

WOMEN IN PHYSICS?
IDENTITY AND DISCOURSE IN TAIWAN

by

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Abstract

This dissertation argues that the deeply held hope for gender equity in science can no longer be simply realized as a project to increase women's participation in science. Understanding women's vexed relations with science requires a reconceptualization of the terms *women* and *science*, not as given categories to signal how "women" are coping with their disadvantaged positions in "science," but rather as two discourses formed in relation to each other, in institutional practices and in particular social and historical contexts. This dissertation investigates discourses of women and science by focusing on women in physics in Taiwan. This focus extends debates about gender and science by showing that the intervention of a particular discourse—in this case, the discourse of "women in physics"—into an existing discursive field exposed the contested terrain of the gender politics of physics and the identity politics of women physicists in Taiwan. "Women in physics" emerged as an internationally legitimate subject position in Taiwan in 1999 following a call to form a local working team on women in physics. The participants I interviewed utilized this internationally legitimate subject position to reconstruct, in different ways, their gendered identities in physics.

Scholarship in the field of gender and science education studies has, over the past three decades, focused on equity and inclusion to address gender inequalities in science. This dissertation suggests, by contrast, that a focus on identity is necessary for understanding gendered career decisions in science. The term *identity* refers to how individuals perceive themselves and how others respond to their claims; identity involves the purposes, interests and contexts of particular naming processes. In the structural inequalities of gender and science, a focus on identity aims to track individual and collective forms of agency exercised in changing discursive fields. This dissertation concludes by viewing curriculum as a discursive field where various discourses provide subject positions and produce potential meanings through teaching and learning. Hope for social transformation can be situated in the interventionary power of new discourses and the subsequent reconfiguration of gendered identities in existing institutional practices.

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CHAPTER 1

INTRODUCTION

I.

Over the past three decades, scholars in the field of gender and science education and the field of feminist science studies have identified gender bias in the norms, beliefs, presentations and practices of science and science education. Calls for alternative sciences and corresponding remedies such as alternative curricula and interventionist projects have taken place in various countries in order to reduce such bias and increase women's participation in science. With such recognition and wide-spread international efforts, however, the percentage of women in science, and particularly women in physics, remains low and the gender disparity persists. Sometimes, these interventionist projects were not appreciated by their targeted groups and were met with anti-feminist resistance from young women at schools (Kenway & Willis with Blackmore & Rennie, 1998). This complex and challenging situation signals to us that pursuing gender equity in science and science education takes more than providing equal opportunities and access to science. What remains under-examined in these interventionist projects is how individuals respond to—and make decisions about—these feminist calls for social change.

In the past five years, scholars in the field of gender and science education studies have recognized the importance of identity issues in learners' responses to curricular interventions. Scholars participating in this new trend recognize that how individuals view who they are is significant to how they respond to available opportunities, resources and discourses. This new research trend is a significant shift in focus from equity to identity in

gender and science education studies. As this new research focus gains momentum, however, less attention has been paid to the question of identity in science at the higher education level. To achieve a continuity of understanding identity from school to higher education to the workplace, and to provide educators and policy makers with a more thorough picture of how identity issues matter to individuals' choices at various stages, I contend that it is necessary to conduct identity studies at the higher levels of science education.

Following this vein, this dissertation focuses on the identity formation and transformation of women at the graduate school level and at the faculty level. In choosing this focus, I have asked the following general questions: 1) For those women who are considered to have kept their identities as scientists through their schooling, how will they view their identities in their current places of study and work? 2) If, according to feminist science studies, women are disadvantaged in the construction of science, how do those women who are already working in science as graduate students or as faculty members cope with such a situation and how do they correspondingly negotiate their identities? 3) What can we learn from their identity reconstructions in order to inform future changes in curricula with a wider understanding of gender problems in science?

This dissertation uses feminist poststructuralist theories of discourse as a framework to analyze the identity formation and transformation of women in physics at the graduate education and faculty level. Available and competing discourses form a "discursive field" where individuals shape and contest their identities with the subject positions these discourses provide. Individuals usually recognize or employ particular discourses pertinent to their current situations or challenges. Discourse in this sense refers not only to words spoken or written but also to rules and practices that regulate certain expectations in—and

operations of—institutions. For the identity formation and transformation of women in physics, what makes a physicist and how they should act in physics departments are as crucial as how women are seen in this discipline and what it means to be a woman in her culture and society. The former discursive rules and practices form what I call a “physics discourse,” and the latter discourse about women form what I sometimes abbreviate as a “woman discourse.”

I situate my research in the context of Taiwan because its peculiar status in world politics has generated a special discourse for women in physics working in Taiwan. Under the restrictions of the “one-China policy,” Taiwan is presently denied membership in many world organizations including those dedicated to academic and cultural purposes. Aspiring to be a “normal” participating member of the International Association of Physicists, Taiwan’s local association of physicists executed the task assigned by this international association to form a women’s group in physics in Taiwan, even though there were doubts among many local physicists. The assigned name of the group—the “Working Team on Women in Physics” (WTWIP)—became an international discourse that intervened in the existing discursive field in Taiwan and (to use Louis Althusser’s famous formulation) “interpellated” local women physicists into an internationally legitimate subject position of “women in physics.”

In situating my research in Taiwan, I trace the complex points of intersection of four discourses—the international discourse of “women in physics”; the local feminist discourse in Taiwan; the “physics discourse”; and the “women discourse” in the physics departments and the organizations I investigated—that together form the discursive field wherein women in physics in Taiwan contest their identities, maneuver their strategies, and reconsider what

it means to be a Taiwanese woman in physics. My dissertation research follows the organization of the Working Team on Women in Physics; tracks the four discourses in words and in practices; discusses the viability and durability of the identities of women in physics at the higher education and faculty level; and draws implications from this particular case study concerning curricular designs and pedagogical practices.

II.

I arrange my arguments and discussions in the next eight chapters. Chapter Two reviews the significant literature in the field of gender and science and the field of gender and science education, two fields that have informed each other in the past three decades. I argue that a shift in research focus from equity to identity has emerged in recent years. This shift is not a simple replacement of one term for another. I instead suggest that it involves reformulating equity projects through the notions of identity. In Chapter Three, I discuss and reconsider key terms such as identity, discourse and subjectivity in poststructuralist theories viewed from a feminist perspective. I contend that Foucauldian ideas of discourse and power are not as pessimistic as some critics have claimed. These ideas can help us track individuals' subtle and implicit senses of agency within discursive structures. I also introduce more recent theories of identity and explain their usage in the data analysis chapters.

Chapter Four includes descriptions of this dissertation's research background, research context and research methods, as well as a reflection on writing about "others". I first show variations of women's under-representation and the "leaky pipeline" phenomenon in different countries, including Taiwan. I then describe the importance of Taiwan as the

research context and introduce the organization of the WTWIP in Taiwan. In the last section of this chapter, I investigate the politics and poetics of writing a dissertation with an attempt to blur the line between the researcher and the researched while recognizing that I am solely responsible for the writing.

Chapter Five and Chapter Six analyze how physics is a discourse and how it relates to discourses about women in Taiwan. In Chapter Five, I argue that the foundation of physics—Cartesian Reductionism—provides women with a disadvantaged subject position in physics and the Elite Pedagogy it subsequently produced serves little educational purpose for students' interests. In Chapter Six, I draw on cultural studies theories to interrogate a double Othering process of women in physics. With the assumed male norm in physics, women—and the idea of women—are othered in daily discourses and practices concerning femininity, motherhood, sexuality and attire. With the assumed cognitive superiority of physics, some women physicists viewed themselves as exceptionally excellent cases and othered women who were not physicists. Their identities as “women” and/or “physicists” are simultaneously both-and and neither-nor.

In Chapter Seven, I narrate how the WTWIP was organized in response to the international discourse of women in physics and the complex challenges it faced from various directions. Different women physicists showed different levels of approval of the topic of “gender” inside their departments. Their differences are grounded on the ideas of “the upbringing of Chinese women” and are magnified along a generational gap that evolved alongside the feminist movement in Taiwan after the lifting of the long-enacted martial law (in effect from 1947 to 1987). Chapter Eight depicts the identity reconstructions of the participants during and after the organization of a local symposium held by the WTWIP.

Their identity reconstruction processes show that both the availability of various discourses and the intervention of a legitimate and powerful discourse are crucial to the viability and durability of an identity such as women in physics. Identity reconstruction and identity politics ferment individuals' career decisions and affect whether these women want to stay in physics. I then draw conclusions from my dissertation research in Chapter Nine.

As my project focuses on women's participation in physics, it does not pay as much attention to the question of "what physics?" from the perspective of feminist science studies, except that I have briefly discussed the norms, values and beliefs in physics in Chapter Five. Indeed, research concerns about what hinders women's participation in science must be accompanied by equally weighted concerns about what kind of science we are talking about and whether it is worth striving for greater women's participation in it. Without the latter line of questioning, the former project runs the risk of soliciting more "womanpower" for the dominant and proved-to-be-problematic kind of science. On the other hand, studies on "the woman question in science" still have value in pinpointing the immediate problems in the power structure of such an influential enterprise—science. My dissertation is an initial and partial attempt to collect pieces of a larger puzzle. Subsequent research projects should involve inquiring into women scientists' responses to feminist criticisms of science and how their responses can inform the possibility of alternative sciences.

My dissertation research examines and contributes to the recent shift to an identity focus in gender and science education studies. It extends the coverage from the school level to the graduate school and faculty level to enable us to see a continuity in our understanding of identity topics in science. It invites conversations among researchers of identity studies in science education to help us think through a comprehensive reform of science curricula. For

studies on women in science, my research provides the case of women in physics—the discipline that is typically seen as the hardest science and the discipline in which women have often (but not always) had the lowest percentages of participants. For women's studies investigations of non-traditional career choices, my research adds to existing research on women in engineering, in mathematics, in medicine, in law and so on. For a broader readership concerned with the topic of identity, my research attempts to contribute an interdisciplinary approach that blends gender studies, science studies, science education studies and cultural anthropology.

III.

My dissertation evolved from a personal history and developed with a methodological attempt to blur the distinction between the researcher and the researched. My undergraduate major was physics and I also completed a Master's degree in physics by building a laser. With this educational background, I first worked as an optical engineer, then became a physics teacher at a university preparatory school in Taiwan. While I was teaching physics, I pursued my interest in humanities and social sciences by completing another master's degree, this time in anthropology. I am not precisely a physicist, nor am I a physics dropout. People sometimes call me a physicist for particular reasons but most of the time they do not. My identity as a woman in physics is influenced by the views of my interlocutors, the purposes of their naming, the situations and the surroundings I inhabit. My identity as a woman in physics is entangled with how physics is seen and what being a woman means in the culture and society of Taiwan. By talking with women physicists whom I knew from my time in physics, or others from the same cultural and societal

background, I came to understand how cultural and social forces had framed my arrival at the current stage of my life through various processes of identification and disidentification.

Through the process of researching and writing this dissertation, I came to identify problems in the discursive structures of physics, of Taiwanese culture and science education. From an autoethnographical point of view, when I interviewed these women in physics and when we shared similar experiences with each other, we were not only conversing with our certain fixed identities but were co-constructing our identities at the moment of exchange, in the ways we talk about questions of identity. Our identity formations affect how we fashion who we are at this moment and in the future, how we see where we fit in, and where we might go from this point on.

On many occasions, I have been addressed as “you are the physicist here”; in other occasions, I have been deliberately excluded from the identity of “physicist”. Who I am is certainly not only who I think I am but also how others respond to my claims. My changing relations with physics are ambiguous ever since I stretched out of the boundary of natural science research and reached “the other side” in anthropology and education. My identity as, or not as, a woman in physics has never been settled. The fact that it is constantly brought into question indicates that being a physicist is a valuable identity with invested power and interests; being counted as a physicist is worth something.

Identity politics always involve the purposes of naming and who has the power to name. As the international community of physicists is calling their female colleagues in Taiwan into a particular subject position, I wish to explore what interests and power are involved in this act of naming and, crucially, how the Taiwanese women respond to it. I

share this dissertation with those whose identity as women in physics has been under question—those who have thought, asked, or asserted: “Ain’t I a woman in physics?”¹

¹ This is a parallel to bell hook’s (1981) famous book *Ain’t I a Woman: Black women and feminism*.

CHAPTER 2

FROM EQUITY TO IDENTITY

In this chapter, I argue that a shift in focus from equity to identity in gender and science education studies has emerged in recent years. This shift is not a simple replacement of one term for another; instead it involves reformulating equity projects through the notion of identity. To explicate such a shift, this chapter traces major themes in discussions relating to gender and science and gender and science education.

The first section of this chapter, “Feminist Reflections on the Sciences,” discusses what Sandra Harding calls “the science question in feminism” by examining the problems connected with positivist sciences. Harding (1986) points out that gender and science research has extended its focus on “the woman question in science” to a focus on “the science question in feminism.” The former highlights concerns regarding why so few women remain in the sciences, and how we may be able to identify factors that disadvantage women and improve the situation. The latter, instead of problematizing women and their participation, problematizes science itself, criticizes its positivist, narrow nature that involves Western, bourgeois, masculine projects, and asks what benefits may lie in a feminist reconstruction of a different “science.” The first section of this chapter adopts Harding’s “science question” and employs feminist perspectives to discuss both epistemological and methodological concerns about what counts as science and whether this is regarded as feminist science(s). In the second section “Gender Issues in Science Teaching and Learning,” I show how “the woman question in science” is manifested at the school level and has concerned many feminist science educators. In their research, “the woman

question in science” is mainly discussed as a matter of gender inequity, and several corresponding remedies are proposed to mitigate this inequity, without adequately challenging the nature of positivist science. In the third section “Gender Inclusive Science and Its Poststructuralist Turn,” I trace the development of “gender-inclusive science” as a more recent and commonly accepted model that aims to combine thoughts and discussions from both the science question in feminism and the woman question in science. In this development, a feminist poststructuralist turn clearly emerges that leads to a focus on “identity study” in science education among feminist scholars. In the fourth section “How Identity Issues Matter in Science Education,” I review the recent research conducted by several feminist science educators, on identity issues in science learning and teaching, and explain how and why identity issues matter, in science and in science education. Finally, I argue that a shift in the focus of gender and science education studies, from *equity* to *identity*, requires further investigation into the significant role identity plays in the decisions made by individuals involving gender and science.

Feminist Reflections on the Sciences

The Problems with Positivist Science

Evelyn Fox Keller, a prominent pioneer in feminist critiques of science, laid out several major problems arising from male dominance of positivist science. Her work can be regarded as the foundation of feminist criticism of science on which later criticisms are based. In her classic work “Feminism and Science,” Keller (1989a) argues that feminist and

minority critiques of science can be arranged on a four-point continuum from liberal to radical, the four points revealing the strong androcentric bias of science.

