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Zimbabwean Female Participation in Physics: Factors of Identity Formation Considered as Contributing to Developing An Orientation to Physics by Female Students

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Abstract
The study investigated the Zimbabwean female participation in physics, with special emphasis on the factors of identity formation considered as contributing to developing an orientation to physics by female students. The main study from which this paper was taken explored the influence of identity formation on the Zimbabwean Advanced Level (A' Level) female adolescent students in physics. Four high schools that were offering physics at A' level in the Midlands Province, in Zimbabwe were targeted. Nine female adolescent students eighteen years and above: three doing mathematics and physics, one doing physics without mathematics and five doing mathematics without physics were chosen. The instrument that was used for data generation was semi-structured interviews. The results of this study indicate that amongst other factors the main factors of identity formation considered as contributing to developing an orientation to physics by female students are: need 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 and career aspirations. On the other hand, gender insensitivity, male peer harassment and gender stereotyping are, factors in identity formation they considered as inhibiting the development of an orientation to physics by female students. This causes fewer female students to opt for physics as one of their A' Level subjects. The formation of a negative physics identity by female adolescent students influences their perceptions of physics and their participation in the subject.
Keywords: Identity formation, negative or positive physics identity, physics and participation

1. INTRODUCTION

It has long been argued that science education is a male domain and a masculine culture (Murphy & Whitelegg, 2006). 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, 2006). 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[1] 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

[1] Power, authority and possession are passed on from father to son.

and historically constructed concept. We define who we are by the ways we experience ourselves 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.

2.RATIONALE AND RESEARCH QUESTIONS

Female students are under-represented in science when Zimbabwe needs more scientists to meet its developmental agenda in a technological world. The importance of science is officially recognised in terms of the central place given to science in the Zimbabwean secondary school curriculum (Government of Zimbabwe Circular Minute Number 14, 2004). Despite this, female students are under-represented in science while Zimbabwe needs more scientists to meet its developmental agenda in a technological world. More so, science according to Gudyanga, Adam, and Kurup (2015), plays an influential role in the life of an individual and the development of a nation in that it provides the basis for an innovative and globally competitive workforce. Zohar and Bronshtein (2005, p. 62) explore the "effect of small female enrolment in physics" and they point out that fewer female physics students adds to the problem of fewer physics students in general. When females choose not to study physics in high school it leaves smaller numbers of students that are available to become scientific professionals. Due to its relevance to technology and infrastructure, physics tends to limit advances in many areas of scientific study. Although a large number of western studies (Coyle, 2006; Murphy & Whitelegg, 2006; 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, Sonnert, Sadler, & Shanahan, 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 factors of identity formation considered as contributing to developing an orientation to physics by female students 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 research question described below.

- What factors of identity formation could be considered as contributing to developing an orientation to physics by female students?

This question was 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. There is therefore need to consider culture, identity and identity formation as well personal and social identities in the next section.

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[1] way in a schematic[2] 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).

IDENTITY AND IDENTITY FORMATION

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, Kruger, & Burger, 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?'

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.

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

[1] That is, are not concerned with gender schemas
[2] That is conform strongly to gender schemas

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.

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 factors of identity formation considered as contributing to developing an orientation to physics by female students

THEORETICAL PERSPECTIVE

A di-hybrid theoretical framework underpins this study where **Gender Identity Formation** is nested within Wenger's (1998) **Communities of Practice** and Sfard and Prusak's (2005) notion **Identity as Stories** (see **Figure 1**).

Wenger's (1998) social theory posits that individual learning is the development of modes of participating with others in society. Communities of practice are therefore a specific type of community that constitutes the most important arenas in which individuals learn. 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. In this regard, gender and identity formation issues are contextually embedded in culture and history; these in turn influence our perception, thinking and practice (Wenger, 1998).

Sfard and Prusak (2005) on the other hand, define identity as a set of reifying, significant, endorsable stories about a person. "Story…is a portal through which a person enters the world and by which their experience of the world is interpreted and made personally meaningful," (Connelly & Clandinin, 2006, p. 375). As Sfard and Prusak (2005) suggest that people shape their daily lives by stories of who they and others are and how they interpret their past in terms of these stories. These stories, even if individually told, are products of a collective storytelling. They 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, 2005, 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. Since identities are stories (Sfard & Prusak, 2005), by narrating their stories, female students were authoring their identities as they interacted in their CoP (Wenger, 1998). This study implements the suggestions of Sfard and Prusak and uses the collection of narratives as a methodological strategy for studying the factors of identity formation considered as contributing to developing an orientation to physics by female students

Figure 1 shows a di-hybrid theoretical framework combining communities of practice (Wenger, 1998) and the notion of identity as "story" (Sfard & Prusack, 2005). Nested in a combination of these two theories is a fairly new perspective for understanding and analysing the factors of identity formation considered as contributing to developing an orientation to physics by female students.

