Part I

Science and Technology in Society: Discourse, Perspectives, Practices and Policy

1

Discourse and Practice of Science: Implications for Women in Africa

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Introduction

The focus of this chapter is the role of science and technology in socio-economic development in the world today. It examines the 'packaging' of science that leads to the exclusion of Africans generally, and of African women in particular. The differences between men and women in terms of how they access and use science and technology is now well documented (Harding and Hintikka 1983). Most studies show that women are excluded not only from science classrooms but also from scientific and technological fields and professions. Feminist research in science studies has been two-pronged—with one branch handling 'the women question in the sciences' (i.e., women's participation in sciences) and the other 'the science question in feminism' (i.e., the construction of 'feminine knowledge'). There have been lots of debates and research on women in the sciences but few empirical studies on construction of feminine knowledge. Not enough answers have been provided for such questions as whether gender-differentiated approaches to understanding of science can be observed or whether male and female students, in tackling investigative problems, display different 'images' (understandings) of scientific knowledge.

The literature on girls and science is vast, ranging from theoretical speculations and interpretations (Kelly 1981, 1987; Walkerdine 1989) to empirical research (Crossman 1987; Spear 1987; Kelly 1985; Whyte 1986). These studies are, of course, part of an even wider body of literature concerned with gender in education.

Recently, women's participation in sciences has been tied to identities. Gendered identity refers to the sense of self, including the conscious and unconscious thoughts and emotions of the individual as a gendered being. Studies have shown that girls may position themselves as not being interested in sciences and technologies be-

cause doing science is 'for men' and therefore not the 'correct' identity for a girl. Some of these constructions are very subtle, as I will show shortly. Such feminine-gendered identities are said to reproduce the ideology of domesticity among girls.

Gender is a socially constructed attribute of an individual based on sex. It has a pervasive influence on us whether we like it or not. There is always gender differentiation in any context; one is seen as either male or female and treated as such. Such differentiation does not necessarily translate into discrimination or bias. There is reason to believe, for example, that the rights of some African women have actually been safeguarded through gender differentiation. However, with modernisation, the notion of gender has become synonymous with sexism and its negative connotations of discrimination, usually of the female gender. Nevertheless, gender is a complex category that is continuously variable; it is not fixed but changing.

This instability of gender enables us to explore ways of changing the participation of women in science and technology. As Cameron (1997) aptly says:

> Gender is regulated and policed by rather rigid social norms, but this does not mean … [men and women are reduced to automata, programmed by early socialisation to repeat forever the appropriate gendered behaviour ... [T]hey are conscious agents who may engage in acts of aggression, subversion and resistance. As active producers rather than passive producers of gendered behaviour, men and women may use their awareness of the gendered meanings that attach to particular ways of speaking and acting to produce a variety of effects.

Science and Technology in Society

What is science? This question can be answered in various ways. When posed during the Gender Institute for Laureates in Dakar in 2003, the question caused a heated debate. Questions were even asked as to whether Africans *have* any science. Can different cultures have different sciences? Is it possible to talk of multiple sciences when referring to human knowledge? If so, whose science were we really discussing in this conference? This paper does not address such fundamental questions but instead pursues the generally agreed-on notion that, when one talks about science and technology today, one thinks of the 'high-tech' science practiced from and by the Western/Northern nations. In this chapter, I will be referring to this idea of science without going into the contentious debates mentioned above.

This Western science is first and foremost a discourse of 'technology', defined as 'a way of thinking/speaking and doing things' (Halliday and Martin 1993). Science in this sense has driven industrialisation and the development of new technologies and has consequently acquired special significance in society. Today's debates over post-modernity, technology and the globalisation of politics, economics and culture are posited upon this science. As Luke (1992) argues:

> What counts as 'science' in the period since World War II has been focal in the development of Western Nation States, to the point where historical winners and losers in economic, strategic and geopolitical realism are assessed in terms of technology and scientific prowess.

Luke traces the dominance of science in society to the late nineteenth and early twentieth centuries when scientists (i.e. laboratory scientists), government institutions and corporations began to work together in Europe and America and the results of laboratory research began to be adapted for practical purposes by government and business. It is from this time that applied approaches to physics, mathematics, statistics, electronics and computing, communications and engineering emerged. Our modern technocratic society has its basis in this symbiotic relationship between governments, corporations and research science, particularly after World War II. The process has shaped the character of everyday life, from mass consumer culture to research and academic institutions. Science and technology, in the worldwide context, have become the dominant mode for interpreting human existence: everything 'from the discourse of technocracy and bureaucracy to the television magazine and the blurb on the back of the cereal packet is in some way affected by the mode of meanings that are science' (Luke 1992).

