMENT BY OR ON BEHALF OF INVESTIGATOR(S)

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Gudyanga Anna Mrs</td>
<td>declare that:</td>
</tr>
<tr>
<td></td>
<td>I have explained the information given in this document to</td>
<td>(name of participant)</td>
</tr>
<tr>
<td></td>
<td>and / or / her representative</td>
<td>(name of representative)</td>
</tr>
<tr>
<td>2.</td>
<td>He / she was encouraged and given ample time to ask me any questions;</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>This conversation was conducted in</td>
<td>Afrikaans</td>
</tr>
<tr>
<td></td>
<td>And no translator was used OR this conversation was translated into</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>I have detached Section D and handed it to the participant</td>
<td>YES</td>
</tr>
</tbody>
</table>

**Signed/confirmed at**

On 20

**Signature of interviewer**

**Signature of witness:**

**Full name of witness:**

### C. DECLARATION BY TRANSLATOR (WHEN APPLICABLE)

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>I,</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>ID number</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Qualifications and/or</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Current employment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>confirm that I:</td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Translated the contents of this document from English into</td>
<td>(language)</td>
</tr>
<tr>
<td>2.</td>
<td>Also translated questions posed by</td>
<td>(name of participant)</td>
</tr>
<tr>
<td>3.</td>
<td>Conveyed a factually correct version of what was related to me.</td>
<td></td>
</tr>
</tbody>
</table>

**Signed/confirmed at**

On 20
I hereby declare that all information acquired by me for the purposes of this study will be kept confidential.

<table>
<thead>
<tr>
<th>Signature of translator</th>
<th>Signature of witness:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Full name of witness:</td>
</tr>
</tbody>
</table>

D. IMPORTANT MESSAGE TO PATIENT/REPRESENTATIVE OF PARTICIPANT

Dear participant/representative of the participant

Thank you for your participation in this study. Should, at any time during the study:

- an emergency arise as a result of the research, or
- you require any further information with regard to the study,

Kindly contact Gudyanga Anna Mrs: email address – gudyangaa@gmail.com

telephone number +263 773 420 631 or 083 364 0375
Faculty of Education NMMU

Prof Denise Zinn; Faculty Chairperson. Tel: +27 (0)41 504-2953 Fax: +27 (0)41-504-2822 E-mail Faculty Chairperson: denise_zinn @nmmu.ac.za

Date ......................................

Ref: H13- EDU-ERE-008

Contact person: Gudyanga A Mrs

Dear Participant

You are being asked to participate in a research study. We will provide you with the necessary information to assist you to understand the study and explain what would be expected of you (participant). These guidelines would include the risks, benefits, and your rights as a study subject. Please feel free to ask the researcher to clarify anything that is not clear to you.

To participate, it will be required of you to provide a written consent that will include your signature, date and initials to verify that you understand and agree to the conditions.

You have the right to query concerns regarding the study at any time. Immediately report any new problems during the study, to the researcher. Telephone numbers of the researcher are provided. Please feel free to call these numbers.

Furthermore, it is important that you are aware of the fact that the ethical integrity of the study has been approved by the Research Ethics Committee (Human) of the university. The REC-H consists of a group of independent experts that has the responsibility to ensure that the rights and welfare of participants in research are protected and that studies are conducted in an ethical manner. Studies cannot be conducted without REC-H’s approval. Queries with regard to your rights as a research subject can be directed to the Research Ethics Committee (Human), Department of
Research Capacity Development, PO Box 77000, Nelson Mandela Metropolitan University, Port Elizabeth, 6031.

If no one could assist you, you may write to: The Chairperson of the Research, Technology and Innovation Committee, PO Box 77000, Nelson Mandela Metropolitan University, Port Elizabeth, 6031.

Participation in research is completely voluntary. You are not obliged to take part in this research you will not be affected in any way and you will incur no penalty and/or loss of benefits to which you may otherwise be entitled.

If you do partake, you have the right to withdraw at any given time, during the study without penalty or loss of benefits. However, if you do withdraw from the study, you should return for a final discussion or examination in order to terminate the research in an orderly manner.

Although your identity will at all times remain confidential, the results of the research study may be presented at scientific conferences or in specialist publications.

This informed consent statement has been prepared in compliance with current statutory guidelines.