The first critique proceeds from a basic observation that almost all scientists are men and leads to inquiries such as “Women in science: Why so few?” Because of the apparent inequality in numbers, advocating the recruitment of more women and girls for science became a major theme in the equity project, especially in the 1970s in North America. However, as Keller points out, even with a critical concern for equality, such solutions usually consist of a *liberal* project demanding that girls and women gain equal access to the range and depth of positivist science already available to boys and men. The problem with this liberal approach is that its focus on numerical equality does not challenge the traditional concept of science. This approach can often merely recruit women to serve as “substitute” manpower. This being the case, why recruit women at all? Thus, how the presence or absence of women affects the nature of science requires more and deeper examination of the nature of science. Compared to the other three critiques identified by Keller, this first approach is the least radical. However, being liberal, this approach is the one taken by many influential associations and institutions in the US such as the AAAS (American Association for the Advancement of Science) and the NSTA (National Science Teachers Association). The NRC (National Research Council) has also made this approach explicit in its national Science Education Standards (Eisenhart & Finkel, 1998). This kind of “compensatory” strategy, whose aim is to enable disadvantaged people to “measure up” to an established standard already set by the advantaged group, is in fact functioning to perpetuate the same system that is supposedly in question.

The second and slightly more radical critique states that the predominance of men has led to a bias in the choices and definitions of the questions with which scientists have concerned themselves. For example, menstrual cramps, a serious problem for many women, have never been taken seriously by the medical profession; a second example is that early contraception research focused primarily on contraceptive techniques for use by women, which may have caused many problems for women's bodies. This critique has helped to locate a similar bias in many science research projects appealing, in the process, to more women's participation in order to redefine and reframe what science research is worthwhile. But, as Keller has also pointed out, this approach still does not touch the very conception of what counts as science. A fundamental critique of science is more than simply expanding the choices and definitions of scientific questions.

The predominance of men in science also leads to a third problem, that the actual designs and interpretations of science experiments are gender-biased. For example, virtually all of the animal-testing research on rats has been performed with male rats. The female ones were excluded because, as the male scientists alleged, their biological cycles would "complicate" the experiments. Also, in primatology, the common descriptions of male-female interaction in a primate troop, dominated by a majority of male researchers, viewed the lone male in a troop as the troop leader, an assumption arising from the bias of the privileged white males' social status. Only in later research, did a few female researchers demonstrate that the social organisation of some primate troops is better explained by matriarchy, and that female primates tend not to limit their sexuality to one male. In this new interpretation, the male role in a troop can be very minimal if its only role is to provide necessary materials for females' offspring.

The fourth form of critique, moving away from the liberal domain, focuses on scientific ideology itself. It questions the very assumptions of objectivity and rationality that underlie scientific enterprise. Tracing the dualism and dichotomy that arose from Western Enlightenment, Keller points out the problems in modern positivist science: the division of emotional/intellectual labour; the demarcation of mind/nature; and the split of subject/object (1985). In Western science, impersonality, detachment and objectivity are valued exclusively, while other human resources such as personal intuition, feelings and connectedness are discarded, in order to comply with scientific rationale. The repudiation of these resources is derived precisely from the conventional naming of science as “masculine,” coupled with the equally conventional naming of these resources as “feminine” (Keller, 1989b, p.38). This asymmetric assignment colludes and resonates with social and cultural practices where masculinity is usually assigned to the male and femininity to the female. This asymmetric assignment also at the same time buttresses the unequal power politics of gender in science. Barbara McClintock’s success has shown that the so-called “feminine” values are equally important in contributing to the advancement of science that improves the lives of human being (Keller, 1983). With Keller’s reclamation of the so-called “feminine” resources, later researchers informed by feminist poststructuralism and postmodernism have attempted to place the criticism of such positivist science outside this masculine/feminine trap (see Haraway, 1991). Instead of claiming to produce universal knowledge, processes leading to situated knowing are much more pertinent and appreciated among feminists concerned about the nature of science.

Sandra Harding (1986, 1991) has taken on the task of reflecting upon objectivity in science, especially from a philosophical perspective. She questions the conventional

unchallenged epistemology and methodology of science and argues that objectivity, at its foundation, is based on a nature/mind dichotomy developed among a particular science community in seventeenth century Europe. Thus this kind of science does not reflect the ultimate criteria of objectivity, but presents the interests of a small group, namely western middle-class males. In this sense, she argues that “the natural sciences are a particular kind of social science” (1991, p. 309) and their objectivity is indeed a “weak objectivity.” Further, this kind of science functions as a “truth regime,” in Foucauldian terms, that oppresses other forms of knowledge production through alternative routes by other cultural and social groups. These other forms of science are exactly the resources by which “weak objectivity” can be improved to become “strong objectivity” (1991, 1993), in which what counts as science, and how to achieve scientific knowledge, are evolved from the experiences of various gender, class, racial, economic and political groups.

Harding further proposes “standpoint epistemology” as an epistemological framework to achieve “strong objectivity.” In contrast to “empiricist epistemology,” where researchers try to be detached and aloof, and pretend to be objective and invisible, the knowing subject in standpoint epistemology is embodied and visible; subjects and objects of knowledge are fundamentally connected rather than separated; knowledge is produced by communities rather than by individuals; and subjects of knowledge are multiple, heterogeneous and contradictory, rather than homogeneous, unitary and coherent. Ultimately, standpoint epistemology refers to the distinctive ways of generating scientific knowledge for distinctive groups of people according to their very distinctive living contexts, that is, their situated natural and cultural locations (Harding, 1997).

The works of Keller and Harding are innovative but also integrated with work of other feminist science critics such as Helen Longino (1989), Donna Haraway (1991), Ruth Ginzberg (1987/89) and others. While others have paid attention to issues other than gender and science, the works of Keller and Harding are the most focused on the nature, ideology and language of science. Although they have received criticism from an anti-postmodernist camp that consists of several scientists and researchers who launched the “science-war” (see Gross & Levitt, 1994; Koertge, 1998), their work remains firmly influential and is cited in almost every piece of work on gender and science education.

In addition to feminist scientists such as Keller and science philosophers such as Harding, eco-feminists are also gravely concerned about the consequences of the use of modern science and technology. The economic development of the so-called “first world,” and the subsequent expansion of political power, are usually advanced by the massive use of contemporary science and technology; this is used as the vehicle into the “third world” as a means of “helping them develop.” This does not always mean that the economies of these third world countries are “improved,” but the women and children in these countries often become victims of such “development.” Women are losing their cultural possessions such as land and their traditional living skills for survival. Vandana Shiva (1988) challenges the myth that the third world should/must “catch up” to developed countries and argues that women and nature are marginalized and exploited by such development—a process she argues should more aptly be described as “mal-development.” She explores the unique place of Indian women in their natural environment and contends that women are victims of this mal-development as well as its “saviours.” Her analysis shows how these women’s efforts

constitute a non-violent, and humanely inclusive, alternative to the dominant paradigm of the massive use of contemporary science and technologies.

These critiques and discussions over the nature, ideology and use of science are important, because only after a thorough scrutiny regarding the kinds of science worth pursuing, can one justify advocacy and the necessity to recruit more girls and women into science. Getting more females into science should not become a slogan that functions to reproduce colonized womanpower, upholding the existing system, but should be a means to achieve a critical mass of women who can potentially change the nature and practice of science from within. A thorough discussion of the nature and ideology of science can provide the necessary conceptual tools for feminist scientists to construct an alternative science. The priority of science research inquiry should be focused on women and other historically subjugated groups, through contested epistemologies and methodologies, and should be based on feminist standpoint theories.

Debating Feminist Science(s)

Several scholars have debated the idea of “feminist science,” either in the singular form that refers to its generic meaning or in the plural form that deliberately points to a multiplicity of knowledge(s). In these debates, feminist scholars present four approaches, conceptualizing the ideas *for* or *against*, feminist science. I present the arguments of Evelyn Fox Keller, Helen Longino, Sandra Harding and Donna Haraway as the leading figures in these four approaches.

Evelyn Fox Keller advocates adding the traditionally devalued qualities of science such as feeling, empathy, affection, eroticism and intimacy to the existing dualist and

dichotomist objectivity, proposing a “dynamic objectivity” to replace it. Although she presents McClintock’s story as an example, she does not approve of the idea of a feminist science. For Keller, feminist science conveys the notion of a “separate reality” (1989b, p.42) and places women scientists in a disadvantaged place:

To ask women scientists to accept the notion of a different science representing a different reality would be to ask them to give up their identity as scientists—in much the same way, incidentally, that traditional science has asked them to give up their identity as women. (p. 42)

Keller encourages women scientists to read McClintock’s success not as an invitation to rebellion, but as evidence of the legitimacy of differences within the established criteria of scientific truth and as making room within the prevailing canon to accommodate different questions, different methodologies and different interpretations. The issue of an alternative science, for Keller, is to seek a larger canon rather than a different one.

Keller’s focus on the content of science has received criticism from other feminists (Harding, 1986) who contend she ignores the social, political and economic constraints that a female scientist must face. McClintock’s success does not guarantee the success of other female scientists. Feminist critiques of science should also focus on why some research projects receive recognition, while others do not. What made McClintock’s work invisible for thirty years then suddenly visible and worthy of a Nobel Prize? These challenges direct feminist concerns to the context of scientific knowledge production.

In contrast to Keller's content-orientated approach, Helen Longino proposes a context-orientated approach to the debate, also cautioning against the idea of a feminist science. Longino (1989) points out that the current social, cultural and political environment for practicing science is not friendly to a woman scientist's alternative approaches or to any scientist attempting to approach science from a different direction. To "do" science requires more than just the will to do so, as scientific inquiry takes place in a social, political and economic context that can impose many institutional obstacles to innovation. In her opinion, science must be seen as practice rather than content. Instead of pursuing a feminist science, one should believe that, in principle, it is possible to conduct science as a feminist, but in practice, it is impossible until current conditions change.

On the contrary, Sandra Harding is more optimistic and committed to the development of feminist science(s). For Harding, the purpose of proposing "feminist science" is neither to create a kind of women's science or a feminine version of science, nor does it refer to a singular separate reality that merely trades one absolutism for another; this is something over which Longino has expressed concern (Longino, 1989). Rather, the central concern and essential concept of feminist science should focus on the processes (how) and the purposes (why) of knowledge making. In a sense, she also focuses on the contextual—social, cultural and political—backgrounds that influence the construction of Western science.

Harding argues for feminist science using a two-pronged approach—methodology and epistemology. From a methodological perspective, Harding argues that feminist science requires a "strong objectivity" which implies a systematic examination of scientists' assumptions and beliefs in the doing of science. The formation of a "strong objectivity"

requires scrutiny of the social and cultural privileges and resources allocated to the evolving beliefs of scientists within historically situated social relations (Harding, 1991). From an epistemological perspective, feminist science requires “feminist standpoint epistemology,” which, at the current stage, legitimizes a research priority on science questions focusing on women and minorities. Women and minorities, Harding argues, are historically and politically subjugated groups; modern science owes them space in the inquiries of science. Therefore, it is imperative to gain knowledge from the subjugated to refine and maximize “objectivity” in order to produce plural knowledges that are *for* marginalized people (Harding, 1993). Feminism and other liberatory projects support each other in the fight against dominant values and against knowledge that favours dominant groups. This leads to a discussion of the fourth approach: constructing feminist sciences as situated knowledges.

Donna Haraway's (1991) take on this debate does not answer directly whether she agrees with or opposes the idea of feminist science(s) but further advances the conceptualization of Harding's “strong objectivity.” Haraway introduces an advanced poststructuralist perspective to the discussion by stating that “feminist objectivity means quite simply situated knowledges” (p. 188). For Haraway, feminist sciences are partial, situated knowledges generated by the “positioning” of the split subjects; only partial perspectives promise objective vision. The *knowing* subject, she argues, is a split and contradictory self, and the *known* object is a witty agent. This view of feminist sciences focuses on a capricious subjects' partial, limited knowing of equally capricious objects as actors/agents. Haraway's conceptualization of situated knowledges has pushed the debate of feminist sciences out of the realm of absolutism, separate reality, essentialism and

monolithicity. She opens the next scene in the feminist science(s) debate, which is yet to be imagined by the researchers and feminist science educators of the next generation.

Other Strategies

Other feminist strategies exploring gender issues in science involve disputing the conventional discourse on women's under-representation in science, by recognizing the vast amount of scientific work that women have done, thus reclaiming the term "women's science." For example, in her study of the early history of women in university physics departments in the Toronto area of Canada, Alison Prentice (1996, 1999) challenges the problematic use of the term "non-traditional" in describing physics as a career choice for women. She argues that women have historically occupied a fairly high percentage in physics department faculties in the Toronto area and that science only became a "non-traditional" choice for girls after World War II. Margaret Rossiter (1995) points out that, starting around 1954-1955 in the US, there was a sudden explosion of discourse urging women to study science, primarily in order to become laboratory workers or assistants. At the same time this discourse functioned to restrict and minimize the roles women might play and to make sure any increase in scientific womanpower would be safely channeled into traditional service roles. Women in these sectors, recruited into science but moved to the margins, are usually not counted as scientists. Eisenhart and Finkel (1998) investigated where women succeed in science and where they go when they leave; what Eisenhart and Finkel call "elite science." They found that a remarkably high proportion of women, in environmental action groups and nonprofit conservation agencies, are utilizing their scientific abilities. Eisenhart and Finkel label this kind of science "women's science." This

use of the term “women’s science,” though, is tricky because it feeds into the tension between giving women adequate recognition for their contributions to science and subscribing to a binaristic and possibly essentialist dichotomy of women’s science vs. men’s science.

Gender Issues in Science Teaching and Learning

Research into gender issues, conducted in a school context, is usually concerned with the “women question in science”—why do fewer women than men choose science as one of their school subjects? Although the overall female percentages in school science classrooms in a Euro-American context have been gradually increasing over the past three decades, the percentage differences among biology, chemistry and physics indicate that further refined research is necessary to discern what is happening within the different subjects. In the following paragraphs, I investigate previous research into the women question conducted in the context of the UK, the US, Australia and Canada to show that their research topics usually follow one or both of two major themes: the factor search and the remedy search. The factor search involves how educators identify factors that disadvantage women in their learning of science; the remedy search involves projects to improve such situations. In the factor search, I present two models proposed by Nancy Brickhouse (1994)—the deficit model and the inferior treatment model. In the remedy search, I discuss several projects corresponding to the call for “fairer treatment.”

Factor Search: The Deficit Model and the Inferior Treatment Model

Nancy Brickhouse (1994) has pointed out that the equity project in science education can be categorized into two models: the deficit model and the inferior treatment model. To explain the differences in the achievement and participation in science between females and males, earlier diagnoses utilized a deficit model, asserting that girls lack the cognitive ability to practice science and that only a very few exceptional women can “handle” it. Although some social scientists have criticized this model as sexist, it is unfortunately still a common perception on the part of many male professors and students in science and engineering departments, especially when they look around and find very few women in their disciplines. It is also a popular explanatory model for the gendered achievement gap in contemporary international tests. The fundamental problem of this model is that it does not challenge the existing authority and the inequity caused by the system but blames the victims of the system.

