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THE ROLE OF DEVELOPMENTAL, EDUCATIONAL, CULTURAL, SOCIOLOGICAL AND
PERSONALITY CONSTRUCTS IN REINFORCING WOMEN'S PARTICIPATION IN SCIENCE AND
TECHNOLOGY : PERSONAL PERCEPTIONS OF SCIENCE AND THEIR IMPLICATIONS FOR
WOMEN'S PARTICIPATION IN SCIENCE.

GENERAL INTRODUCTION

In the first instance, the main experiences that I have encountered in embarking on this research is that people have different perceptions of science. This is quite acceptable as we all come from different backgrounds, brought up in with different beliefs and values. We also have different perceptions of things.

As this is a talk on perceptions, I shall start from my own personal perceptions. It is said that the one's perceptions makes the person (Merleau-Ponty, 1962).

I came upon this study not purely by chance, but also by some design. Throughout my life, science has played a great part in my activities, and it is not only now that I have thought deeply of it's impact on my lifestyle. However, it is only lately that this study of women and science has evolved into an "academic" pursuit. As the study progressed, it became obvious that my own experiences and other people's experiences are not mutually exclusive.

I am a very ordinary person. I am a 43 year old woman who have lived in New Zealand most of her life. I was educated by the New Zealand Educational system, attended primary schools and secondary school in Hamilton and obtained Degrees and Diplomas from tertiary institutions from tertiary institutions in New Zealand. As a teacher, I have taught in primary and secondary schools. In accordance to what a woman is expected to do, and I did it gladly, I married, and raised two fine children, at the same time, having involvements in business and counselling environments through family business connections. I now teach in a tertiary environment, and have research interests in education psychology, human development, language and science learning. I followed the life-styles of my growing daughters with vested interest in terms of their development such as their likes and dislikes of school subjects, science being a very pertinent one. Throughout my life-span, one love has been SCIENCE. I have

a first degree in science (biochemistry, plant physiology, and Japanese) which I completed while raising my very young daughters. I have a graduate degree in Biochemistry (Enzymology) which was completed when my daughters were not so young - in fact, in their difficult teenage years. In between times of family duties, I have worked in scientific laboratories. In whatever environment, I have always wondered at what science meant for people because to me, it was that science meant life. With the philosophy in mind, I attempted to look into a research topic for a Ph.D which I hope that when completed could contribute to the knowledge that there is about women in science.

The experiences of women in science is my first concern. The significance of these experiences, both personally and academically became more prominent as the study progressed. The 'dilemma' about women and science was perceived by me later in life. In my childhood, science had always meant enjoyment. As a graduate in science, and starting to realise that there are not many other women pursuing the same scientific interest. As a graduate in science, I encountered the problems which female peers encountered, that is, not being able to make use of the knowledge which we have gained through having a satisfactory position in the workforce. " It is not particularly attractive for women because they are involved in the 'technician' type area...they are doing the really boring routine work...."

(Transcript from interview with young woman completing a management post graduate degree after having completed a MSc in Technology, 1991).
Comments along this line are very common in everyday conversation. As a teacher in schools, the perceptions which I received were also not encouraging.

" Science is not a subject for girls - boys would not like us if we took science."

(Form 4 girl, 1992)

" Be a scientist...you're joking...you have to be a boy to be a scientist!"
(Standard 4 girl, 1992)

" Science is not a good subject to take, it won't get us jobs when we leave school".

(Form 6 boy, 1992)

(Transcripts from interviews with school children of different levels.)

As a tertiary teacher, the messages I get in the 1990's is still that science is not a good career choice for girls and for some boys.

Quantitatively, there is an abundance of statistics weaving an impression with numbers that some students, particularly female students, who do not "like" science. Many statistics showed low enrollment of female students in secondary school courses (Ministry of Education: Research and Statistics Division, 1989). In tertiary courses, fewer female students than male students are majoring in science at the university levels. This scenario is common both here and in overseas countries. This scenario begs the question to why few women study science and fewer still persist in science-

related occupations. I personally thought that my study is important to those concerned with equity in science, in education, in the upbringing of children, and in the quest for equal opportunities.

PERSONAL PERCEPTIONS OF SCIENCE.