Yours sincerely

Mrs Anna Gudyanga

RESEARCHER

Email address: gudyangaa@gmail.com

Tel nos. +263 773 420 631 or +2783 364 0375
APPENDIX 9: REQUEST FOR PERMISSION TO CONDUCT RESEARCH IN SCHOOLS

The Provincial Education Director
Ministry of Education, Sport, Arts and Culture
Midlands Province
Gweru
Zimbabwe
New Govt. Complex, 10th Street
Box 737

REQUEST FOR PERMISSION TO CONDUCT RESEARCH IN SCHOOLS

Dear Sir/Madam

My name is Gudyanga Anna Mrs and I am a PhD student at the Nelson Mandela Metropolitan University in Port Elizabeth. The research I wish to conduct for my doctoral thesis entitled: participation of zimbabwean female students in physics: subject perception and identity formation. This project will be conducted under the supervision of Dr K. Adam (promoter): tel-27 41 504 4041, email address- kathija.adam@nmmu.ac.za and Dr R. Kurup (co-promoter), 27 41 504 4024, email address- raj.kurup@nmmu.ac.za of (NMMU, South Africa)

I am hereby seeking your consent to “to approach three schools in the Gweru district to provide participants for this project”.

I have provided you with a copy of my thesis proposal which includes copy of the consent form to be used in the research process, as well as a copy of the approval letter which I received from the NMMU Research Ethics Committee (Human).
Upon completion of the study, I undertake to provide the Department of Education with a bound copy of the full research report. If you require any further information, please do not hesitate to contact me on +27 83364 0375 or +263 77420631 and e-mail address- gudyangaa@gmail.com. Thank you for your time and consideration in this matter.

Yours sincerely

Mrs Anna Gudyanga

Nelson Mandela Metropolitan University
APPENDIX 10: PERMISSION FROM MIDLANDS STATE UNIVERSITY

MIDLANDS STATE UNIVERSITY
P. BAG 9055
Gweru
Zimbabwe

FACULTY OF EDUCATION
DEPARTMENT OF EDUCATIONAL FOUNDATIONS, MANAGEMENT & CURRICULUM STUDIES

24 June, 2013.

Ministry of Education, Sports, Arts and Culture
P. O. Box 8022
CAUSEWAY

RE: SPECIAL PERMIT TO CONDUCT RESEARCH IN THE MINISTRY

The Faculty of Education’s Department of Educational Foundations, Management and Curriculum Studies at Midlands State University is seeking your permission to allow Mrs Anna Gudyanga, a lecturer in the department studying for a PhD with Nelson Mandela Metropolitan University, to conduct her research in Gweru District schools.

May I take this opportunity to thank you for the cooperation you have rendered always in this respect.

Dr. Wonderful Dzimiri, Ph.D.
Dept. Chairperson- Educational Foundations, Management & Curriculum Studies
APPENDIX 11 A: PERMISSION TO CONDUCT RESEARCH

Dear Sir/Madam,

APPLICATION FOR PERMISSION TO CARRY OUT AN EDUCATIONAL RESEARCH AT THE PROVINCIAL OFFICE IN MIDLANDS PROVINCE

Permission to carry out a research on

Research on Participation of Zimbabwean Female Students in Physics: Subject Perception and Identity Formation

In Midlands Province has been granted on these conditions:

a) that in carrying out this you do not disturb the learning/teaching programmes in schools.
b) that you avail the Ministry of Education, Sport and Culture with a copy of your research findings.
c) that this permission can be withdrawn at anytime by the Provincial Education Director or by any higher officer.

The Education Director wishes you success in your research work and in your University College studies.

EDUCATION OFFICER (PROFESSIONAL ADMINISTRATION AND LEGAL SERVICES) FOR PROVINCIAL EDUCATION DIRECTOR: MIDLANDS
APPENDIX 11 B: PERMISSION TO CONDUCT RESEARCH

All communications should be addressed to
“The Provincial Education Director, Ministry of
Education, Sport, Arts and Culture”
Telephone:222911/4
Fax:226482 or 228595

Ministry of Education
Sport, Arts and Culture
P.O Box 737
GWERU

Mr/Mrs/Miss Anna Chirumhanzu
MIDLANDS STATE UNIVERSITY
P. Bag 9055
GWERU

25 JUNE 2013

Dear Sir/Madam

APPLICATION FOR PERMISSION TO CARRY OUT AN EDUCATIONAL RESEARCH IN SCHOOLS IN MIDLANDS PROVINCE

Permission to carry out a research on

PARTICIPATION OF ZIMBABWE FEMALE STUDENTS IN PHYSICS: SUBJECT PERCEPTION AND I DENTITY FORMATION

In Midlands Province it has been granted on these conditions:

a) That in carrying out this you do not disturb the learning/teaching programmes in schools.
b) That you avail the Ministry of Education, Sport, Arts and Culture with a copy of your research findings.
c) That this permission can be withdrawn at any time by the Provincial Education Director or by any higher office.

The Education Director wishes you success in your research work and in your University College studies.