This model also reflects a general sexist tendency of research into gender disparity in education in the 1970s. Strategies for changing such disparity were usually based on sex role socialization theory and tended to focus on changing girls rather than changing curricula. Such research focused on how we might interact with girls to shape them differently; how to make them more autonomous; how to change their attitudes; how to give them self-esteem; how to make them want to do math and science. On contesting the scholarship of “fixing” girls’ self-esteem, Kenway, Willis and Nevard (1990) pointed out the problematic conceptualization of such strategies as these strategies blame the girls for having “deficient” and “victim” status; the burden of change rests on girls, as if it were the girls’ “inadequacy” that needed mending. These strategies are problematic, in that they seek to change the

individuals rather than the social structures that oppress them. Individuals may perceive themselves as causing the problem while the gender power structures are left unchallenged.

From the late 1980s to the early 1990s, the equity project of gender and science finally changed from asking why girls “couldn’t” do science to why girls “won’t” do science. This change of approach resonates with a similar change of approach in studies of gender and math (Willis, 1989) which took place in the same era. Scholars began to ask questions about what happens in classrooms and schools that contribute to the gender disparity in science and what kind of inferior or inequitable treatment discourages girls’ participation in science. Focusing specifically on the school context, Alison Kelly (1985a) located three ways in which schools contribute to the construction of science’s masculine image. The first and most obvious is the numbers—the image of a disproportionately large number of males studying and teaching science presents difficulties for girls to identify with such a career. Secondly, there is a masculine bias in the presentation and packaging of curriculum materials. The way science is presented, the language it uses and the examples and applications it addresses imply science to be masculine and, especially, military. Thirdly, classroom behaviours and interactions often present elements of both masculinity and femininity that are developed in out-of-school contexts and are transformed into classroom behaviours in ways that establish science as a male preserve.

Following Kelly’s layout, researchers have identified several factors that affect girls’ science learning and career choices, including gender stereotypes in teacher-student interactions, classroom dynamics, issues of sexual attractiveness, and biased methods of assessment. For example, researchers have found that both female and male students consider science as more appropriate and important for boys than for girls, and students’

impressions of the traits of scientists are more often associated with masculinity than with femininity (Kahle & Meece, 1994; Sadker & Sadker, 1994). Teachers rated boys' work higher than the same work done by girls; if girls' work was praised, it was more likely because of its neat presentation rather than its substantive content (Spear, 1987a,b). Jones and Wheatley (1990) observed that females were called on less often in class and were asked fewer questions. In Taiwan, She (1998) reports similar findings in a female teacher's science classroom indicating that even female science teachers often teach in ways that favour boys. This research suggests that, although female science teachers may be role models for female students, their presence does not guarantee that female students are sitting in a classroom with less gender stereotypes. This finding resonates with another finding in British Columbia, Canada that most female teachers do not consciously make a special effort to reach female students (Gaskell, McLaren, Oberg, & Eyre, 1993). For sexual image issues, Head's (1987) earlier study found that girls who choose science are considered socially and sexually less attractive and this factor was still, recently, reported as a factor affecting girls' choices in science. For example, Priest (2000) reported that girls, gifted in science and maths, are at a high risk of playing to gender stereotypes and hiding their talents. When asked why they dropped out of their gifted programs in grade 7 and 8, these girls replied that being gifted was not a quality that boys found attractive. Giftedness and femininity are not considered compatible in conventional social and gender codes. Walkerdine (1989) also points out that in school assessments femininity was equated with poor performance, even when the girl was performing as well as the others. Assessment studies have long shown that students' performances on traditional assessments may be largely attributed to gender and personality traits rather than to knowledge and understanding (Kahel & Lakes, 1983).

Murphy (1996) also found that female students often feel alienated from traditional assessment techniques. This finding prompted her to seek alternative strategies.

Remedy Search: Remedies to Ameliorate Gender Inequities in Science

Education

Some researchers suggest that all-girl classes or all-girl schools may be a solution to the problem of gender stereotypes. Early research has documented that girls in single-sex schools view physics and chemistry as less masculine than girls in mixed schools (Ormerod, 1975; Vockell & Lobanc, 1981). In a more recent study, researchers found that a much larger percentage of girls at all-girl schools chose to enrol in science courses than did girls in mixed-sex public schools (Campbell and Evans, 1993). It seems that social roles and gender stereotyping can be partially ameliorated in this kind of classroom setting. However, Guzzetti's (1998) study shows that girls' success in an all-girls grouping does not persist once they join mixed-sex groups as the gender codes and gendered expectations start to function among the male and female students. Further, Kenway and Gough (1998) pointed out that single-sex classes for girls were often read as re-inscribing girls to traditional femininity. Same-sex schooling settings solve the problem of gender stereotypes in some ways but induce and reinforce them in others.

Other remedies have attempted to repackage science in ways that will attract more females. For example, "girl-friendly science" was an idea first used at the first GASAT (Gender and Science and Technology) conference in 1981 (Raaf, Harding & Mottier, 1981). Its goals included applying women's ways of knowing into teaching, by making course content and pedagogy less alienating for women and by warming up the classroom climate

for women. For example, Smail (1984) proposed developing a nurturing science curriculum that focuses on “relationships,” “people” and creating a “network world view” in order to avoid the sex bias in the old curriculum and classroom dynamics. Smail (1987) also advocates the inclusion of real-life examples and an introduction to related career opportunities, in order to encourage girls to give physics a second chance. Jan Harding (1985) suggests changing curricular presentation according to social contexts to make science more acceptable to girls. These remedies are working on the dichotomy of femininity versus masculinity and on the assumption that women are more relational and men more detached.

However, as Jan Harding has pointed out, over time, girl-friendly science became associated with the perception that, for various reasons, science had to be made *easier* for girls. Consequently, girl-friendly science came to be perceived as low status science and began losing momentum (Parker, 1994). Moreover, this program has been labelled a “superficial ploy” and criticized as merely being concerned with giving girls a “fair deal” (Bentley and Watt, 1986:124). Many scholars point out that it leaves the very masculinity of the content and style of science untouched or unchallenged (Bentley & Watt, 1986; McLaren & Gaskell, 1995; Kenway & Gough, 1998). In fact, repackaging science with a traditional assignment of gender roles did not succeed in attracting girls into science. Teaching air pressure with vacuum cleaners, heat-transfer with cooking, electric circuitry with domestic wiring, and energy changes within the household (Kelly, 1976) reinforces gender stereotypes. In the GIST¹ project, Kelly (1985b) discovered that girls were less enthusiastic

¹ GIST, Girls into Science and Technology, was an action-research project run by the Department of Sociology at the University of Manchester, UK, in 1984. It attempted to explicate girls’ under-achievement in physical science and technical subjects at school. More description can be found in Kelly, Whyte and Smail (1987).

than boys about learning how a vacuum cleaner works and that girls were not particularly keen to find out what baking powder does.

The approach of girl-friendly science later became “female-friendly science” and was adopted and promoted by Sue Rosser (1990, 1997). Rosser contends that the evolution of female friendly science can be seen as “phase theory.” She proposes a six-stage model for curriculum transformation to facilitate the inclusion of more women and men of color into science. However, her linear stage model still sees women as the problem and calls for a liberal project of “adding in” women and women’s perspectives to science. In the final stage, her goal is to utilize womanpower to “expand” and “improve” the quality of existing science but does not fundamentally challenge its nature and ideology, its historical assumptions and its political structure. Krienberg and Lewis (1996) also adopt a similar approach and propose to redefine science into a “transformed, reconstructed gender-free [science] curriculum” (p. 197). The introduction of a “gender-free” curriculum indicates a return to and a re-embracing of the heavily-criticized objectivist model of modern science; no mention that the dream of any gender-free item is incomprehensible and impossible in a poststructuralist era.

Solving the women question in science has its value by promoting women’s participation in order to reach a critical mass in science for possible change; it also has value in raising gender consciousness among female scientists. The rationale behind this manoeuvre, however, is one of liberalism. Seeking liberal equity must accompany a thorough examination of the nature and ideology of science, the role of science in a broader political economic context and the identity of scientists as science practitioners.

Gender Inclusive Science and Its Poststructuralist Turn

Gender Inclusive Science

A more recent trend brought into the discussion on gender and science education reform is “gender-inclusive science.” This trend carries general responses to Keller’s (1985) eloquent criticism on the symbolic and characteristic masculinity of modern science, and Harding’s (1991) advocacy in applying standpoint epistemology to stress the experiences of women and minorities in the development of a feminist science with a “strong objectivity.” At first, starting from the late 1980s to the mid-1990s, the conceptual framework of gender-inclusive science focused on two parts: gender inclusion and strategies to achieve such inclusion; and reflections on the nature of science and science education.

The first part emphasizes the active inclusion of girls in science, in order to engage them in the asking of scientific questions relevant to their lives, to value what they can bring to the science classroom and to develop corresponding teaching strategies for teacher education. Many feminist science educators have endeavored to make “gender-inclusive” science education a more developed and accepted term within research communities (e.g., Haggerty, 1996; Harding & Parker, 1995; Hildebrand, 1989; McClintock Collective 1988; Roychoudhury, Tippins, & Nichols, 1995; Weinburgh, 1995). Their mandates can be summed up in Harding and Parker’s (1995) definition of “gender inclusive science”:

... a gender inclusive science curriculum is one which values what both boys and girls bring to science classrooms and one which challenges existing definitions of science. It must probe the social construction of both gender and science, challenging

the power differential of gendered relationships and working towards an understanding of science which embraces all human beings. (p. 539)

The second part reflects upon the nature of science and science education and seeks to challenge scientific orthodoxies. For example, Brickhouse (1994) argues that science needs to be taught in ways that enable students to understand its multicultural nature, its controversial character and its relationship to the world so that their masculine images of science will be challenged and hopefully changed. That is, science teachers can give students an education not only *in* science, but also *about* science. This advocacy corresponds to the WISE² (Women in Science Education) group's call for the learning of science to be much more than the learning of facts, theories and procedures. Science learning must also mean learning about the norms, beliefs, values, discursive practices and ways of acting and reasoning that are acceptable within the community of scientists (WISE, 1994, 1995). In general, their concerns involve two areas: what type of science is taught and the way in which it is taught. These concerns of gender-inclusive science are based on a social constructivist perspective and can be compared to Calabrese Barton's (1998a) four characteristics of gender-inclusive science: scientific knowledge is acknowledged as culturally and socially bound; scientific knowledge is reflective of nature's holistic, interactive and complex existence; the scientific contributions of women and minorities are

² As of April 1998 (WISE, 1998), the WISE group consists of eight feminist science educators from various campuses in the US. Most of them are based at Michigan State University. They are Lynnette Cavazos, Graduate School of Education, University of Santa Barbara; Constanza Chiappe Hazelwood, Teacher Education Program, Northwestern Michigan College; Elaine V. Howes, Department of Scientific Foundations, Teachers College/Columbia University; Lori Kurth, Department of Teacher Education, Michigan State University; Paula Lane, Department of Teacher Education, Michigan State University; Gail Richmond, Department of Chemistry, Michigan State University; and Kathleen J. Roth, Department of Teacher Education, Michigan State University.

incorporated into a historical analysis of the development of scientific knowledge; and science is practiced through multiple ways of knowing.

This two-part focus of gender-inclusive science from the late 1980s through to the mid-1990s has generated extensive discussion on gender and science education and has attracted attention from the science education community. This focus emphasizes the inclusion of females in order to challenge and change the existing practice of science education and to rethink science teaching and learning from a critique of gender politics. It also calls for a political investigation of the nature of science from its social and cultural context. It has optimized the feminist criticism of science and utilized gender as a factor to examine many important questions in the teaching and learning of science. Its strong focus on gender, however, also runs the risk of merely attending to one analytical dimension and overlooking others, such as ethnicity, race, class and sexuality. Its advocacy for inclusion, nonetheless, appears to be “adding females” without scrutinizing what it means to be a female.

Some Problems and the Poststructuralist Turn

Several scholars have noticed these problems. For example, claiming that science necessarily occupies the superior role of masculinity over femininity is at the same time reinforcing cultural dualism; an emphasis on the “feminine” side in the reconstruction of science is reasserting this dualism (Kenway & Gough, 1998). Making associations between the subjectivities of male students and the masculinity accorded to abstract science runs the danger of essentialism (Hughes, 2001). In a debate arranged by the *Journal of Research in Science Teaching* Volume 37, Issue 4, Atwater (2000) questions whether the study of

females in science education falls into a presentation that “white is the norm and class, language, lifestyle and religion are non-issues” (p. 386). Other feminist researchers (e.g., Howes, 2000; McGinnis, 2000; Rennie, 2000) responded to the question and agreed that intersections among gender and ethnicity, class, language and religion are necessary in the future research on “inclusiveness” in science education. Rennie (2000) also cautions that gender and sex are not the same, yet quite often critics’ use of the word gender actually refers to biological sex. Inquiries into the nature of “inclusiveness” and the intersections among gender, sexuality, ethnicity, class, language and religion will inevitably become entangled with *questions of identity* especially in the poststructuralist era. The above concerns and conversations thus sharpen the conceptualization of gender-inclusive science.

Feminist poststructuralism (Weedon, 1987) draws upon work in linguistics, psychoanalysis and philosophy and, in my opinion, has at least four major theoretical tools to offer for feminist science educators’ reflections on issues of gender and science. First, poststructuralism dismisses the idea of finding an ahistorical truth and denies the claim of a universal unitary scientific knowledge. Second, poststructuralist feminists have demonstrated how male-female dualism as a foundation of science arose in the Enlightenment and how its rise was enmeshed in the oppressive history of science over nature (Harding, 1986). Careful critics of science are advised not to follow the masculine/feminine dichotomy based on such Enlightenment models of science. Third, poststructuralist feminists emphasize the plurality in the meaning of gender. Research into aspects of gender should account for a diversity of the meanings of gender and attend to the variable grounds of class, race, ethnicity, religion and sexuality. Research on gender and science cannot avoid scrutinizing the historical, social and cultural contexts that support or

restrict what it means to be a girl, a boy, a man, or a woman in their communities. Fourth, individual subjectivity and identity are not unitary and fixed, but complex and constantly shifting. They are formed and transformed in response to the construction of the meanings of gender intersecting with other social, cultural, historical and political factors.