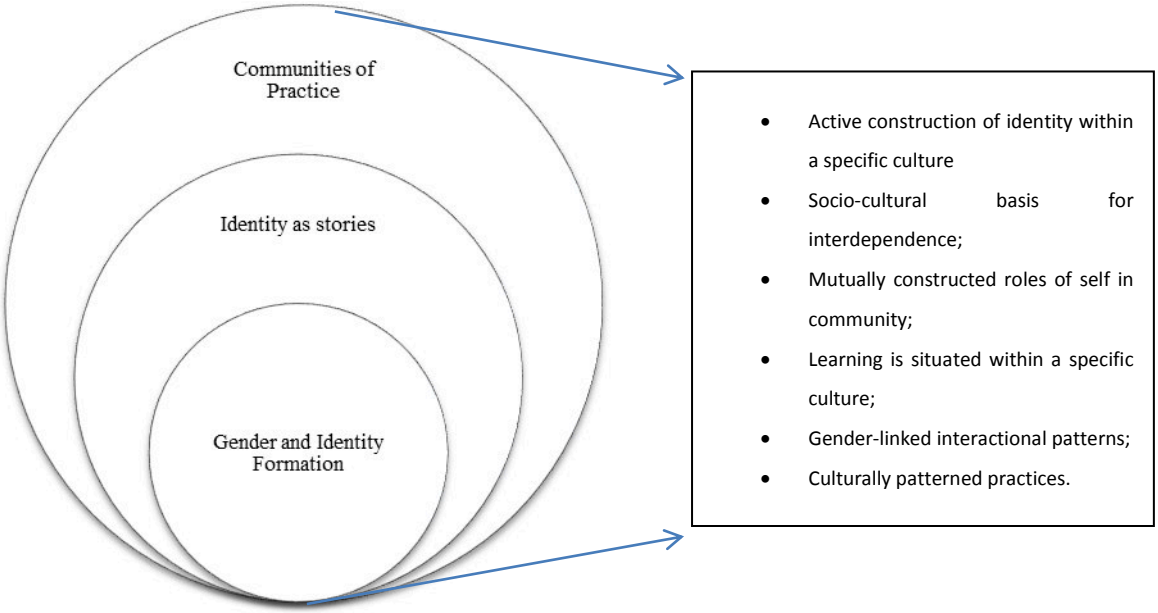

Figure 1: A di-hybrid theoretical framework within which Gender and Identity Formation is nested.

For the purposes of this study, these two theories are used as a lens to analyse female student narratives in order to ascertain the factors of identity formation considered as contributing to developing an orientation to physics by female students. In communities of practice female students construct roles for themselves in gender-linked interactional patterns and learning takes place within this framework. In narrating who they want to be in science, they construct possible roles for themselves which are influenced by socio-cultural contexts (Markus & Nurius, 1986). Hence, this is a useful lens that was used to analyse the narratives of female Zimbabwean students as described in the research methodology. In short The two frameworks used in this study are sociocultural in nature and they provided theoretical lenses used to respond to the research question

RESEARCH METHODOLOGY

A qualitative research design grounded in the interpretive paradigm using narratives was deemed appropriate because this study sought to explore the Zimbabwean female participation in physics, with special emphasis on the factors of identity formation considered as contributing to developing an orientation to physics by female students. 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.

Sample and Context

The schools in Gweru district were stratified first into three categories, namely, rural impoverished and living on less than $200 per month, high density urban (low income between $201- $400) and low density urban schools (middle income of above $400-$999). One school representative of each category was selected for this study.

An initial sample questionnaire[1] was used to purposively select female students whose narratives could provide rich information required to answer the research question of this study. 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 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 earners. Rural schools are poorly resourced with no laboratories. The impoverished community is not formally educated. Nine[2] participants were purposively selected for this study. 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; 2013). The rationale for choosing a context where female students were doing mathematics only was included as they are potential students who could have chosen to do physics as well. Once suitable participants were identified, semi-structured interviews were employed to develop their individual narratives.