Science and technology have also determined the international distribution of wealth and power. Today, dependence on corporate science and technological expansion is a key means for the expansion of state power and legitimacy. Scientific nations translate into rich economies, while nations that lag behind in science and technology translate into poor economies. The yoking together of state-funded military industrial complexes with corporate capital and academic scientific research has been witnessed in modern wars, such as those in the Middle East, but has also been witnessed in the global economy, in HIV/AIDS research and in reproductive technologies. While it should not be forgotten that some of this research has been at the centre of heated ethical debates and controversies, for example, the science of cloning, in general, what has come to count as science in technocratic culture is science that is applied, corporate and profitable.

Africa does not seem to fit very comfortably in this overall picture. It is a consumer continent, buying its technology from the West while providing the West with raw materials to produce this technology. African scientists and government institutions do not appear to apply or make profitable the outcomes of their laboratory research. Yet the African leaders who led the fight against colonialism realised that the European monopoly of science enabled and perpetuated colonialism. At independence, science was promoted as a central factor for development and is still equated with power and cultural worth. Thus, science subjects continue to be very important in education throughout Africa.

The question is whether science education in African nations has been successful in developing scientists, particularly when we consider gender. How much of the science learned is actually put to use? Below, I turn to science education, using Kenya as an example to consider issues of science and gender in schools where, supposedly, the new crop of scientists are being raised. First, I examine male dominance in science and in education generally.

Male Dominance in Science, Technology and Education

Science is transmitted formally through schooling, but there has been a concern that, in this transmission, girls and women are not adequately involved. Science is overwhelmingly male-dominated in terms of who is or can be a scientist. This is true not only in Africa but throughout the world, and this gendering of science has therefore been a global concern for some time. The problem has been approached from many different angles. One has been a broadly psychological angle that tries to understand why girls avoid sciences and looks for answers in girls' attitudes and personality traits. In this approach, girls are seen as the source of the problem. Their own psychological characteristics are seen as contributing to their failure to perform well in science. A second approach is from a sociological and structural angle in which science is seen as a socially constructed process, a set of practices produced in schools in accordance with societal norms. Since society is an institution that assigns men and women different roles, with different obligations and expectations, this division is also mapped onto school subjects.

Male Image of Science

The sciences, especially the physical sciences, are overwhelmingly male-dominated in terms of who teaches it, who is recognised as a scientist and also the way science is packaged (Kelly 1985). Most textbooks thus portray scientists as men (Obura 1991). The 'masculinity' of science inheres in the form and content of scientific knowledge and in the underlying belief that this knowledge can only be successfully pursued by men and boys. Easlea (1986) has shown that scientists are expected to be aggressive, individualistic, self-confident and competitive. Various cultures associate men with competence in the design and control of apparatus and machines, while women are associated with competence in activities demanding care and nurturing. Thus, it is no wonder that science is associated with the image of masculine ability.

The masculine image of science is further seen in the way in which the scientific method of inquiry expects scientists to be guided by logic and facts alone. Scientists are expected to pursue a ruthless analysis of reality exemplified by the suppression of all emotion or wishful thinking in order to arrive at the goal of 'truth' about nature. However, such methods are now being contested as not wholly desirable, as they lack 'feminine' intuition and feeling, yet intuition can lead to scientific discovery. Even more striking in modern science is the extent to which male scientists portray nature, the supposed object of scientific inquiry, as metaphorically 'female'. Merchant (quoted in Easlea 1989) suggests that one of the most powerful images in science is the 'identification of nature with a female, especially a female harbouring secrets' (1989). A scientist who can 'woo' secrets out of nature is acclaimed as a genius. This imagery can be related to the larger problem of patriarchal discourses, thinking and knowledge that exclude females (Easlea 1986, Walkerdine 1989, Harding and Hintikka 1983, Rose 1994).

Nilan (1995) brings an interesting angle to this imagery of science. She talks of the gendering of school subjects in which gendered identities are connected with an

orientation towards clusters of subjects perceived as either 'hard' and 'masculine' (physics, maths, economics) or 'soft' and 'feminine' (humanities, arts). An important question researchers have asked is what kind of influence this masculine image has on students, particularly girls. Many researchers have suggested that this image is the root cause of the under-representation of women in the scientific world. In fact, students are said to perceive science as masculine from a very early age (Kelly 1981, 1987).

Studies in science education have been carried out by physical scientists as well as by researchers in many different disciplines—sociolinguistics, sociology, history, feminist studies and philosophy of science—and this is now a broad and increasingly diverse field of study. In the social sciences, the focus has been on the institution of science, the practices of scientists and the nature of scientific knowledge, i.e., the question of what constitutes scientific knowledge (Rose 1994). In linguistics, the problem is seen as the language of science and how scientific knowledge is constructed in language (Myers 1990; Halliday and Martin 1993).