Toward Feminist Poststructuralist Identity Questions

Some feminist science educators have adopted this poststructuralist turn and identity issues have become a major focus in their recent research. For example, the WISE group underlines the importance of identity issues in science teaching and learning in a pamphlet designed to display how their approaches differ from those of mainstream science education communities³. Gwyneth Hughes (2001) demonstrates an anti-essentialist approach in the study of science students' multidimensional identities and argues that gender inclusivity must attend to any discriminatory discourses and practices within which student scientist identities are formed and transformed. Calabrese Barton (1998a) uses a concept of "positioning" to analyze students' situated identity formation in an urban setting and calls for an understanding of situated knowing and learning in science. Nancy Brickhouse and her colleagues (Brickhouse, Lowery, & Schultz, 2000; Brickhouse & Potter, 2001) have

³ The WISE group position themselves as a group "forced into a marginalized position by those in power" (WISE, 1998, p. 34). They have invited the NARST community into their discussion and provided a "Call to Action" pamphlet to address their different stances regarding various issues in science education from the mainstream. For example, in response to the common call to "attract more girls to science," they question the assumptions of the "deficit of girls" model and advocate the need to recognize what girls can bring to science. In response to another common idea that "science teaching should be hands-on, minds-on and linked to everyday experience," they point out the naïve concepts of experience in the idea and postulate the importance of identity issues in science teaching and learning. "Experience," according to them, "is a product of identity in multiple communities—gender, racial, religious, cultural, socioeconomic. Everyday experience is not the same for everyone.... For science teaching to connect with some people's experiences, it must touch their hearts as well as their minds and hands." (WISE, 1998, p. 35)

conducted research on a group of schoolgirls' identities with various ethnicities. Their work will be further discussed in the next section.

Why and How Identity Issues Matter in Science Education

Identity and Learning

Scholars of practice theories⁴ such as Lave and Wenger have asserted that issues of identity are crucially related to issues of learning (Lave & Wenger, 1991; Wenger, 1998). Learning, according to these scholars, is situated and must be perceived as a process of identity-formation. Learning is not merely a process of acquiring knowledge through a cognitive phenomenon that happens in individuals' minds. Instead, it should be understood as a series of decisions about what they want to know; what they want to ignore; who they think they are; and who they want to be, under socially situated conditions such as gender, race, class, religion and so forth. Such decisions are made at the intersection of individual agency and societal constraints and are informed by the subjects' previous identities; these decisions also inform and transform these subjects' future identities. Learning can be seen as a process for individuals to find livable identities in a complex world. As individuals seek meanings to build identities, learning becomes a delicate balance between what learners choose to know and what they choose to ignore (Wenger, 1998).

⁴ Following Eisenhart's and Finkel's (1998) definition, practice theories focus on how people generate meaning systems as they participate in everyday, local activities, and on the ways these meaning systems connect people to broader patterns of social reproduction or change. These theories investigate what meanings are produced within and about everyday activities, how knowledge, identities and learning are situated in practice, and how everyday activities and meanings organize participants in wider relationships of power. For example, see Bourdieu (1977), Ortner (1984) and Connell (1987).

Identity and Learning of Science

The importance of identity issues in science learning appears in Nancy Brickhouse's early and frequently cited article "Bringing in the outsiders" (1994). This article is usually cited for its perspectives on gender and ethnic differences in science and its call for the inclusion and recognition of groups traditionally marginalized by elite science. For issues of identity, it also points out a potential identity problem for these "outsider" science learners when they come to decide what they want in the future. Within the curricular structure of schools, unlike the subjects of social studies or English, science is not a school subject that is expected to be understood by everyone. Students may opt out of science as early as Grade 10 if they cannot see adequate relevance or build some identification with it. If science keeps its elite, white, male, middle-class nature and image, members of ethnic minority groups and women may not identify with it, may not steer their careers onto the science track and may only choose subjects they believe will be of use to them as adults.

In her later work, Brickhouse and her colleagues continue to reflect upon and deepen the discussion of identity issues in the learning of science, by incorporating practice theories such as those of Lave and Wenger, on identity and situated learning. "If students are to learn science, they must develop identities compatible with scientific identities" (Brickhouse, Lowery, & Schultz, 2000, p.443) because learning has to be thought of as an apprenticeship where students forge identities in communities of practice. They argue that how students engage in school science is influenced by how students view themselves, that is, whether or not they view themselves as the kind of person who engages in science (Brickhouse et al., 2000); and educators need to know how students' engagement in science is related to who they think they are and who they want to be (Brickhouse, 2001). On examining urban

schoolgirls' contestation of their science identities, Brickhouse et al. found that school science does not provide learners with a wide range of identities (Brickhouse et al., 2000). For example, some girls may have to construct their science identities through activities not chosen or approved by school discourse of traditional science.

The narrow definition of school science usually causes trouble for "outsiders" or members of traditionally marginalized groups when identifying with science. School science is usually defined and presented in terms of how well it matches with what professional scientists do (Brickhouse, 2001) and such narrowly defined identities are found incongruent with women's gendered identities. For example, young women may refuse to participate in scientific activities that are not consistent with their gendered identities or refuse to participate in nontraditional science methods or careers which do not resonate with their gendered identities (Carlone, 1999; Eisenhart & Finkel, 1998). Choosing to engage or not to engage in school science tells us how individual identities are forming and transforming in interaction with prevailing and dominant discourses and structures of power. As Brickhouse (2001) states: "the decision to disengage, resist and ignore is the important other side of engagement and learning" (p. 287). Understanding issues of identity, marginalization and engagement in school science becomes essential for teachers to prepare student scientists of diverse identities (Brickhouse & Potter, 2001).

Calabrese Barton has also developed a scholarship of identity study in response to the call for "science for all" (Barton, 1998a, 1998b, 2001). She questions how inclusive the science education community is in its efforts to understand the meaning of science for all. Barton follows critical pedagogy and feminist pedagogy concerning the production of knowledge, culture and identities (Giroux, 1991; Gore, 1993), to examine the representation

and identity questions in pursuing science. She argues that pedagogical questions of representation and identity in teaching and learning science are understood alongside issues of power and actuality; such as who has the power to fashion the images of science and the identities in science and in what ways are these images and identities fashioned (Barton, 1998b). For Barton, pedagogy in the science classroom is about the struggle for “identities” and “representation”; it asks us to think about much more than mere scientific concepts when we think about helping all children to become scientifically literate. The identity question in science is important because it asks who we think we must be, in order to engage in science. Barton pays particular attention to the socially, politically and historically situated identities of urban homeless children in acquiring access to science and illustrates how significantly different life experiences can intimately shape the ways in which children engage with each other and the ways in which they think about science. Instead of following the traditional paradigm, where science lies as a target at the center to be reached by students at the margins, Barton’s approach is to relocate students’ identities to the center of science education.

Gender Identity and Science Education

With their research on gender identity in the learning and teaching of science, Jim Gaskell and his colleagues warn us about the difficulties of making gender visible in classrooms. They found that the invisibility of gender issues in classroom discussions among students and teachers has complicated gender identity construction inside the classroom and in peer interaction (Gaskell & Hildebrand, 1996). Many teachers talked about gender as a personal factor rather than a group trait. Girls tend not to connect their struggles in physics

with the gendered context of science, while they would recognize an invisible yet existing sexism in some other conversations (McLaren & Gaskell, 1995). Students may also adjust their subject choice according to how other people talk about gender and science. For example, in research conducted with grade 10 students, several girls spoke of taking physics even though they said they were not interested in the subject. They were aware of the pervasive concern about the need for more girls to enroll in physical science and they “wouldn’t let the side down” (Gaskell & Hildebrand, 1996). Students are constantly constructing their identities and positioning themselves in relationship to others having power over them or about whom they care. Their identities as gendered beings are complex and situated. Their decisions in messy, complex situations embody their priorities and will be judged by the reactions of the communities in which they live (Gaskell, Hepburn, & Robeck, 1998). Indeed, gender identity is not a simple issue. It intersects with ethnicity, race, class, sexuality and biography in the construction of identity.

Identity, Discourse and Agency in Science Education

The intersection of gender, class and ethnicity in the construction of students’ scientist identities is a recent research topic that has attracted attention from feminist science educators (e.g., Atwater, 2000; Barton, 2001; Brickhouse & Potter, 2001; Hughes, 2001; Howes, 2000; McGinnis, 2000; Rennie, 2000). Gwyneth Hughes (Hughes, 2001) undertook research in a city school and a post-16 college in the UK to examine how students produce their scientist identities within the competing discourses of curriculum, ethnicity, feminism and gender. Students’ scientist identities cannot be adequately depicted within isolated rigid

categories such as gender only or ethnicity only. She stresses that a multidimensional approach is necessary in order to avoid a one-dimensional essentialist perspective.

For example, in her findings, female students did not reject science just because they were marginalized in the discourse of masculine science, while male students could drop out of physics and still embrace the masculinist values in the science curriculum. An Asian female student managed to stabilize her identity as a successful female scientist by drawing on the discourse of Asian parental pressure for school success to overrule the implicit contradiction between her subjectivity as a female and the anti-femininity science discourse. In this case, both the science curriculum discourse and ethnicity discourses are necessary and mutually implicated. Another example from Hughes involves a black female student who rejected conforming to the traditional white, submissive, feminine role and used feminist discourse to celebrate her nontraditional choice. She was also able to create female “new scientist” subjectivity with her reconfiguration of the dominant science curriculum discourse. In this research, Hughes identifies at least four different discourses regarding gender or ethnicity: a discourse of physics as a masculine, white, middle-class, hard science; a discourse of biology as a more feminine science for females because of its affinity to “human interests”; a discourse of ethnic minority as “outsiders” to societies and the values in which they reside; and a discourse of feminism for support of nontraditional career choices.

Hughes provides a research model illustrating how to portray and track students’ identity constructions within various discourses and how these discourses compete against, or cooperate with, each other in the process of identity construction. This kind of research follows the feminist poststructuralist contestation of identity as complex, shifting and constantly constituted and reconstituted through a range of discursive practices. It also uses

the concept of “positioning” to understand individuals’ placing of themselves within available and regulatory discourses in order to adapt recognizable and acceptable social identities (Davies, 1993)⁵. For Hughes, the goal in stressing a gender-inclusive science is as much to challenge intellectual abstraction and rigid epistemology as to identify and resist discriminatory discourses and practices. It is as important to provide various discourses for students to construct their identities, as to observe how students construct a wide range of scientist subjectivities through their reconfiguration of dominant discourses. It is through such reconfiguration and positioning that student agency becomes visible.

From Equity to Identity

The poststructuralist turn in gender and science education studies, along with the aforementioned recent research by many scholars, suggests a shift in focus in this field from a concern with equity to a focus on identity. This shift, though, is not a simple replacement of one term for another. In no way does it suggest that previous goals for equity have all been accomplished; nor does it propose that equity is no longer a relevant concern in gender and science education studies. Instead, this shift in contemporary scholarship recognizes a necessary refinement of equity inquiry. It involves reformulating equity projects through the notion of identity. It aims at achieving equity through an understanding of identity.

⁵ In her book *Shards of Glass* (1993), Bronwyn Davies adopts a poststructuralist approach to seek strategies for educators to work with children in order to go beyond their gendered identities. For Davies, Poststructuralism provides a radically different conceptualization for an understanding of the process of becoming a gendered person. It is important to enable children to see for themselves the discourses and storylines through which gendered persons are constituted; and to see the cultural and social production of gendered persons that they are each caught up in. In her conceptual framework, children are not seen as passive recipients, but as producers of culture, who make themselves and are made within the discourses available to them.

I have arranged my arguments in response to Sandra Harding's two questions and have described their merger through a poststructuralist turn. In addition to this structure, my arguments can also be rearranged into three trends to help identify the shift from equity to identity: fixing the girls, fixing the teaching and fixing the science. Fixing the girls project includes research bearing assumptions such as ordinary women *cannot* do science and only those *exceptional* ones can; girls' attitudes towards science are problematic and thus require some change; and girls' self-esteem is low and thus needs to be raised. Fixing the teaching project includes research that aims to fix the unequal attention given to male and female students; gender stereotypes reproduced in interactions in classrooms; comments and evaluations in favour of a particular gender; and heterosexual assumptions and interruptions between female and male students. Fixing the science project includes stressing science as a social construction; investigating the language, metaphors and examples used to illustrate scientific concepts; examining the epistemological and methodological bases of science; identifying the norms, interests and beliefs intrinsic in the designs and interpretations of scientific questions; and contesting the alternative conceptualizations of objectivity.

The structure of these three trends helps to identify problems and challenges inherent in studies stemming from a gender equity focus. For example, fixing the girls project commits a fallacy of mixing "don't do" with "can't do." Looking for girl-friendly or female-friendly ways to fix teaching in classrooms leaves the nature of science unchallenged and assumes that boys and males are the norm and girls or females have special needs. The difficulties facing the project of fixing the science encompass tremendous philosophical issues, involving the conceptualization of feminist science(s), and the genuine difficulty in constructing alternatives. Through these three trends, an equity focus has achieved

considerable success by providing alternative curricula and demanding gender-sensitive pedagogies. Limits facing an equity focus also emerge when it comes to disentangling “won’t do” from “can’t do” and questioning how the meanings of gender are constructed and contested within the norms of science and science classrooms.

The gender equity focus has, in the past three decades, energized scholars to identify gender bias in the presentations and practices of science and science education. Corresponding remedies such as alternative curricula and interventionist projects have been implemented in order to reduce gender bias and increase the participation of females and minorities in science. However, researchers have already found that attempts to persuade girls to pursue particular subject and career choices often adopted a rather authoritarian model of pedagogy—preaching rather than teaching—and such a model failed to adequately address the complex issues of reception and identity (Kenway & Gough, 1998). A mere focus on structural equity is not enough to advance the goal of equity toward success. It is clear that pursuing gender equity in science and in science education takes more than providing equal opportunities and access to science. A shift in research focus from equity to identity has thus evolved to examine individuals’ choices regarding science and the meanings and senses of themselves that they attach to such choices. An identity focus enables us to understand choices as being closely enmeshed with individuals imagining who they are and what they can do. Such choices must be understood within the discourses and power structures of disciplines and societies. Feminist poststructuralist theories on what it means to be a female or a male in the discursive practices of science and science education are useful and crucial to such identity inquiry.

A focus on identity should not be mistaken as a focus “merely” on individuals, thus overlooking structural and societal constraints. In my research, I use Foucauldian theories of discourse to discuss the interactions between individual agency and structural constraints. Individuals are never fully “free” from, or fully “controlled” by, social structures. Identity formation and career decisions can be seen as evidence of individuals exercising their “conditioned” agency under both structural and societal constraints. Therefore, identity focus is working on, and bridging, both the individual and structural sides. Theories of discourse are particularly pertinent for the exploration of such topics, as I explain in Chapter Three.

Also, an identity focus on issues concerning girls’ participation in science should never be misunderstood as a focus aimed at “fixing” girls’ identities before entering science. This type of misunderstanding indicates two conceptual problems. First, it repeats the “fixing the girl” model, thereby blaming the victim and leaving oppressive social structures unchallenged. Second, it reflects a narrow understanding of the term “identity” as something people possess; a property that pre-exists before individuals “bring to it” structures such as science and society. Identity, in my understanding, is not a static property that individuals “own” but a dynamic process of becoming. Identity formation is a process, within which the individual and the structure encounter and interact. Identity only exists in constant interaction with social structure and context. That is, there is no such thing as pre-existing “fixed identities”—that is, asking girls to prepare their scientist identities at the ready, before choosing science. Their scientist identities are formed within, and with respect to the changes surrounding, science.