Perceptions could mean anything to anybody. Taking the biological description, perceptions could mean the physical properties of some stimulus such as hue, saturation and brightness, the receptor organs, the eye with its iris, fovea, lens and retina, and the transmission of impulses from the receptor to the brain. In this discussion, the perceptions of how one constructs reality are also important. This is very much akin to social perceptions. Social perception is concerned with the impression one has of a social stimulus or a set of stimuli. This impression is modified by the perceiver's past experience and the individual's state at the moment sh/he is viewing the stimulus of interest.

In the study of the personal perceptions of science, I came across many perceptions which help to define how people perceive things.

I will review some of my findings in a form of a workshop. The theme for this workshop will be listener friendly and it will be in an exploratory tone.

I shall start with some transcripts which I have accumulated on what people think science is:

The question I gave to my participants was simply:

"What is science to you?"

For each transcript I invite you to give input to the discussion.

(Summary of Participants - see Appendix 1)

(Summary of Transcripts - see Appendix 2)

Many issues were raised from this small sample of people's perceptions of science. My intent is to relate them to the issues which have been identified by previous researchers.

THE IMAGE OF SCIENCE

The fact that scientific knowledge has grown in the male domain and has become socially accepted as a male discipline seemed fairly strong in people's perceptions. This issue has been well documented in science education and history of science literature (Davies, 1991; Massey, Quintas, and Wield, 1992). Science historians such as Londa Schiebinger found it perplexing in that modern science has evolved from a feminine occupation to a masculine occupation. Kelly (1985) outlines four ways in which how science is now perceived as a masculine discipline. They are:

1. Science is defined as masculine in terms of those who study it, teach it, and are recognized as scientists;
2. Classroom interactions allow science to be established as a male arena;
3. The way in which science is presented is masculine;

4. The type of thinking labelled as scientific is perceived to be a

masculine mode of thought.

According to Kelly, this view of science is the result of the male traditions associated with scientific study. For example, the military, where science is a strong study, has excluded women from its study and practice until very recently. Such traditions encourage a deterministic perception of the relationship between science and masculinity. Moreover, the ideas that science and related concerns are masculine could be generalised to mould perceptions about all or the majority of men; traditional stereotypes that are perpetuated rather than challenged. The challenge for science educators is to present scientific knowledge in a less masculine context, and more importantly, to perpetuate the view that knowing scientific knowledge does not render a woman less feminine. The challenge in this research is to see whether such notions are ingrained in the New Zealand society, and that whether they are in fact correct. Further discussions in relation to the image of science and scientists will be discussed in terms the theories concerned in child development.

GENDER DIFFERENCES IN THE PARTICIPATION IN SCIENCE

Another issue raised can contribute to the discussion of gender equity in science learning. In any discussion concerned with this issue, two important questions are prominent. They are:

1. Why is there a gender difference in participation in science learning and activities?
2. What solutions are there?

Much research in recent years have tried to answer these questions. An overview of findings so far proposes that the factors which could contribute to gender differences in science education are numerous. These may include: Sex roles; socialization; differences in cognitive development; attitudinal differences; content of scientific knowledge, economics; confusion in scientific objectivity and others. All these and other factors have tried to answer the first question, but not many suggestions have been made to answer the second question.

Two main groups of factors that can enlighten and provide understanding to the dilemma can be subsumed under two main groups. They are:

1. Sex-role development and expectations.
2. Socialization and societal expectations.

Achievement in school science has been related to sex-role development.

Much international research concludes that the characteristically low achievement of girls in science is an aspect of the feminine sex role (for example: Elliot and Power, 1987). This manifestation illustrates learned behaviour which is appropriate for some female members in our society. The prevalence of such distinct behavioural patterns raises the question on how these behaviours are acquired during development.

Many theories of socialization can contribute to the explanations of this social manifestation. Three prominent theories espoused in human development are:

1. The Psychoanalytic Theory as espoused by Freud and his followers.
2. The Social Learning Theory.

3. The Cognitive Developmental Theory.

The two main theories which educational researchers make reference to in regard to achievement in science are the Social Learning Theory and the Cognitive Developmental Theory. However, the Psychoanalytic Theory is not totally discounted in terms of its importance in people's inclination to form stereotypes, more specifically, sex-role stereotypes, an important stumbling block or invisible barrier for girls and women involved in non-traditional personal roles or career involvement.