M. Matinga
Education Officer (Professional Administration and Legal Services)
FOR PROVINCIAL EDUCATION DIRECTOR: MIDLANDS PROVINCE

194
APPENDIX 12: LETTER OF INVITATION TO SCHOOL HEADS

LETTER OF INVITATION TO SCHOOL HEADS

Participation of Zimbabwean female students in physics: Subject perception and identity formation.

My name is Gudyanga Anna Mrs, and I am a PhD student at the Nelson Mandela Metropolitan University (NMMU). I am conducting research to find out the influence of identity formation has on the perceptions and participation of female students in physics in Zimbabwe. I am under the supervision of Dr K. Adam (Promoter) and Dr R. Kurup (co-promoter). The Provincial Department of Education has given approval to approach schools for my research. A copy of their approval is contained with this letter. I invite you to consider taking part in this research. This study will meet the requirements of the Research Ethics Committee (Human) of the NMMU.

Aims of the Research

The major aim of this study is to find out the influence of identity formation on Zimbabwean female students’ perceptions and participation in physics.

The following sub objectives are required to meet the primary aim of the principal investigator’s research:

The research aims to:

1. Find out the contexts which influence the identity formation of female students with respect to their participation in science.

2. Find out the facets of identity formation that are displayed by female students in physics.

3. Find out identity factors that influence female students’ perceptions of physics.
4. Find out what identity factors influence female students’ perceptions of physics on their participation in physics.

Significance of the Research Project

The research is significant in four ways:

1. This study will contribute to the formation of new knowledge creation that will be pertinent to science and technology education in Zimbabwe.

2. This study will also provide physics educators, physics planners and the government with detailed information on the role identity formation plays on the perceptions and participation of Zimbabwean female adolescent students in physics.

3. It therefore engages key stakeholders in science education in revealing the characteristics of identity formation that are displayed by female students and the identity factors which influence their perceptions on their participation in physics. The findings will also be used by teachers, counsellors and parents as they help to develop a positive attitude towards physics and encourage participation of female students in this important subject.

4. Science without physics is incomplete, since there can be no technological advancement without physics. In other words knowledge in physics is needed for technological advances that drive the economy of a country.

Benefits of the Research to Schools

1. The findings will also be used by teachers, counsellors and parents as they help to develop a positive attitude towards physics and encourage participation of female students in this important subject at your school.

2. Physics contributes to technological infrastructure and provides trained personnel needed to take advantage of scientific advances and discoveries. Without physics there would be no cars, cell phones and television sets (to mention but a few) which you are using at your school.

Research Plan and Method

There are sixteen High Schools in Gweru District that are offering science subjects at A-level. Schools will be stratified first before purposively sampling three. Of the three schools one will be from the rural areas (rural poor community), one high density urban school (low income) and one low density urban school (middle income). This is because different contexts affect identity
formation of these adolescent female students differently (Kroger, 2007). Female adolescent students in form five and six doing science subjects in three High Schools in Gweru District of the Midlands Province in Zimbabwe will be part of the population hence the participants will be A-level female adolescent students. Sample questionnaires will be used to select six female A-level students from the three schools. All the A-level female students doing mathematics and not with physics and all those doing physics and mathematics will be asked to fill in the sample questionnaire.

The researcher will immerse herself in the lived experience of the participants of this study in the context of how their identity formation has and will influence their perceptions and participation in physics. This study is situated within the narrative inquiry approach for data generation. The generation of data is not limited to the written or the spoken word but it includes the active representations of ideas, and the use of drawings. Drawings done by female students are a type of visual methodology. They can be used as a form of expression, reflection and therapy (Stuart, 2007). Drawings will enable the three female students doing mathematics and physics (one from each of the three schools) not only to access their experiences but also to reveal these experiences and perspectives to others. These three female students doing physics and mathematics will draw the scientist as well as drawing labelled and explained diagrams/cartoons showing major highlights of their life (narratives diagrams). This can be followed by either draw and write or draw and talk and then follow up interviews. The female students will be told to remember that what is important is not how well one draws but what new insights one can gain through the drawing process (Pithouse 2011). They will expose and explore their perceptions as well as experiences in learning science in general and physics in particular (Stuart, 2007). Narratives on the other hand (done by three female students doing physics) will focus on the whole person and how identity elements are integrated via one’s life story (Kroger, 2007). The researcher will rely on interviewing these six female students (two students from each of the three selected schools i.e. one doing physics and mathematics and another doing mathematics but not with physics when she is potential candidate to do physics). Narrative research inquiry will enable the researcher to get the perceptions and participation of female students towards physics by means of one hour in-depth semi-structured interviews spanning over a period of four days and direct observations in natural settings and by accessing participants’ subjective factors such as thoughts, feelings and desires. In conducting taped interviews, the meaning and context of the interview will be captured more completely by
the researcher who will write out field notes about facial expressions and tone of voice as a supplement to each interview. Classroom observations of participants during their normal theory lessons (of forty minutes each) and laboratory work of 1 hour twenty minutes will be videotaped and used to establish the participation and interaction patterns of female students in physics lessons. The researcher will also focus on the process of interaction amongst individuals in the specific contexts in which people live or work, in order to understand the historical and cultural setting of the participants (Creswell 2007). The researcher will use field notes after returning from each interview (Strydom, 2002) which will provide this study with personal log that helps the researcher to keep track of the development of this thesis and to visualise how the research plan has been influenced by the data. The researcher will analyse school documents like registers, records of work and composition of the teaching staff by gender to determine the patterns of enrolment by subject and gender and science staff by subject by gender will also be carried out dating back five years. Information from the Zimbabwe Schools Examination Council (ZimSEC) will be sought. The records from ZimSEC will show the number of students who would have sat for A-level physics by gender for the past six years, for November examinations (i.e. 2006 to 2012).