Discourse of Science

The discourse (language use) of science subjects needs examination. Millar (1989), Driver (1989) and Solomon (1989) have shown how classroom science is a social activity involving teachers and students and have stressed that language plays a crucial role in forming and consolidating ideas. In classroom talk, teachers need to pay attention in order to achieve a balanced participation of girls, particularly when interactions are initiated by pupils. More importantly, however, science language is a specialised discourse used in specific social situations. Halliday and Martin (1993) have traced the evolution of science discourse over the years as a 'discourse technology'—a linguistic semiotic practice developed in order to do specialised kinds of theoretical and practical work in social institutions. As a discourse technology, science has a special significance. Science discourse and its dominant practices dictate a lot of human activities. Halliday and Martin (1993) argue that this discourse has become the language of literacy for the elite and notes that the discourse of science has evolved over the years in contrast to the discourses of folk wisdom. Othiambo (1972) argues that science discourse ignores folk wisdom, which Africans are closer to.

Science discourse has its own methods of inquiry, language and imagery. Some of the prototypical features of scientific discourse, according to Halliday and Martin (1993), include 'objectification' (i.e., actions, events and qualities presented as if they are objects), a high concentration of content words (i.e., complex technical taxonomies within a single clause), passive forms, nominalisation and ambiguities (i.e., a string of nouns leaving inexplicit the semantic relations among them). Such forms of language can be unfriendly to most people. In short, science language is different from ordinary language. Science language is used to express relationships of classification, taxonomy and logical connections. As a genre, it is not a narrative like literature or history. It is special because of its content, its written and spoken genres, its activity structures and styles. For example, there is much use of the

impersonal passive voice. People tend to disappear as actors and agents. Colloquial language, personifications, figurative language, irony, humour and exaggeration are avoided. Fiction and fantasy give way to talk of 'facts' (Lemke 1990). As such, scientific literacy and the mastery of what is called scientific knowledge is the exclusive domain of a few. It is elitist. Scientific practices end up excluding women, ethnic minorities within the Western world and whole groups of people in the southern hemisphere, mainly because of this specialised science discourse.

Specifically, what puts students, particularly girls, off in sciences? Most studies have shown that learning science means learning the conventional forms of organising scientific reasoning, talking and writing. Doing science also involves conducting investigations, using apparatus, observations and measurements. In a science class, activities such as demonstration and exhibition of physical and chemical processes are prevalent. In her study of science practical work done by students, French (1989) observed that, from the procedures used to the language and the final conclusions, science classroom practice adheres to the meanings and values of science as an institution. Science is treated as objective truth.

Lemke (1990), as part of extensive studies of science classroom practice, has looked into what science values mean to learners. In a detailed study of the science classroom, he observed that science was consistently presented as 'objective' knowledge. In the process, as he argues, 'more than just science was being communicated in these classes…. [A] set of attitudes towards and beliefs about science, education, students' abilities, and society itself were being taught as well'. Lemke shows that science is difficult for students not only because of its technical aspects but also because it creates what he calls a 'mystique of science' that sets up a pervasive and false opposition between the world of science—objective, authoritative, impersonal—and the ordinary world of human uncertainties, judgments, values and interests. Thus, he argues:

> … it is not surprising that those who succeed in science tend to be like those who define the 'appropriate' way to talk science: male rather than female, white rather than black, middle- and upper-middle class native English-speakers, standard dialect speakers committed to the values of North European middle-class culture (emotional control, orderliness, rationalism, achievement, punctuality, social hierarchy, etc.).

As a result, Lemke observes:

> It is only people whose backgrounds have led them to speak more like science books do, learn in a particular style, and a particular pace, already have an interest in a certain way of looking at the world and in certain topics and problems that will have a chance of doing well in sciences.

Lemke's argument brings to the fore some questions that are especially pertinent to Africa. What language should be used to teach science to African children? Should science in African schools continue to follow that worldview and topics? If scientific language and thinking can be hard to grasp even for certain males, how much worse must it be for African females? Sadly, few studies have been done in the science classroom in Africa to examine these issues, and most have involved survey/statis-

tical methods rather than in-depth qualitative classroom studies. Below, I turn to one example of the latter.

Gender and Science in a Kenyan Classroom

This Kenyan study (Kitetu 1998) opens a small window into the interactions of gender and science education in Africa inside the classroom and points to how we can begin to rethink science and technology research and application. The study involved research conducted over three years and produced diverse findings regarding the handling of science as a subject, classroom management, use of language and construction of gendered identities. In this chapter, I can only provide a glimpse into these findings.