The main thrust of the conglomerate of social theories suggest that parents, peers, and teachers play a dominant part in the moulding of children's behaviour and in establishing habits and roles. These theories can be further differentiated into reinforcement theories and observational theories. Reinforcement theories argue that reward for sex-appropriate behaviour are the main mechanisms by which sex roles are acquired. The essence of this theory is that the child learns which behaviour is approved and which has been disapproved and, in order to gain approval, repeats that which has been favoured until it becomes second nature. In the context of gender difference studies, children tend to imitate people who they see as being like themselves. Hence observational theory suggests that that is important for the learning of sex-roles; the more sex-typed behaviour the child observes; the more sex-typed the child's own behaviour and attitudes are likely to become.

Cognitive developmental theories differ from social learning theories in several aspects. The child is motivated to achieve competence rather than reward. As part of their attempt to make sense of the world, children develop and put together a cluster of attributes which they label male and female and then, they try and copy the appropriate cluster. When a child is secure in a sex role, s/he achieves competence. This approach conceives of a child as as an active participant in structuring his/her experiences, in formulating sex-role concepts. In contrast, social learning theories see the child as essentially passive, being moulded by external forces. It is important to realise that all factors espoused by these theories are open to criticism, and that there are other cultural specific theories of socialization which these three main Western theories do not accommodate. In the context of what a person wants to do, all reasons given to why such a direction is made are open to argument and criticism. The arguments become more heated when constructs such as achievement, motivation, performance and learning styles are included into the discussion. The relevance of social learning and cognitive theories in explaining the gender differences in science achievement has received much attention. According to

the reinforcement theory, differential moulding would take place through parents, teachers and peers, indicating that science is more suitable for boys and girls. For example, boys might be strongly rewarded for success in terms of science learning and strongly criticised for failure, while the reaction to girls' performance could be more neutral or sometimes hostile if a girl does well in science. Hence comments like the one below are

often directed to girls during their school days:

"It doesn't matter if you did badly in science, girls usually do badly in science anyway"

(Transcript from interview with Parent, 1992)

Within the Attribution Theory framework (Weiner, 1986), such a comment is considered seminal to much of the negative perceptions to science held by girls who have encountered comments during their lives.

The reinforcement theory would also suggest that parental approval and disapproval are important in ensuring that boys and girls play with different toys. This will eventually affect performance in science because boys' toys (mechanical building kits, electric trains, meccano sets, etc) are efficacious in developing scientific skills than are girls' toys (dolls and prams). These assumptions however require more indepth research before any generalizations or conclusions could be made.

The projected importance of the mentioned factors in shaping girls' attitudes in science are not sufficient to account for the uniformity of the observed sex differences in achievement from country to country (Kelly, 1981). Girls do not do better in science in schools where a larger proportion of science teachers are women, nor in countries where a larger proportion of science students are women. The gap between the sexes in science is no smaller in countries with an active commitment to equality between the sexes than in countries with no such pretensions. Hence the lack of variation between different nations in the extent of the achievement gap between the sexes in science suggests that culture may not be the determining factor in science achievement.

THE IMAGE OF SCIENCE

The cognitive developmental theory may explain in part the constancy of the sex differences in science achievement from country to country. If science achievement has a masculine image in any society, then, boys will be motivated to achieve competence in science as part of their developing masculinity, conversely, girls will see success in science as not being compatible with their developing femininity and so avoid it. It seems that society has given science a masculine label and most children has led that label remain through their personal experiences. The patriarchal society, wherein the power and prestige of knowledge is exemplified by males can only consolidate the views of those children who do not challenge the prevailing perception. However, this point, as others, requires indepth updated research before any conjectures or conclusions could be made.

THE IMAGE OF A SCIENTIST: STEREOTYPIC IMAGES

If the image of science to male and female members of the society is different from childhood, this image does not seem to improve as the child of either sex grows up and is capable of making sense of the world by his/her own accord. At present, the popular image of science and scientists to the public is not good. Stableford (1979) examined the fictional portrayal of the scientists before the twentieth century "has inherited the mantle (and public image) of medieval alchemists, astrologists and sorcerers" (p. 553). For this reason, they were

frequently portrayed as obsessive and socially maladjusted, often to the point of being insane. Rae (1982) examined the portrayal of the scientists in general as well as in science fiction novels and found that "scientists are men of vision, albeit sometimes a vision which lies outside the law and the laws as we know them." This year, in my studies with standard four students, I found that their perceptions of a scientist is still decidedly male, a studious type of person, like "Young Einstein" (A character from a recent science fiction film).