Permission will be sought from the learners prior to their participation in the research and only those who consent will take part in the study. Data collection will be done by the researcher herself. All information collected will be treated in strictest confidence and neither the school nor individual learners will be identifiable in any reports that are written. Participants may withdraw from the study at any time without penalty. The role of the school is voluntary and the School Principal may decide to withdraw the school’s participation at any time without penalty. The data collected is not in any way sensitive. If a learner requires support as a result of their participation in the survey steps can be taken to accommodate this.

School Involvement

Once I have received your consent to approach learners to participate in the study, I will

- arrange a time with your school for data collection to take place
- obtain informed consent from participants
Further information

Attached for your information is the copy of the Participant Information Statement and Consent Form.

Invitation to Participate

If you would like your school to participate in this research, please complete and return the attached form.

Thank you for taking the time to read this information.

Mrs Anna Gudyanga                      Dr Kathija Adam
Researcher                              Supervisor
NMMU                                    NMMU
Tel: +263 773 420 631 or +2783 364 0375                        +27 41 504 4041
Email address: gudyangaa@gmail.com                      kathija.adam@nmmu.ac.za
I give consent for you to approach lower 6th and upper 6th female students to participate in the study entitled Participation of Zimbabwean female students in physics: Subject perception and identity formation.

I have read the Project Information Statement explaining the purpose of the research project and understand that:

- The role of the school is voluntary
- I may decide to withdraw the school’s participation at any time without penalty
- Lower 6th and Upper 6th female students will be invited to participate and that permission will be sought from them.
- Only learners who consent will participate in the project
- All information obtained will be treated in strictest confidence.
- The learners’ names will not be used and individual learners will not be identifiable in any written reports about the study.
- The school will not be identifiable in any written reports about the study.
- Participants may withdraw from the study at any time without penalty.
- A report of the findings will be made available to the school.
- I may seek further information on the project from Mrs Gudyanga Anna on +263 773420631 or +2783 364 0375
• Interviews will be voice recorded and classroom observation video-taped.

__________________________  ____________________________
Principal                          Signature

__________________________
Date

Please return to: Gudyanga A., 158 Owens Road, Ridgemont, Gweru, Zimbabwe.
CONSENT FORM TO PARTICIPATE IN THE STUDY

Participation of zimbabwean female students in physics: Subject perception and identity formation.

I, ________________________________________________, agree to have participated freely in the study carried out by Mrs. A. Gudyanga, titled as above. I hereby confirm that the recorded interview audio data, the transcripts made and the stories derived are correct.

Signature………………………………………………………

Date…………………………………………………………….

• PO Box 77000 • Nelson Mandela Metropolitan University • Port Elizabeth • 6031 • South Africa • www.nmmu.ac.za
17 September, 2012

Re: CANDIDATES THAT REGISTERED FOR ADVANCED LEVEL PHYSICS

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J.C. Maramba  
Assistant Director - Test Development, Research and Evaluation  
ZIMBABWE SCHOOL EXAMINATIONS COUNCIL
APPENDIX 16: LANGUAGE DECLARATION

Crowdsteer
19 Mark Street
Springfield
Port Elizabeth
24 December 2015

To whom it may concern

This document serves to confirm that the following thesis paper has been checked:

NAME: GUDYANGA ANNA MRS

STUDENT NUMBER: 212448463

Submitted in fulfilment of the requirements for the
Doctor of Philosophy
In
The Faculty of Education
at the
Nelson Mandela Metropolitan University

This paper has been checked for:

1. Grammar
2. Spelling
3. Punctuation
4. Other formatting errors

I have left my comments in the review section.

Should you have any queries, please do not hesitate to contact me.

Kind regards

Johan Vosloo Cell no. 0828524377