My purpose in focusing on identity is to reveal the problems and inequities in the existing structures of power. I approach this goal by analyzing the discursive structures wherein identity formation and transformation take place. In the next chapter, I explain how this goal can be approached, using theories of discourse, identity and agency.

CHAPTER 3

THEORIES OF DISCOURSE, IDENTITY, AGENCY

Identity formation and transformation are two of the key aspects in understanding individuals' choices regarding school subjects or personal career. Poststructuralist theories and feminist reformulation on the topics of subjectivity and subjection provide theoretical tools to understand individuals' identity formation and transformation. In this chapter, I discuss and reconsider concepts of "discourse," "subjectivity/identity" and "agency" as the key terms in the analytic framework of my data. In the first section, I compare Foucauldian concepts of discourse and Althusserian concepts of ideology to ponder the formation of subjectivity in relation to degrees of agency. In the second section, I show how feminist scholars have followed and refined discussions on identity and agency and how they are applicable to the case of women in physics.

Theories of Discourse and Subject

Discourse

Discourse is groupings of words, statements, symbols, and signs, spoken and/or written, imposed, adopted, circulated and exercised in particular ways that manifest values, norms and beliefs inscribed to, and reassured by, individuals who utter them and institutions that posit them. Through these particular ways, discourse regulates behaviors and expectations corresponding to an individual's sense of sanity and an institution's purpose of operation.

Many theorists have explored and extended the usage and coverage of the term “discourse.” This term originated from linguistic usage but has been transformed and widely used in other disciplines. French linguist Benveniste defines the term “discourse” in the broadest sense as “any utterance involving a speaker and a hearer, and an intention, on the part of the speaker, of influencing the hearer” (Macey, 2000, p. 100). Benveniste’s definition informed other scholars, such as French historian Michel Foucault and linguist Michel Pecheux, to think of discourse as an intersubjective phenomenon, rather than a direct product or expression of subjectivity. This direction of the theorizing of discourse puts the concept of subjectivity into question. Subjectivity is no longer a given property owned by an autonomic, independent, “free” subject, as defined in Humanist terms. Subjectivity should be considered as formed within discourse and as being under constant contestation because discourse plays a constituent role in the production of the symbolic systems that govern human existence and position human beings as subject (Macey, 2000). Such conceptualization opens up questions about subjectivity and agency formed and performed in relation to discourse.

Foucauldian theories of discourse are developed along with terms such as regulation, sanction, government, power, control, knowledge and institution. Michel Foucault defines discourse as “practices that systematically form the objects of which they speak... Discourses are not about subjects; they constitute them and in the practice of doing so, conceal their own intervention” (Foucault, 1977, p. 49). For Foucault, discourse is important in that it gives rise to collective social attitudes or mentalities that define certain social categories or produce operational meanings such as madness or insanity. These collective attitudes and mentalities form a ground on which knowledge as power is produced to govern

social and intellectual procedures. Power is something circulated through discourse-defined procedures with the participants' certain consent, rather than as a repressive top-down controlling figure. It circulates within society rather than being owned by one group. For Foucault, power relations never simply imply domination or imposition. Foucauldian notions of discourse steer the perception of power away from a repressive hypothesis, towards "a form of action or relation between people which is negotiated in each interaction and is never fixed and stable" (Mills, 1997, p. 39). In actions and relations between people, discourse regulates what can be said, who has the right to speak, who is silenced and what counts. Discourse is realized by rituals that sanction the types of people who have the power to utter certain types of statements and put them into effect. For example, only a priest or registrar can legally marry a couple; an actor who "marries" someone on stage is not legally married to that person (Mills, 1997). Sanctioned discursive practices, or practices sanctioned by discourse, are constituent in the operations of institutions and the demeanors of individuals. Through sanctions, discourse distributes power. As Kenway and Willis (with Blackmore & Rennnie, 1998) point out, discourse gains, assigns and circulates power and control through its inscription in institutional structures and practices. It is through discourse that meanings and people are made and through which power relations are maintained.

Discourse and Ideology

Conceptualizing discourse in terms of power, regulation, control, and government signals a near-synonymity¹ of "discourse" to the term "ideology." My description of

¹ David Macey (2000) points out the similarity between discourse and ideology by saying: "The very wide use of the term [discourse] reflects structuralism's promotion of the linguistic model as a model for all communication; it is thus possible to speak of the discourse of advertising, or the discourse of Impressionist painting. Here, "discourse" easily becomes a near-synonym for "ideology." (p.100)

discourse in the previous paragraph presents exactly this kind of similarity. Before Althusser's intervention, earlier discussions about "ideology" tended to portray it as "ideas in the mind" that could include beliefs and meanings. However, the attempts to link these beliefs to practices and historical process tended to be reductive, as if meanings and beliefs could instantly reflect reality, and be formed into consciousness (Macdonell, 1986). Such an approach to ideology supposed that ideas had an abstract existence. It pushed Althusser to argue for their material existence. Althusser re-orientated the study of ideology by emphasizing that ideologies have, first of all, a material existence (Althusser, 1971). He identified a list of "apparatuses," including religion, education, the family, the law, the system of party politics, trade unions, communications and culture through which contemporary capitalist countries operated ideologically. Althusser's argument is that ideologies exist in apparatuses, forming part of the State where they are interconnected by social and class conflicts, traversing those apparatuses. His argument escapes from the abstract view of beliefs and meanings as either free-floating or coming from consciousness. Althusser holds that consciousness is constructed through ideologies. As Diane Macdonell has pointed out: "his radical emphasis on their material existence leads to this reconception: Ideologies are systems of meanings that install everybody in imaginary relations to the real relations in which they live" (Macdonell, 1986, p. 27).

Althusser does not invent the term "ideology" but emphasizes its material existence and opens up investigation about how the State works to remain in control. Such emphasis on material existence and practically identifiable apparatuses is an important mark in continuing discussions about Althusserian theories of ideology. For example, Barrett (1980) defines ideology as "the generic term for the processes by which meaning is produced,

challenged, reproduced and transformed” (p.97). In this formation, the word “processes” is a key word indicating the Althusserian root of this formation. Davies (1993) also understands ideology as:

According to Althusser, individuals, in learning to speak and to interact, come to see ideologies as their own, informing and stemming from their own desires and choices, and therefore not as something that they should either be wary of or challenge. (p. 14)

In this sentence, it is the action “learning to speak and to interact” that stresses the practices and apparatuses through which ideologies are installed and seen as one’s own.

Concepts, such as “meaning production and reproduction,” “seen as one’s own,” “imaginary relations,” “apparatuses” and “State control,” consist of a vocabulary of key words that appear in both the theorization of “discourse” and that of “ideology.” It is fairly easy to see the near-synonymity of these two terms by simply replacing the word “ideology” with “discourse” in the above definitions and see them still make perfect sense. Davies (1993) has made it clear that “the concept of ideology is very similar to what poststructuralists mean by discourse” (p. 14). Both ideology and discourse focus on the practical processes that form meanings. The apparent difference has been that discourse theories pin down language and symbolic systems as the agency of subject production, whereas ideology theories work on the types of operations that employ discourse. Therefore discourse can be a direct, visible instrument of ideology. Words, statements, symbols and signs are the primary foci in discourse theories. Davies states that discourse can be

understood as individuals “speak/write the world into existence as if it was their own” (p. 13). I see discourse as an oral/verbal/written/visual realization of ideology.

Subjectivity, Subjection, Subject and Identity

Not surprisingly, the concepts of subject, subjection and subjectivity are similarly contested in both Althusserian ideology theory and poststructuralist discourse theory. Both theories work against the Humanist view of “Man” and work to depict how ideologies and discourses place individuals into certain positions.

Humanist ideas of the subject are criticized as carrying bourgeois assumptions of a free, independent, individualist human existence and of Man, who is the source of knowledge, meaning, and history. Althusser points out that the thesis “it is man who makes history” has prevented any scientific investigation of history, while its political effect is to disarm men and women in the labour movement (Macdonell, 1986, p. 37). Man, in humanist ideas, is seen as a center of initiative, an originator of thoughts. Althusser worked against this thesis and further questioned how the humanist senses of “obviousness” and “common sense” were achieved through ideological formation. He argues that it is ideology that places us in an imaginary relation to real relations. It is imaginary because it works through recognition and identification to “interpellate” individuals into positions. Althusser gives an example, now famous, to illustrate how ideology calls individuals into subject positions and gives rise to subjectivity in day-to-day practices:

...ideology “acts” or “functions” in such a way that it “recruits” subjects among individuals or transforms the individuals into subjects by the very precise operation

which I have called interpellation or hailing, and which can be imagined along the lines of the most commonplace everyday police (or other) hailing: "Hey, you there!" ... The hailed individual will turn round. By this mere one-hundred-and-eighty-degree physical conversion, he becomes a subject. Why? Because he has recognized that the hail was "really" addressed to him, and that "it was really him who was hailed" (and not someone else). (1971, pp. 162-163)

In this paragraph, the "recognize-then-become-subject" process presents a strikingly similar picture to the poststructuralists' understanding of "the person as made through the discourse they have available to them" (Davies, 1993, p. 14). The similarity between discourse and ideology is obvious in the following parallel. With discourse theorists saying: "the subject is an effect of certain discursive formations" (Macey, 2000, p. 83; also see Mills, 1997, p. 103), again, it still makes sense if we replace the word "discourse" with "ideology" and the saying becomes: "the subject is an effect of certain ideological formations." The "interpellation" process has a similar function, "subjectification", in poststructuralist theories; however, the latter gives more room to ponder the concept of agency, which will be discussed later.

One flaw in Althusser's picture of interpellation, as pointed out by Diane Macdonell (1986), is that he leaves out the possibility that the individual may turn around, knowing the police have hailed wrongly, and still get arrested. Such a flaw raises a fundamental critique of his philosophy: "to displace the myth of an essential human nature, he lays before us a single and general mechanism of all ideology" (p.39). With the near-synonymity between "ideology" and "discourse," a similar critique faces Foucault as he conceives that power is

everywhere. For example, Edward Said (1986) complains that Foucault imagines power “to be so irresistible and unopposable,” and thinks about power “from its actual realization, not of opposition to it” (p. 151).

Also working against the humanist tradition of subject, Foucault proposes the idea of the “death of man.” He argues that the classical image of “man” is a creature defined by the laws of philology, economics and biology—a product of the episteme² of the modern age. The modernist idea of subject has always been dependent upon the notion of an anthropological human essence and been given a constitutive or self-constitutive role that the subject is conceived at an anthropological point of origin (Macey, 2000, p. 83). Two attributes essential to the understanding of subject/identity in modernist Western culture are autonomy and agency (Harre, 1989). To attain full human status, children must achieve a sense of themselves as beings with agency and as individuals who make choices about what they do and be responsible for those choices (Davies, 1993, p. 9). As Davies said, “The assumptions, within humanist discourses about identity, were liberatory, in their original intention and in many of their effects” (p.10). To counter-argue this humanist and liberatory

² Episteme is the ground of thoughts, or a conceptual grid, on which certain statements, within a certain period of time, are deemed as true and natural, while others false and unusual. Michel Foucault coined this term in his book *The Archaeology of Knowledge*. Many scholars have developed interpretations to help understand the term. For example, Diane Macdonell states that, episteme “may be understood as the ground of thoughts on which, at a particular time, some statements—and not others—will count as knowledge” (1986, p.87). Sara Mills says that an episteme is “the sets of discursive structures as a whole, within which a culture thinks. Groups of discourses make up the structures of an episteme” (1997, p.56). According to her, “an episteme includes the range of methodologies which a culture draws on as self-evident in order to be able to think about certain subjects. Foucault shows that within certain periods there is a tendency to structure thinking about a subject in a particular way and to map out certain procedures and supports for thinking” (p. 57). Episteme can also be understood as “a conceptual grid that delimits the possibility of all knowledge in a given period and within which a culture orders the world and construes truth and reality” (Johnston, Gregory, Pratt, & Watts, 2000). David Macey gives an explanation and example to illustrate episteme as a term “to describe the historical set of relations uniting the various discursive practices and discursive formations that generate the sciences and other forms of knowledge.” “Episteme is not in itself a form or body of knowledge; it is a structure defining the conditions that both make knowledge possible and restrict its scope. Until the end of the Renaissance, the knowledge that made up Western culture was governed by the episteme of ‘resemblance,’ the world was a microcosm reflecting a macrocosm, or a book of natural symbols that could be read and interpreted like any other book” (2000, p. 113).

theme, Foucault sees the self as an effect of certain discursive formations³, or an effect of discursive structure, but nevertheless interacting with those structures (Mills, 1997, p. 103). According to Foucault, subjectivity is constantly constituted and reconstituted in discourses each time individuals think or speak in certain terms or statements. These statements do not exist in isolation since there is a set of structures that makes those terms and statements valid and gives them their force. We have access only to the discursive structures and it is through speaking/writing within these structures, that our sense of selves is shaped and reshaped, according to the discursive positions available to us. Persons are made subject through the discourses and discursive positions they have available to them—a process called “subjectification” (Davies, 1993, p. 13).

Subjectification and Resistance

Subjectification is similar to interpellation, in that they both “hail” persons into certain discursive or ideological positions, and form the subjects. However, they are also different in that escape from interpellation comes through “scientific knowledge” yet resistance to subjectification is already available and contained within discourses themselves. Althusser argues that through interpellation, subjects are installed in an imaginary relation that forms subjects’ “false” consciousness; such mistaken recognition of subject positions lies in the fact that ideologies are not based on “true” scientifically based knowledge. For

³ I found the excerpt of “discursive formation” in David Macey’s book *The Penguin Dictionary of Critical Theory* (2000) very useful in understanding this phrase: “Discursive formations are the products of discourses and of their formation of objects, subject-positions, concepts and strategies. Nineteenth-century psychopathology includes a wide variety of phenomena within the category of mental illness (which it constitutes as an object of knowledge), determines the role of subjects such as doctors and health administrators, produces concepts of the normal and the pathological, and then generates strategies for the treatment of the mentally ill. Relations of force and power are involved at every level of a discursive formation” (p. 101). Discursive formations do not refer to “things.” Non-discursive formations include institutions, political events and economic processes.