Of course, this portrayal of scientists is a stereotypic one. Some reasons suggested for this stereotype are that in the transformation of the modern scientists into popular scientist, the scientist suffers from a general bias against intellectuals; research work done by scientists is generally not visible to the wider audience; there is confusion between science and its technological applications and that, scientists themselves often cultivate the image of "the remote, superbly dedicated, logical and humourless individual". Part of this research is to challenge this image, as women in science cannot be such a remote (dedicated certainly) creature, far from it, when women are usually concerned with the nurturing of children and the smooth running of the family unit. However, it is important to ask whether this disquiet about the current images of science and scientists is based on evidence of current community perceptions to science (Schibeci, 1986) and whether this disquiet acts as a barrier to the theme of science for all.

THE DEFICIT HYPOTHESIS

There are other theories that account for the shortage of girls in science. It is possible that the under-representation of females in science courses and in professions may relate to the differential abilities to the kind of analytical problem-solving. This deficit hypothesis receives substantial support from the repeated findings of sex differences in reasoning abilities, spatial problem-solving and other abilities (e.g., Jones, 1988; Pilburn & Baker, 1989; Stuessey, 1984) which most science teachers would rank high on their list of requisite abilities for success. An alternative hypothesis suggests that various performance factors may prevent females from showing their ability in science; variations in experience may have the effect of reducing performance in the context of unfamiliar problems. Anxiety might influence achievement on highly manipulative tasks that involve complex equipment. This research proposes to study in depth some of these suggestions and findings, in particular, the linkages that may occur in attributions, abilities and achievements of learners in science.

CONCLUSION

In this workshop cum seminar, I have touched on some issues which have assisted me in my research. Some of these issues are embedded in developmental, educational, cultural, sociological and personal constructs which affect us everyday. What has become pertinent to me was that as learners, we are affected by negative and positive responses to our achievement. In science learning, and hence, further participation in

science-related activities, these affective responses form a solid base as to what we choose to do to satisfy our goals and destinies. Taking that stance, I have taking the direction to study the affective responses to science learning, using the Attributional Theory as the basic theoretical framework. Elaboration of this approach would require a sequel paper to this one.

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APPENDIX 1
SUMMARIES OF PARTICIPANTS

TABLE 1 FEMALE PARTICIPANTS

Name	Age	Occupation
J(C)	15	STUDENT(SCHOOL)
B(C)	18	LAW STUDENT
T(C)	27	PHYSICS TEACHER
K(C)	36	LAB. TECHNICIAN
Y(M)	38	HOUSEWIFE
K(C)	40	CONSULTANT
M(C)	50	MATURE STUDENT

C= CAUCASIAN

M= MAORI

TABLE TWO MALE PARTICIPANTS

Name	Age	Occupation
P(C)	14	STUDENT(SCHOOL)
K(C)	30	LECTURER
J(C)	32	COMPUTER OPER.
G(C)	33	LECTURER
E(C)	41	RESEARCHER
K(C)	42	LECTURER
J(C)	46	RESEARCHER

APPENDIX 2

TRANSPARENCIES

TRANSPARENCY ONE

J (14) FEMALE

Generally, it's the study of living things and how they work...but a definition that holds for me is a definition that includes performance...how something can go...the best it can be...the most work for the less effort...how to make things most efficiently...that's what I want science to hold for me...

TRANSPARENCY TWO

B (18) FEMALE

When I think of science, I think of school subjects like biology, physics and chemistry, and also medicine...it it also has things to do with electronics...things which are useful to you in your life... If you want a highly paid industrial job with a lot of responsibility...you've HAVE TO DO SOMETHING LIKE A SCIENCE DEGREE...KNOW A LOT ABOUT ELECTRONICS...THINGS LIKE THAT...

TRANSPARENCY THREE

T (18) FEMALE

For me, there seems to be a slow realisation of what science is to me...science is just a branch of knowledge...that anybody can do ...given the right kind of background...it's just about knowing about something...of course...you have to start at certain levels...you can't have someone out of the streets to do a research into an ailment of a sheep or something like that...

TRANSPARENCY FOUR

K (36) FEMALE

Science means the laboratory and equipment. Their presence meant social responsibility and better management. The morality of using funds...what should be spent in the laboratory...those sorts of issues are in science too...not just the pure technical progress. The social and moral areas need attention. There is nowhere near enough attention on those areas.