The study was prompted by the problems facing girls and sciences in Kenya, voiced by different interested groups. A few studies had already been done, but none had addressed science classroom discourse and gender. Two key questions guiding the study, were: 'why girls were not involved in the sciences and why the few who were involved performed so dismally'. Focusing on language and other practices of the physics classroom, the study set out to examine the construction of gender in the physics classroom. Physics was chosen because it was perceived as being the most gendered of all the science subjects in the curriculum. Using an ethnographic approach, classroom interaction and laboratory activities were observed and audio-recorded. Participants were then interviewed to get their perception of the activities they were involved in. This was a descriptive study. Statistical methods have not been very fruitful in showing the social relations that obtain in science education as far as gender is concerned, but the ethnographic approach in this study helped unearth subtle gendered behaviour.

The study showed that science teaching and learning adhered to the discourse of global science in terms of the genre of science, i.e., in relation to learning the conventional formats for organising scientific reasoning, talking and writing. Doing science in these classrooms involved conducting investigations, using apparatus and making observations and measurements. Activities such as demonstrating and exhibiting physical and chemical processes were prevalent. This is an area where more research and debate should be done in order to discuss the science appropriate for the African child. This would mean looking at the language in use, the content and the application expected from this learning. The study showed that concepts were often too foreign, especially when explained in a foreign language and, moreover, in a scientific form of that language. The tools and materials were also often unfamiliar.

The students, however, were expected to fit into this discourse. A telling remark from one female student interviewee confirmed this. On failing a class test, she was asked where the problem was and replied:

> …I think I explained it here …. Maybe I explained it the way I explain in other subjects *where you use your mind*…. Maybe I was expected to explain in physicist terms. (Emphasis mine)

This student had the feeling that science was different from other subjects. In science, one was required to remember things as they were taught, not in one's on way or by using one's own mind! Science needs to be demystified and taught as a normal part of human experience. This was not happening here.

Gendered identities were constructed in both verbal and non-verbal activities. Teachers addressed girls and boys differently. Boys were talked to in harsher ways (i.e., confrontational tones, e.g., 'why did you?…', said loudly) in contrast to the softer tones used on girls. Also, in the laboratory, the boys and the teachers did the 'hard' experiments (i.e., measuring, cutting, constructing) for the girls, thus gendering the girls as different or weak. The girls also fitted into this positioning without question. They did the traditionally feminine, 'soft' activities such as reading instructions, writing and washing up after experiments. One teacher explained: 'You are not supposed to be harsh on girls but we have to be friendly so they do not feel that they are being punished by doing physics'. The girls interpreted this treatment as being 'favoured', yet such positioning has serious implications for girls' advancement in science; if they are not 'pushed' like the boys, they are likely to fall behind.

This gendered construction of the physics classroom was clearly based on the wider society's perceptions of feminine and masculine gender roles and identities. Kenyans generally are very careful in the upbringing of girls. A 'properly' brought-up girl (in terms of feminine attributes) is 'protected' and cannot go places on her own, even if it is safe, since this does not project the right image. Science, and education generally, do not fit into this cultural picture. This thinking is changing, but very slowly.

This Kenyan study urgently requires not only duplication with similar groups throughout the region but also in terms of the world view obtaining within Africa in relation to science, technology and language. Research should also focus on the gendered discourses (beliefs). For example, it would be good to know how cultural identities of femininity (e.g., 'a good girl stays at home or gets home early') are in opposition to science and school identities (e.g,. 'good students work long at a science project in the school laboratory'). Research should also look into culturally determined gender interpersonal relations (e.g., 'members of opposite sexes don't sitwork together') in opposition to school interpersonal relations such as working in mixed-sex groups or teachers of different sexes giving individual student tuition. Research should also handle the cultural gender role of girls as 'mother's helpers', and see how this is in opposition to school roles, such as having enough time to do homework.

Conclusion

This paper has examined how gender is implicated in science, showing how research all over the world has shown women to be uninvolved or excluded from science. I have also shown how science, as taught in schools (the main way of perpetuating science), excludes certain groups of people, mainly groups in the southern hemisphere and women. The Kenyan study shows in a small way how gender identities

are constructed while doing science in school; girls remain girls and boys remain boys and are treated as such, not as learners or upcoming scientists.

In sum, I should note that issues surrounding science and technology are complex. There are issues of discourse and practice (discourse as ways of thinking, ideologies, values and meanings that surround science and also discourse as images and language). There are also concerns regarding the way science is taught in schools, such as the foreign languages used and the worldview advocated, not to forget the whole issue of globalisation, which complicates matters further. The Kenyan study provides a small window on how African teachers and students are grappling with the sciences (the language, the experiments, the topics and the gendered roles) and shows how teachers and students draw much of their understanding from the society in terms of interpreting not only the science concepts but also the worldview, gender roles and identities. It is along all these facets of gender science and technology that recommendations are made for African feminists to address analytic skills.

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