Althusser, science is an absolutely objective means to providing truths. On the contrary, Foucault interrogates the building of “the regime of truth” and points out that through discursive formation, knowledge is always a form of power. Scientific knowledge is exactly a form of power, and through scientific discourses, knowledge produces identifiable subject positions (a process of subjectification) and regulates our sense of self. Foucault does not give science the privilege of being *the* escape but considers it as one of the “traps.” For Foucault, escape is a non-issue, and opposition strategies lie in the concept of resistance that is already contained within the very same discourses. Foucault says:

Discourses are not once and for all subservient to power or raised up against it... We must make allowance for the complex and unstable process whereby discourse can be both an instrument and an effect of power, but also a hindrance, a stumbling-block, a point of resistance and a starting point for an opposing strategy. Discourse transmits and produces power; it reinforces it, but also undermines and exposes it, renders it fragile and makes it possible to thwart it... Discourses are tactical elements or blocks operating in the field of force relations; there can exist different and even contradictory discourses within the same strategy; they can, on the contrary, circulate without changing their form from one strategy to another, opposing strategy. (1978, p. 100-102)

In this excerpt, Foucault stresses that the tactical operation of discourses, without changing their form, is already a starting point for an opposing strategy. Utilizing contradictory

discourses and destabilizing discursive processes are key actions in the operation for resistance.

In my opinion, Foucault places equal emphasis on discourse as power and discourse as resistance, but he is usually seen as accentuating too much, how discourses exercise power without adequate elaboration of how resistance is possible. In his article "Foucault and the Imagination of Power," Said (1986) criticizes Foucault's emphasis on the productivity of power and how it became an analysis of how discipline and discourse get things done, accomplish real tasks, and gather authority, without hope of change. Said argues that Foucault is profoundly pessimistic in his view of power and his lack of interest in the force of effective resistance. "Foucault's imagination of power," in Said's words, "is largely *with* rather than *against* it" (p. 152, original emphasis). I consider Foucault's imagination of power *both* with *and* against it. Nancy Hartsock (1990) also has similar complaints. She argues that Foucault pessimistically turns subjects into passive objects. For her, Foucault's work is useless for women's emancipation because it aims, not to change the world, but to redescribe or reinterpret the world (power) once more.

Said and Hartsock's critiques are incisive when considering discourse as similar to ideology⁴, but both overlook the optimism of discourse as resistance. This criticism originated, I believe, partially from the fact that Foucault's works before, and in, the seventies are mostly on discourse as power. Only in his later works does he stress the resistance part of discourse and starts to write a history of desiring subjects⁵. This uneasy

⁴ As I pointed out in the previous section, there is a similar critique facing Althusser's conceptualization of ideology.

⁵ In his later works, Foucault moves away, but not too far away, from his earlier conceptualization of self and subject through terms of government. He begins to use the "use of pleasure" and the "care of the self" to write a history of the desiring subject. In these later studies, he describes the self as an aesthetic and ethical object to be created and cultivated, whilst pleasure is viewed as a disciplined form of self-government rather than an unbridled liberation of repressed desires. Please see Macey (2000, p.135).

disentanglement of resistance from power is a conceptual conundrum and has caused discourse theorists' profound doubt about its feasibility. For example, Diane Macdonell (1986) says: "If power is always already there, if every power situation is immanent in itself, why should there ever be resistance?" (p. 122). Such doubt has also resulted in another discourse theorist, Sara Mill's (1997) opinion that Foucauldian discourse theory is, for feminists, "very difficult to use without modification" (p. 102). In my opinion, if we take into account Foucault's optimism in resistance in the paragraph I quoted above, what Mills considers as feminists' modification of Foucault's work on discourse is actually elaborated application rather than modification, as I will discuss in the section immediately following.

For Foucault, all notions of resistance are already contained within the notions of power *and* all notions of power are already contained within the notions of resistance. Since resistance is attached to agency, Foucault's arguments point towards a sense of agency. Again, for Foucault, all senses of agency are already discoursed, *and* agency is defined as ways of clashing and meshing, reorganizing, and (re)appropriating the existing discourses.

Feminist Interpretations of Identity with Agency

Agency and Feminist Application of Discourse Theories

Feminists are among those who find discourse theories useful and who have proceeded with various applications. For feminist researchers, the concepts of subjectivity, subject position and subjection are important tools to elaborate an understanding of the processes through which being a gendered person is achieved and through which the meanings of gender are constructed. Subjection is a complex matter, as it elucidates how

persons take up and/or are subjugated to, gender positions. Poststructuralist theories enable feminists to understand the position of those who are cast in powerless roles, not simply that of victim.

Earlier feminists' theorizing of gender roles tended to see femininity simply as an ideological category that is imposed on women. With discourse theories, scholars such as Dorothy Smith (1990) see femininity as discourse where women actively work out their subject positions and roles in the process of negotiating discursive constraints. For Smith, discourse is something people *do*, not something they are subject to. Foucault's discourse theory thus provides an analytic lens to read women's engagement in the process of subjectification/subjection, rather than just to view them as passive victims of oppression. Ideology theory also tends to posit an oppressive agent, such as the State, whose interests ideological practices served. However, it is hard to see feminists' major target—hierarchy—as an agent. As Mills (1997) points out, practices that oppress women are not uniform, thus, feminist analysis has to focus on multiple discourses rather than a single one as the cause of the determining factor in women's subjection.

In the early development of feminists' application of discourse theories, Chris Weedon recognized the importance of multiple discourses in the constitution of subjectivity and further identified the importance of multiple *and* contradictory discourses. In her book, *Feminist Practice and Poststructuralist Theory* (1987), Weedon incorporates Derrida's concept of "difference" into her understanding of Foucault's theory of discourse and subjectivity. The former implies that the meanings of signifiers depend on their discursive relations and locations, and are open to constant rereading and reinterpreting. The latter pays close interrogation to the social power relations of these discursive relations and locations.

Weedon conceptualizes a poststructuralist subjectivity which is “precarious, contradictory, and in process, constantly being reconstituted in discourse each time we think or speak” (1987, p. 33). She contends that, situated in various and conflicting discourses, the individual is always a site of subjectivity struggle and potential change. These varied and even contradicting discourses constitute a discursive field wherein subjectivity is contested. Weedon states:

Discursive fields consist of competing ways of giving meaning to the world and of organizing social institutions and processes. They offer the individual a range of modes of subjectivity. Within a discursive field, for instance, that of the law or the family, all discourses will carry equal weight or power. Some will account for and justify the appropriateness of the status quo. Others will give rise to challenge to existing practices from within or will contest the very basis of current organization and the selective interests which it represents. Such discourses are likely to be marginal to existing practice and dismissed by the hegemonic system of meanings and practices as irrelevant or bad. (p. 35)

In this statement, while recognizing the importance of the availability of multiple and contradictory discourses, Weedon also points out the difficulties in creating such a condition. Discursive practice for resistance does not necessarily threaten or disrupt the existing power and is usually marginalized, or simply accommodated, by it. For instance, the principle of equal opportunities in education, work and science does not dismantle the existing patriarchal relations that inform the very production and regulation of participating subjects

in these fields. Usually it turns out to simply *add* women and minorities as extra substitute human forces into the same structure and serves the interests of those originally in power. This argument provides a critical perspective for investigating women's participation in science.

The availability of multiple and contradictory discourses is important and feminists have emphasized how to analyze discourses in conflictual relations rather than in isolation. For example, Sara Mills' (1991) earlier work attempts to set discourses of femininity in relation to discourses of feminism and discourses of colonialism in the nineteenth century. Prevailing conduct books and advice manuals for women in the nineteenth century had to offer examples or illustrations, that is, discourses, of "the opposite" or "the condemned" in order to define and contrast "the correct" or "the praised." They can be read as the straightforward indicators of signs of the degree of women's oppression; they can also be read as an indication of the scale of resistance and the route of rebellion. Advice to prevent children masturbating and discussions about drug usage have similar effects. In discursive fields, "what is" is defined and constituted in relation to "what is not"—a process Macdonell calls "meaningful antagonisms." Meaning and subjectivity are constructed, contested, and disrupted within discursive fields, wherein various discourses, especially contradictory ones, call individuals into positions.

Agency is thus a legitimate concept under such conditions. Agency is never a vehicle by which individuals exercise their independent volition. Agency is defined when discursive subjects (as the outcome of the previous discursive structures) act or test out possible subject positions under the conditions of current discursive structures constituted of available multiple and contradictory discourses. It is in the playful and creative reading of discourses,

made possible in, but not limited to, meaningful antagonism, that the moments of resistance and agency are possible. Several feminist poststructuralists have delineated such moments of resistance. Others have illustrated their definitions of agency, containing notions of resistance. For example, Weedon's delineation of agency in feminist practice argues:

Although the subject in poststructuralism is socially constructed in discursive practices, she nonetheless exists as a thinking, feeling subject and social agent, capable of resistance and innovations produced out of the clash between contradictory subject positions and practices. She is also a subject able to reflect upon the discursive relations which constitute her and the society in which she lives, and able to choose from the options available. (1987, p.125)

Here, Weedon makes it clear that resistance and innovations are produced, not by the humanist liberalist selves, but "out of the clash between contradictory subject positions and practices" (p. 125, see above quote). This is a clear recognition of discourses' significant roles in constituting subjectivity and agency. Bronwyn Davies (1993), in her influential work on bridging poststructuralism to education, further explicates notions of agency for resistance, innovations, and reflections. Davies' definition, in my opinion, lays out an action plan for poststructuralist agency for change:

A different definition of agency...is to do with a combination of:

- the ability to recognize the constitutive power of discourses;

- the ability to catch discourse/structure/practice in the act of shaping desire, perception, knowledge; and
- engaging in a collective process of re-naming, re-writing, re-positioning oneself in relation to coercive structures. (1993, p. 199)

Both Weedon's and Davies' definitions of agency provides me with analytic tools to understand women's participation and choices in science as a discursive field, where multiple and contradictory discourses, such as those about science and about women, coexist and compete. The only thing I have to point out is that researchers who are concerned about notions of agency within discourses are still walking on slippery terrain. The poststructuralist conceptions of agency can easily slide back to those of the humanist of independent individuality. That is, "making decisions according to available options (or discourses)" can be so easily understood as reproducing a humanist approach. Readers of poststructuralist theories need to constantly remind themselves, with a "humanism" warning sign, while reading and writing about agency. Here are two examples of its precarious nature.

When Dorothy Smith argues against the image of women as the victims or dupes of patriarchal ideology, she argues that women are "actively" working out their subject positions and negotiating discursive constraints. However, the notion of agency attached to the "negotiation" in her arguments is not clearly articulated. That is, it is not clear how discourse-produced individuals are suddenly "able" to "actively" work out a subject position with the optimism and rebelling power, to invert or even pervert the existing discursive structure. Another example is Bronwyn Davies' conceptualization of agency. Davies says that the individual subject is one who continues to speak/write into existence those same

discursive structures through those same discourses. "But as a speaking subject, they *can* also invent, invert and break old structures and patterns and discourses and thus speak/write into existence other ways of being" (Davies, 1993, xviii, my italics). Her use of "can" attracts my attention. In my opinion, the turn from reproducing the same discursive structures to "can" break the old structures is where the humanist trap is located. It could be trivialized to statements such as "yes, we are all under certain constraints, but we 'can' do things differently too."

Therefore, words such as "can," "capable," "able," and "ability" in poststructuralist writing/reading/speaking should not be taken for granted with conventional understandings. They are signs calling us to question what *enables* these abilities and capabilities. When we imagine individuals, situated within available and contradictory discourses, and making decisions accordingly, we should not imagine them as standing in a "discourse shop" with total shopping power to choose. Instead, they are discourse-constituted agents with strings, connecting the previously discursive formations *inside* themselves to the currently existing discourses. These strings pull them in various directions that define a multidimensional space where these agents play with these strings. As for which outcome of string play counts, it is contingent upon the power structure dwelling in the discursive structures that sanctions what counts as crazy/insane or creative/radical. Conditions exist for the "other ways of being" to be recognized or accepted. "Radical or even disruptive variations are generally only accepted by others if one's capacity, to know what ought to be, is not likely to be called into question" (Davies, 1993, p. 9). Other ways of being have to be built as based on, or in comparison to, the existing discursive structures that are used to judge a person's capacity

for rebuilding. Previously and currently existing, multiple and contradictory discourses define the conditions of agency.

Identity and Agency Informed by Historicity and Practicality

The development of feminist poststructuralist theories is one of the foundations of many recent theories on identity and agency. Over the past few years, for example, Dorothy Holland, Jean Lave and Etienne Wenger have become major figures in bringing historicity and practicality to identity and agency theories. These scholars have been working alongside classical inquiry, as to how to perceive and portray the interactions between the individual and the collective, or agency and structure, and the significance of such dynamics.

On exploring the relations between individual agency and the regulating structure, Dorothy Holland and Jean Lave refine the theory of practice and elaborate a concept of “history in person” (Holland & Lave, 2001). Instead of viewing individual struggles as resistance to the discursive structure, they recognise the mutually constitutive nature of long and complex social and political struggles, and the historically fashioned identities-in-practice and subjectivities that they produce. Individuals are participants of historical structuring and have brought historical structures of privilege, rooted in class, race, gender and other social divisions to the present locally situated practices. In turn, historical structures also provide resources for participants to use in their practices and leave traces in their experiences. In daily practices and lived activities, subjects both participate in and produce cultural forms that mediate the political-economic, social and cultural structuring of social existence. Long-term transformative struggles are thus telling sites for understanding the forging of identities and the working creativity of historically produced agents.

Holland and Lave draw two constellations of relations to delineate interactions between the person and the structure. The first is a constellation of relations between the subjects' intimate self-making and their participation in contentious local practice—what they refer to as “history in person.” The second is a constellation of relations between contentious practices and broader, more enduring struggles that are locally realised, shaped in practice, and that shape individuals' subjectivities. The local contentious practices are sites where enduring struggles and “history in person” encompass each other, take shape, and are sites where we trace out the intimate constitution of historical identities, in person and in process. Holland and Lave propose several concepts for understanding the interactions between these two constellations and the interplay between the local formation of persons in practice and the historical subjectivities in the creation and undoing of enduring struggles. These concepts clearly articulate how identities are evoked and evolve in practice.

First, the relations between the persons and the social, or selves and others, are in a form of constant “dialogism.” “Dialogism” was a concept contested by the critical theorist and semiotician, M.M. Bakhtin. This concept emphasizes the social complexity and generativity of human actors and postulates an open-ended identity with special emphasis on the influences of the social in, over, and through, persons. Dialogism suggests that sentient beings—alone or in groups—are always in a state of being “addressed” and in the process of “answering.” Second, in the process of answering and meaning making, we use the culture genre to “author” the world and author ourselves in the world. The “I” draws upon the languages, dialects, genres and words of others to make meanings and to conduct self-authoring and self-identification. Cultural forms are the significant media through which

identities are evoked in social practice and in intimate dialogue. Third, identities should be seen as configurations of self and other. All dialogic engagements of selves (there is no single self) are struggles across and about differences between selves and others. In local struggles, dialogic selves engaged with others will go through the discursive structuring of gender, class, race and ethnicity that are all realized in local practice and brought from there into the intimate. Senses of identities thus are built around histories of an individual's relations to *particular others*. Fourth, relations among identity-in-practice are serious political issues. Engaging in struggles in the name of specific identities implies that other possible identities and struggles could be crowded out. The multiple identities of a person are always competing and cooperating in contentious local practice at any particular moment. Subjectivities are always forming in dialogues across difference (struggles), where answers to addresses made by the contentious others are authored, in the cultural discourses and practices *at hand*.