Research Instruments and data analysis

The semi-structured interviews were used as instruments to collate individual narratives. The face-to-face interviews did not serve to just elicit information but also served as a means to develop personal narratives. A personal narrative reflects how people understand the world they live in and it serves as a way of communicating their understanding of their world to others (Connelly & Clandinin, 2006).

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 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. 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.).

The data were then transcribed and coded according to emerging themes. Participants were given the transcriptions of both their verbal descriptions as well as their responses to questions in the semi-structured interviews and asked to comment on the accuracy. Relevant changes were made based on participant comments of the final transcriptions as a measure of credibility (Creswell & Miller, 2010). From a thematic analysis of the narratives, a number of themes were identified that served to elucidate the factors of identity formation considered as contributing to developing an orientation to physics by female students.

ANALYSIS OF RESULTS AND DISCUSSION

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 1 below.

[1] 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 …?

[2] Of the nine participants 3 were studying physics and mathematics, 1 was studying physics only and 5 were studying mathematics only.

Table 1: Factors of identity formation contributing towards an orientation to physics.

S1 Doing physics and mathematics	**S2 Doing physics and mathematics**	**S3 Doing physics without mathematics**	**S8 Doing physics and mathematics**	**S4 Doing mathematics only**	**S5 Doing mathematics only**	**S6 Doing mathematics only**	**S7 Doing mathematics only**	**S9 Doing mathematics only**
FACTORS OF IDENTITY FORMATION CONTRIBUTING TOWARDS AN ORIENTATION TO PHYSICS.								
Need for female role models Encouragement O-level students by Good O-level teaching -Encourage female students not to look down upon themselves high self-confidence and high self-esteem -Educate community against gender stereotyping gender insensitivity	*Need for female role models Encouragement of female students by Good O-level teaching -teach gender sensitivity to male teacher self-confidence and high self-esteem Educate community against gender stereotyping Female to have high self-confidence and high self-esteem*	*Need for female role models models Good O-level teaching teach males not to harass female students -need for positive thinking by female students Female to have high self-confidence and high self-esteem Educate community against gender stereotyping and gender insensitivity*	*Need for female role models encouragement of female students by Good teaching -Parental support and encouragement -Educate community against gender stereotyping Teach girls relevance and importance of physics Female to have high self-confidence and high self-esteem*	*Need for female role models Good O-level teaching Lack of self-confidence and self-esteem Teach gender sensitivity to physics tr -Career aspirations Educate against gender stereotyping Teach girls relevance and importance of physics*	*Need for female role models Good O-level teaching Lack of self-confidence and self-esteem Teach gender sensitivity to physics teacher Career choice Educate community against gender stereotyping Teach girls relevance and importance of physics*	*Need for female role models Good O-level teaching Teach girls importance of physics Teach gender sensitivity to male teacher -Parents to build labs-parental support -Educate community against gender stereotyping Teach girls relevance and importance of physics*	*Need for female role models Good O-level teaching Parental support and encouragement Teach girls importance of physics Teach gender sensitivity to male s teacher Educate community against gender stereotyping Teach girls relevance and importance of physics*	*Need for female role models Good O-level teaching -Career aspirations Educate community that physics is not masculine -teach gender sensitivity to male physics teacher Female to have high self-confidence and high self-esteem Teach relevance and importance of physics*

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."

S1 was the only student who had a female O-level teacher 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.

S3: *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.

From the narratives of the participants, 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. 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 as indicated by S5.

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.*

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.

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.

Hence, 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.

As outlined above, 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.

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. Thus, 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 (Ryan & Deci, 2012) and a lifelong journey. 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.

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).

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, according to (Gudyanga et al., 2015) 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.

As outlined previously, 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, Guttersrud, Henriksen, & Isnes, 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).

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. 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.

Gender insensitivity, male peer harassment and gender stereotyping (see Table 1) 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, 2006) 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, 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. On the other hand, it is important to note that 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 way we are socialised (sociocultural perceptions) affects the way we interact within our communities of practice and, hence, the way we form our identities. 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.

CONCLUSION

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.

A conducive O' Level learning environment on one hand, facilitated female students studying physics and mathematics to form physics identities which seem to have helped them to develop positive perceptions 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. The awareness of the role and relevance of physics appeared to have motivated the female students to study the subject. 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.

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. There is therefore need to introduce gender sensitivity and gender awareness

programmes to pre- and post-training teacher courses. Teachers should also empower the female students and cause them to break away from the cultural norms. I agree with Gudyanga et al. (2015) who recommended that female students need to be afforded a conducive social [particularly at school] 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.

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