TRANSPARENCY FIVE

Y(38) FEMALE

The way I look at science is probably it's another Maori person's thoughts and relationships toward the land. You look upon the influences of the land upon things and upon you. So if anything happens, in terms of influences, ultimately, it will come down to the Maori term, PUTAIAO, which refers to the environment. The influence of science ultimately add up to how the use and abuse of the process and what has happened to the land.

Yes...this perception is very much a Maori perception. My basic notion of science was conceived from the land, from the sea, forests, but it is also conceived from how science is utilised, in the technological world. It brings a fear in me in that it shows that knowledge is abused and that has an impact on our lives. Yes. I also do worry about the effects of science.

TRANSPARENCY SIX

K (40) FEMALE

A woman's view of science is different from that of a man's. A man will look at "truths" in a sense that they have got to be "proven", with empirical data, quantitative data. This is what science is about from a man's point of view. A woman will look at the same issue but she will take into account other aspects which may not be proven empirically or quantitatively. A woman will take note of qualitative type of material. That's what I mean when I say there is a difference in perceptions of science by men and women. How to validate "truth"? The theories we have are based on male theories, put together by male valued judgements. There's a whole lot of things there that you are going to miss if you go by these theories alone because women look at science differently. In our laboratory, the men focus on the equipment, and little else which is part of our working environment....

TRANSPARENCY 7

M (50) FEMALE

Science is not the threat to me as it was...now I see science, all the sciences, in the same light as any learning. Science is one part of the huge vast amount of knowledge...that science can be abstract...or can be experiential...it can be all sorts of things...it doesn't have to fit into all these boxes which I think deliberately in the past and also even now, exclude some people...I'm sure that's deliberate....

TRANSPARENCY 8

P (14) MALE

I remember that when I was in Form one for science we did a test with funnel paper, dotted it with felt pen and put methylated spirits and it went up and drew little lines...that was the only thing that I remembered doing...that's what we ever did do...

Yes...experiments...and we did studies of animals and that type of things...more research...that was pretty easy...you just get a couple of books and copied out of it...I learnt something but the amount of time you spent on it was a bit of a waste...you got three weeks, about ten hours, and you hand in two pages of work...that was it...

TRANSPARENCY 9

K (30) MALE

The realm of science that I work in...everything is fact...there is no philosophy that you could bend towards or bend away from...and it's a science...an occupation which I think which is mentally very demanding...because in work...you try to get a certain job done...if it is

not going properly...you could only blame yourself...for having not grasp the situation...for having made the mistake earlier...or that you are failing in your own capabilities which you know you are capable of actually dealing with that problem...other sciences...I don't know whether they are the same as that...

TRANSPARENCY 10

J(32) MALE

Science to me means that it's a particular line of skill...in a particular technical area as opposed to philosophical area...or other sorts of areas...areas that are to do with tangible things...physical things...science deals with physical things to my mind...that's sort of my rough description...I can think of lots of other ways to describe science...especially the science that I'm in...computer science is very much a tangible, physical thing which works on the basis of techniques that are taught, learnt, developed, and utilised over and over again...so that's what I considered as science...

TRANSPARENCY 11

G(33) MALE

It's possible also the perception of science is becoming more of a male domain because it's males wishing to exercise through science and technology the exercise of force...legitimately, under war conventions to exterminate other people...it horrifies me...I see it as an exercise of power...a way to use and abuse science for people's own personal advantage...war games...competition between people...making sure that others are not likely to survive or pose a threat politically, socially and economically...

TRANSPARENCY 12

E (41) MALE

Initially, I think that I saw science as how other people saw it...very objective...very cold...and there is something out there that is very removed from humanity...something that can be utilised for practical services in the engineering sense...I also see science as a whole enterprise involving a number of people...the whole idea examines what is actually science? What constitutes science? WHAT IS THE DISTINCTION BETWEEN SCIENCE AND TECHNOLOGY. Those questions came into my mind...I had my doubts upon whether people should learn science or not...

TRANSPARENCY 13

K (42) MALE

My definition of science now is much broader than it was when I was at school. I think that I have actually more interests in science although less involvement with it in an academic sense in terms of reading literature. I would say that I have read very few books in science since I have left school...but I am more interested in it...

TRANSPARENCY 14

J (46) MALE

I have difficulties with this one. Science to me is exploring,

finding new knowledges, developing new ways of looking at things, finding out a bit more about things, constructing new understandings and new meanings. It falls into the natural categories of studying the natural world...the physical world.