From a similar theoretical stance, Etienne Wenger, in his book *Communities of Practice* (1998), connects a theory of learning to a theory of identity. His basic assumption in this book is that engagement in social practice is the fundamental process by which we learn and so become who we are. For Wenger, the concept of identity serves as a pivot between the social and the individual so that each can be talked about in terms of the other (p.145). Wenger defines identity as the "negotiated experience" of self in terms of participation and reification, membership, learning trajectory, the nexus of multimembership and belonging, defined globally but experienced locally (p. 150). "An identity...is a layering of events of participation and reification by which our experience and its social interpretation inform each other" (p.151). To build an identity is to negotiate the meanings

of our experience of membership in social communities. Learning can be understood as a way to expand or transform identities.

Wenger defines “identity formation” as a dual process of identification and negotiability—either part being a fundamental half to the other. Identification is “the process through which modes of belonging become constitutive of our identities by creating bonds or distinctions in which we become invested” (1998, p. 191). Processes of identification define which meanings matter to individuals; however, they do not in themselves determine the ability to negotiate these meanings. Therefore, Wenger argues that another fundamental aspect of identity is the issue of negotiability. “Negotiability refers to the ability, facility, and legitimacy to contribute to, take responsibility for, and shape the meanings that matter within a social configuration” (p. 197). It is with the interactions of identification and negotiability that the process of identity formation and transformation take place.

For the identity formation and transformation evolving in organizations, Wenger further introduces the concept of “fields of negotiability” to discuss the possibility of identity change:

The field of negotiability...will affect how their members perceive the scope of their influence and the purview of their contribution. It will therefore affect what they attempt to understand, what problems they try to address, and how they direct their inventiveness. It will affect what they do with the information and resources that are available and what information and resources they seek. Most of all, the field of negotiability will affect what they care about, because they can have an effect on it.

It will therefore affect how they define their own enterprise in relation to the stated charter of the organization. (p. 248)

Wenger's concept of "the field of negotiability" is particularly relevant to my analysis of the research data. Attention was paid to how the research participants perceived the scope of their influence and contribution, which issues were their priorities, what information and resources were available, how they employed them, what kind of effects they wished to see the organization generate, and how they defined their own enterprise in relation to the stated charter of the women's group.

Identities as Self-Authoring in Narratives

Another aspect of identity that is relevant to my research is the way in which my interviewees presented to me their "experiences" and their senses of selves cultivated in such presentations. In the above theories, the word "experience" is commonly used, and its meanings are critical for conceptualizing historicity and practicality. For example, in dialogism, individuals constantly answer and perform in response to constant addresses made by others, and their sense of multiple selves is tied to and shaped into those particular formations of answering, responding and performing at any particular moment. These actions constitute, and are usually referred to as, what we call "experience." Our so-called "experience," or the history in us, is not a kind of pristine or rigid set of facts that took place in the past; it is instead a performance that exists and takes meanings from the formats or expressions in the present (Bruner, 1986). In expressing our experiences, the parts we mention, the emphases we put, the facial expressions that we form, the hand gestures we

make, the tones we use, and the sighs we utter—all are elements that link our historical subjectivity to the identity we are currently making within that particular expression. In Clifford Geertz's words, "experiences...are made; and they are such made things that make them" (1986, p. 380). Each story we construct, and choose to tell in particular ways, subsequently has an impact on our identities. Through expressions, we author ourselves. As expressions cannot fully represent our thoughts and feelings, that is, the history in us, our identity construction is always deferred, unfinished and ongoing.

Interviews and narratives are common forms of expression. Narratives are stories arising from experiences and cannot be determinate or complete. Narratives are always stories about the past and not the past itself. While narrating, the narrator's identities are evolving and are attached to the meanings of the experience provided and constrained in the narrative form. The truth of narrative, as narrative theorists argue (Bochner, Ellis, & Tillmann-Healy, 1997, 1998; Ellis, 1998; Ellis, Keisinger, & Tillmann-Healy, 1997), is not akin to correspondence with prior meanings assumed to be located in some sort of prenarrative experience. The meaning of prenarrative experience is constituted in its narrative expressions in the present. Through the narrative activity of self-creation, we seek to create a world to live in, to become identical to the story we tell. In Adrienne Rich's words, "The story of our lives becomes our lives" (1978, p.34). Narratives and storytelling are thus one form of self-authoring and identity-making.

For narratives that are produced during interviews, however, the self-authoring and identity making in the narrating is more complicated. During an interview, the interviewee is not speaking to herself. Her narratives and stories are expressions of the experience they produce through interaction with a *particular other*, the interviewer, for a particular research

purpose. The research purpose, the interview setting and the questions of the interviewer, all set up conditions and resources for available and pertinent expressions. On the other hand, the interviewee's responses, performances and narratives also set up conditions and directions for the interviewer's further addresses. Identity making in the interview is thus a process co-authored by the interviewee and the interviewer. This co-authoring process is especially true when the interviewer purposely uses her own similar experiences to try to link and weave together the narratives from both sides and make collective meanings out of them. In this process, the interviewer's identities and the interviewee's identities are mutually created and informed in the narrative exchanges. This mutuality will affect how interviewers write about their interviewees and how they understand their own writing. For this purpose, theories of "autoethnography" are particularly pertinent and will be discussed in the next chapter.

In my fieldwork, I have used in-depth interview methods and participatory observations. The ways my participants "authored" themselves in the interviews formed images of their "identities in narratives." The ways they organized their own group of women in physics showed their "identities in practice." Both concepts of identity are central to the analysis of my research.

Applications to Women in Physics

Women physicists, in forming their identities as women *and* physicists in daily practice can be considered as persons situated in an enduring struggle. The broader historical structure through which my research participants have gone, and are going, includes discourses about women and physics shaped within the culture and society of Taiwan. The

organization of their women's group can be considered contentious local practice. It became a telling example of women physicists' intimate self-making that brought together both their historical subjectivities and the structural constraints in the creating and undoing of local struggles. Of particular interest in this research is how the multiple and dialogistic sense of the selves of women physicists are addressed and how these women answer these addresses around the cultural, political and historical structuring of their relations to particular others, such as their male colleagues. The political measures women physicists take, to increase their influence and interests in the community, and the ways they utilise the resources at hand and allocate their various identities (for example, as women or as physicists) to accomplish these measures, are critical foci of the inquiry into their identity formation and transformation.

For the analysis of my research, I will first apply feminist poststructuralist theory to identify available and prevailing discourses that affect women's participation and choices in physics. I will also use the theories of Holland, Lave and Wenger to understand how the research participants' identity transformation can happen through the organization of their own group. As in both perception and practice, science is presented as a "non-traditional" choice for women, where the case of physics is particularly acute and perspectives of discourse, identity and agency are particularly pertinent in understanding women's participation and choices within such non-traditional discursive fields. In fact, this so-called "non-traditional" field is where two different, usually contradictory, and supposedly "traditional" discourses encounter each other. For "women and physics" to be non-traditional, there must be at least a discourse about what is, what counts and what makes physics, and a discourse about what is, what counts and what makes a woman. In the

following chapters, I will show how these two discourses are constructed in both academics and society in Taiwan and also in relation to each other. I will also illustrate how my “women physicist” informants situate and identify themselves within such discursive fields, which consists of at least a physics discourse and a woman discourse, along with a local feminist discourse and an international discourse that interpellates them into positions of “women in physics.” Their decisions and actions resonate with, and respond to, available and contradictory discourses and inform a further understanding of agency.

CHAPTER 4

RESEARCH BACKGROUND, CONTEXT, METHODS, AND WRITING OTHERS

In the first three sections of this chapter, I explain the research background, the research context and the research methods of this dissertation. I discuss my understanding of my role as a researcher in the fourth section and how this understanding affects the writing of my dissertation. In the section covering the research background of this project, I describe women's under-representation and the "leaky pipeline"¹ phenomenon in science, particularly in physics, in various countries. I also show how these two problems have been discussed, in previous studies. In the second section, I explain how I considered the research context and why I chose Taiwan. Particularly, I explain the connection between my personal background and my research. Then, in the section covering research methods, I describe my approach and methods of working with my participants. I explain the technical information relating to my research data, such as the duration of the research time, the number and gender composition of my participants, their positions and relationships and the length of the interviews. All names, including the names of participants, organizations and conference venues, mentioned in this section and the following chapters are pseudonyms in order to protect the identities of the participants. In the last section, I use the theory of autoethnography to further discuss my role in this research and in the writing of this dissertation.

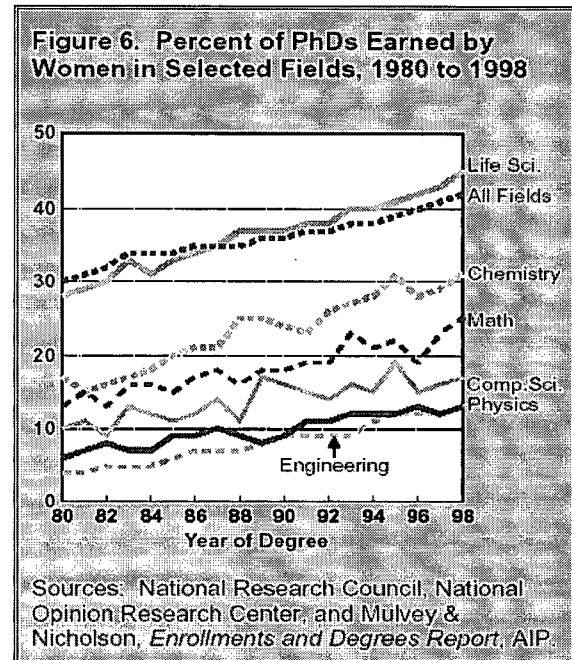
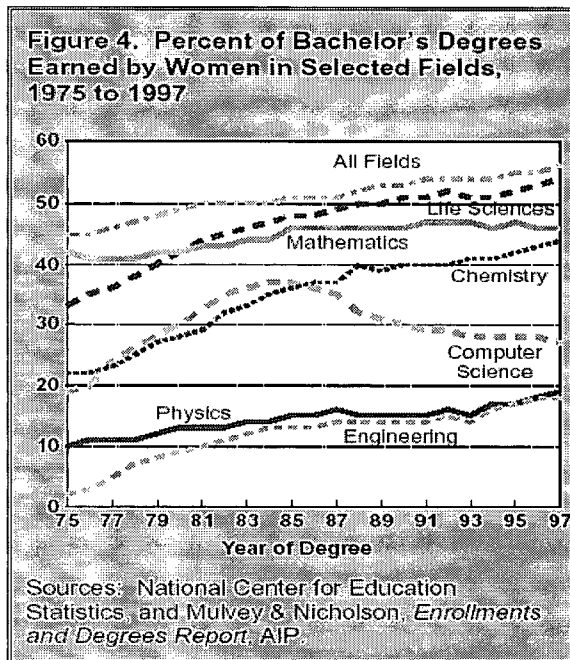
¹ In American literature, the "leaky pipeline" refers to the phenomenon that, in many but not all countries, the percentage of women in physics decreases as the degree level increases.

Research Background

Leaks in Physics

Women's under-representation and the leaky pipeline phenomenon have been identified as global problems in the physical sciences, particularly in physics, with local variations in different countries. In each country, these two problems no doubt, should be understood within local socio-cultural particularities and global similarities. These two issues have attracted attention from educators and scholars since the 1970s and are still the foci of many recent studies and projects (Ivie & Stowe, 2000; MIT Faculty Newsletter, 1999). In recent studies, scholars have acknowledged that, although the gender gap in the physical sciences has been narrowed to some extent, the familiar gender polarisation between physical and biological sciences reappears and re-emerges (Arnot, David, & Weiner, 1996; 1999). Compared to women's higher participation in biology and medicine-related disciplines and careers, in which women sometimes outnumber their male counterparts, the female percentages in various levels of physics remain consistently low (BEMEST, 1997; Gaskell, McLaren, Oberg, & Eyre, 1993; Hatchell, 1998; Ivie & Stowe, 2000). It is clear that women's participation patterns in various science-and engineering-related disciplines are different. It is thus necessary to specify a particular discipline if one's research is about women's experiences in science-and engineering-related careers. I have focused on women in physics because women's participation in physics is consistently among the lowest in the scientific disciplines. Figures 1 & 2 show the cases in the US.

Figures 1 & 2. The low participation rates of women in physics in the US.



Note. From *Women in Physics, 2000*, by R. Ivie. and K. Stowe, 2000, AIP Report: American Institute of Physics. AIP Publication Number R-430. Retrieved January 16, 2002 from World Wide Web: www.aip.org/statistics/trends/reports/wominphys.pdf

Under-Representation and the Leaky Pipeline

In some physics communities, women's under-representation and the leaky pipeline phenomenon have generated adequate awareness to warrant the expenditure of particular resources and research to investigate the factors that cause the two problems. For example, in the US, the American Institute of Physics has conducted research on women's participation in the various academic levels of physics and has recently published a report entitled "Women in Physics, 2000" (Ivie & Stowe, 2000). Using the statistics from their findings, this report dismisses speculation based on common and still rampant stereotypes about women in physics. These stereotypes include speculation that women are not able to keep up with the mathematical demands of physics; that women have less experience with

hands-on learning involving technical equipment and machinery due to early exposure to gendered toys; that women tend to choose careers that do not require long hours away from the family; and that women do not have personality characteristics such as determination, competitiveness, assertiveness and persistence that are compatible with success in science. This report recognises that subtle discrimination and harassment, in addition to the lack of critical mass of women faculty members, are possible factors influencing why some women stay in physics and why others leave. Around the same time, the Massachusetts Institute of Technology published a report on the status of women faculty members in science (MIT Faculty Newsletter, 1999). This report documents departmental discrimination against women in the science faculty, such as gender inequity in salaries, less lab space and fewer university grants allocated to the senior women faculty than to senior men, less influential committee positions and higher teaching load assignments for women.

In April 1998, the journal *Scientific American* also published a special issue of "Exploration" on women's status in science to examine the changes over the past 25 years and to ask why the disparities still persist (*Scientific American*, 1998). This issue analyzes the factors that appear to contribute to the "leaks" in the pipeline. It takes account of factors at various life stages including the experiences of the early family, kindergarten through high school, college and graduate levels and professional careers. For example, gender differences in achievement orientation and self-confidence are to a considerable extent formed at an early stage and may influence later career and life choices. From kindergarten to high school, females are reported to experience a subtle distancing from academic achievement in general and from achievement in the sciences in particular. While girls and boys have been found to perform fairly evenly in lower grades, a critical difference occurs in

middle school. In colleges, research found that young women with scientific aspirations are viewed as odd and the desire to be popular may deter them from taking the first steps in science. More women than men reported that a lack of encouragement from teachers or counselors had been a serious problem for them. In graduate schools, the aggressive and hostile milieu and a lack of encouragement as well as a lack of, or low quality, mentoring have been reported as obstacles that affect female students.

At the professional level, many married women scientists face the challenge of synchronizing the often-conflicting demands of three clocks: their own career clock, their partner's career clock and their "biological clock." In addition, because a much higher proportion of female than of male scientists are also married to scientists, very often in the same field, a large number of women scientists face the "two-body problem" (a famous term in Particle Physics) of finding two science jobs in the same geographical area. Typically, because female spouses are most often younger, and at an earlier career stage, than their male partners, they are in a less advantageous position than their husbands, and so are less sought after by potential employers. Moreover, if the husband's career prospects are considered more promising than the wife's, the couple may conclude that, as a unit, they will be better off giving preference to the husband's career development. These analyses, presented in the special issue, recognize barriers to women's participation in science but run the risk of viewing the problems at the individual rather than the systemic level.

These analyses, although subject to criticism, were apparently adopted by influential scientific communities and were circulated via well-subscribed magazines and web sites among scientists and physicists. In fact, the factors identified here echo the topic themes of the international conference on women in physics that I attended with my participants, a

conference I will describe in the next section. Given the international influence of the American Institute of Physics, the MIT report and the journal, *Scientific American*, perspectives from these analyses can be expected to travel across geographical and cultural distances and affect other countries such as Taiwan, which has been, and continues to be, economically and militarily dependent on, and culturally dominated by, the US since the end of World War II.

Variations in Different Countries

The leaky pipeline phenomenon has been identified for decades as a global problem with local variations. According to an international investigation on gender distribution in world physics departments (Megaw, 1991), the percentages of women at various academic stages, do have an overall tendency to drop from a higher percentage at the bachelor's level, to the lowest at the faculty level; less obvious situations do occur in some countries, however. For instance, in France, the percentages are 24% at the bachelor's level, 21% at the doctorate level and 23% in faculty. In Hungary, 50% in bachelor's, 27% in doctorate, 47% in faculty; in the Philippines, 28%, 60%, 31%; in Italy, 29%, 21%, 23%; and in Poland, 14%, 17%, 17% (see Table 1). In these countries, the problem of women opting out of physics is not as severe.

On the same table, the leaks in the US and UK pipelines are comparatively obvious as they drop dramatically from 15% and 9%, to 3% in the US and from 16% and 12%, to 4% in the UK. This severe drop partly reflects the reason why the US and the UK have long traditions of studying women's participation in the sciences and have accumulated a considerable body of related literature. For the US, slightly better figures were reported in a

recent study. In 1998, 19% of physics bachelor's degrees and 13% of PhDs were awarded to women, while 8% of faculty positions were held by women (Mulvey & Nicholson, 2000). In Canada, a recent survey revealed a similar situation, the figures showing 18, 13 and 4, with a sharp drop to 1.5% at the tenured faculty level (Lagowski & McKenna, 1996). At UBC, the percentages of women students registered in the physics department in the school year of 2001 were 26% for the undergraduate and 14% for the graduate program, with 6% of women at the faculty level.

These percentage differences show that the leaks in the pipeline depend on the local context. The fluctuation of figures in the same category in different countries (e.g. percentages in the bachelor's level ranges from 7 to 50) also indicates that women's participation in physics is a social, cultural and historical phenomenon that needs to be studied in local social, cultural and historical contexts. Local societal factors play a significant role in women's career choices in physics and some interventionist projects are built within such a profile. In the US, interventions are believed to be effective in increasing women's participation in physics (Dresselhaus, Franz, & Clark, 1994).

In Taiwan, the most recent survey reports overall figures of 16.3% for women in undergraduate physics, 8.6% in PhD programs and 8.2% for women faculty in universities (Yang, 1999). While compared to the average percentages in the UK, the US and Canada, the situation in Taiwan is less severe, the problems of women's under-representation and the decreasing percentages in Taiwan remain obvious. As mentioned above, understanding the factors involved in these phenomena requires systematic exploration of the Taiwanese social and cultural context, which I turn to in the following sections.

Table 1

Degrees awarded to Women in Physics and Women as Physics Faculty (%)

Country	Bachelor's	Doctorate	Faculty
Belgium	33	29	11
Brazil	24	31	18
Germany	12	18	8
France	24	21	23
Hungary	50	27	47
India	25	26	10
Ireland	22	20	7
Italy	29	21	23
Japan	7	4	6
Korea	20	5	3
Netherlands	20	4	6
New Zealand	10	11	6
Philippines	28	60	31
Poland	14	17	17
South Africa	24	21	9
Spain	17	21	16
Turkey	38	17	23
Soviet Union	34	25	30
United Kingdom	16	12	4
United States	15	9	4

Note: From "Interventions to Increase the Participation of Women in Physics," by M. S. Dresselhaus, J. R. Franz and B. C. Clark, 1994, *Science*, 263(5152), p. 1392.

Research Context

Interpretations and Myself

After I had surveyed some research on women's participation in physics and finalized my research questions on the identity aspect of this topic, I began to look for communities of women physicists for my research. As I focused on the identity aspect, my research involved interpretations of events, choices and discourses that were meaningful for

my research participants. These meanings were deeply intertwined with their personal experiences and imbedded in cultural, social and historical contexts. I believed that an in-depth qualitative method could better approach what it meant to them to be women and physicists. For this reason, I had to find women physicists who would be willing to share with me their thoughts and concerns; their deep feelings and sometimes private matters—some of them sensitive or unpleasant or both. I understood that to interpret the meaning of their life events and career choices requires certain cultural and social literacy. In a sense, my research project was closer to a kind of anthropological ethnography than one of social “science.” I also understood that it was never an easy task to build trust between researcher and participant over a short time period, while realizing that research projects cannot be life-long and have to be completed within time constraints. For these reasons, I asked myself: why not study women in physics in my home country of Taiwan? I believed that the thirty-five years of my life experience could facilitate a “thick interpretation” of the results of my fieldwork.

The Working Team on Women in Physics (WTWIP)

In the fall of 2001, as I was planning to contact some women physicists in Taiwan, I was by chance connected to Dr. Hong, a full professor in a national university in the southern part of Taiwan. I was lucky to be able to introduce myself to her as an acquaintance from the time when she did her PhD degree while I did my master’s degree in the same physics department. I briefly explained my career path from physics to anthropology to science education and why I hoped to talk to people like her. She responded to me with enthusiasm because, as she told me, she was happy to see a “social scientist” with a physics

background join her current work on women in physics. At that time, she was organizing a Taiwanese delegation to attend the international conference for women in physics in Frankfurt in 2002. This conference was hosted by the International Association of Physicists (IAP), a UN-equivalent organization in physics, whose members were physicists from all over the world.

In its 1999 Assembly, the IAP suggested that each of its member countries investigate the current status of local women in physics in order to form the “Working Team on Women in Physics” (WTWIP) in their own countries. According to the Assembly Resolution, the mandate of the team is 1) to survey the situation for women in physics in IAP member countries; 2) to analyse and report the data collected along with suggestions of how to improve the situation; and 3) to suggest ways that women can become more involved in the IAP. The IAP would then host a conference in 2002 to discuss the results from each member country. In 1999, the president and the secretary-general of the Taiwanese Physicists Association (TPA), both male, attended the Assembly and brought this mission back to Taiwan. Similar to the recognition-difficulties Taiwan has faced in other international arenas, the TPA was not given the status of an independent country member of IAP. As the TPA was seeking to increase its visibility and seeking to foster recognition from other members, such a mission became a good opportunity to act as a “standard” member by carrying out the mission assigned. The two male professors contacted several senior women professors in physics. Finally Dr. Hong responded positively to take on the task and established Taiwan’s own WTWIP in February 2001. The key members were Dr. Hong, Dr. Liao, Dr. Kim, Dr. Chen, Dr. Ma—all female—and two male professors Dr. Shan and Dr. Koh (Dr. Shan was the secretary-general of the TPA at that time). In the fall of 2001, the

Taiwanese WTWIP further generated a sub-working team for women graduate students in physics and was preparing for the 2002 international conference to be held in Frankfurt.

Although the Working Team was formed in a fairly smooth manner, the understanding of its key members of the task at hand, was not homogeneous. For example, their attitudes towards gender issues in physics ranged from questioning whether there was gender inequity in physics to admitting that Taiwan's social and cultural images of women exacerbate women's disadvantages in physics. Some believed in equal rights, but not in feminism. Despite this heterogeneity of positions, however, most were in favour of drawing a clear line between this workshop and, in their words, "those feminist movement groups." This message was clearly shown in the report documenting the establishment of the Taiwanese WTWIP. In five places, this ten-page report highlights statements such as their working group should not "downgrade to any kind of feminist movement groups because it would only cause negative results and offend male colleagues" (quotation from the document).

Why Taiwan?

Such pronounced disassociation from "feminism" underlines another significant point about Taiwan in the context of my research. After World War II, Taiwan began close relations with the US in many spheres such as economics, military, culture and education. Most academics or researchers working in institutions in Taiwan were trained in Euro-American countries, with the vast majority being trained in the US; as such, they reproduced the values, ideas and methods of the systems in which they were trained. This particular history reflects a kind of academic colonization and has consequences for both physics and

feminist studies in Taiwan. In the case of physics, most textbooks are translated reprints or excerpts from popular textbooks from the US². Positions in the Directing Committee of Physics Curriculum in the Ministry of Education were also held by professors trained in the US. These structural factors framed the thoughts about how to learn physics and what physics was about in Taiwan. As far as feminism is concerned, although Euro-American feminist discourses were available in many registers in Taiwan, it did not substantively influence the science community. The common denigration of feminism as it appeared in the ten-page report could be seen as an example of insufficient influence of feminist discourses on the science community in Taiwan. The more recent discourses of science with feminist reflections did not significantly affect discussions in Taiwan until the call for a WTWIP in 2001.

Physicists in Taiwan thus found themselves at a very interesting historical conjuncture. On one hand, in the past three decades, the Euro-American feminist reflections on science had, near the end of the 20th century, created a legitimate position for gender issues to be discussed in the US-led international society of physicists. On the other hand, communities of physicists in Taiwan were not yet ready to acknowledge these reflections even though they had been following the US trends relating to other aspects of physics. It was on the grounds of the political reality of Taiwan and the mismatch of feminist discourse in science that the call for WTWIP served as an interventionist function for Taiwan. In this sense, the mission called for, the task brought back to Taiwan, the ideas behind it and the reactions it generated formed what I called “the international discourse of women in

² For example, at the higher education level, among the authors of popular physics textbooks are Halliday & Resnick, Alonso & Finn, and Douglas Giancoli. For the high school level, the guidelines published by the American Physical Science Study Committee (PSSC) are also important and are used as a common reference for physics textbook editors in Taiwan.

physics.” Among other available discourses, it provided an internationally recognizable subject position in identity formation and the potential transformation of “women in physics” in Taiwan. At this point, it was clear to me that Taiwan was a particularly pertinent context for my research inquiries on discourse and identity.

Research Methods

In-Depth Interviews and Participatory Observation

After I made the connection with Hong, I expressed my enthusiasm for joining the Taiwanese delegation to the Frankfurt conference. I learned about the conference from another woman physicist in Canada and did some research before speaking to Hong. When I spoke to Hong, I was able to present my research commitments in a way that she could trust my ability and my research. Hong agreed that I should go to Frankfurt and promised that she would introduce me to other members in the WTWIP. In return, I would help with the preparation for the Frankfurt conference and the administration of the WTWIP. I started my working relationship with Hong and the WTWIP in December 2001. I travelled to Taiwan in February 2002 to continue my work with the group and to meet the other key members. I joined the delegation to make a presentation at the Frankfurt conference in early 2002³.

After the Frankfurt conference, the WTWIP decided to organize a local symposium for women in physics in Taiwan. This symposium was held near Taipei in May 2002 and became a joint symposium for both women physicists and chemists and a few others in engineering with PhD degrees in physics. Graduate students were also invited to this local

³ I decided not to disclose the exact month of the conference to further enhance the confidentiality of my fieldwork.

symposium. I participated fully in the preparations of the conference and the symposium, as well as in other administrative work such as the election of a new leader of the WTWIP. As I was approaching the end of my fieldwork, Hong found a title to distinguish me from the other women physicists. I was the “Executive Secretary” for WTWIP. After the completion of the symposium, I decided to wrap up my fieldwork because my research period had already covered the two major events of the WTWIP after its establishment. I felt that I had collected enough data to discuss how women in physics in Taiwan reconstructed their identities as women and/or as physicists by responding to an interventionist discourse with international legitimacy. Because of my position as the executive secretary, I was able to use participatory observations as my second research method in addition to the in-depth interview method. I participated in and observed how this group was functioning internally and externally and was connected internationally and locally.

During the period from December 2001 to June 2002, while I was participating in, and observing, the WTWIP, I also interviewed key members of the WTWIP, some participants of the symposium, some males who had institutional and financial authority over the WTWIP and women physicists who had no interest in, or explicitly opposed, the organization of the WTWIP. When I contacted the participants, I explained the purpose of my research and collected consent letters from them. Upon the agreement of the participants, I used a tape recorder. On the occasions when they did not agree or if we were at a preparatory meeting, I took field notes.

In general, in this dissertation I use the term “women physicists” to refer to women who hold PhD degrees, including university professors and researchers in institutions. I use “women in physics” to refer to graduate students and those women who work for

departments or institutions of physics; they usually hold bachelor's or master's degrees in physics. However, the term "women in physics" sometimes covers both women physicists and women in physics.

Overall, I conducted in-depth interviews with four key members of the WTWIP and one-time interviews with others, including ten women physicists, two female graduate students, four male physicists, one female chemist and one woman who had rejected physics after she completed her bachelor's degree. I also collected data from five other "women in physics" who were working in physics-related institutions, two other chemists, one professor in engineering and one science educator. I attended the Frankfurt conference, the local symposium in Taiwan and four preparatory meetings (and numerous phone conversations) for these two events. In total, 27 women and 4 men were involved in this research. The total time taken up in interviews and meetings was two hundred hours. The data consist of interview tapes of one hundred hours; written interview notes; statistics obtained from universities and governmental offices; three hundred and twenty email communications; and documents from symposiums, conferences and organizations.

Participants Highlighted

Among all my research participants, I highlighted the representative cases in various categories according to their various relationships to the WTWIP and importance to my research. Many were cross-category participants because I did not intend to claim a coverage model of my participants' backgrounds. There are roughly five categories: WTWIP key members, WTWIP significant participants, WTWIP student participants, male professors and WTWIP opponents. Information about these highlighted participants can be found in

Table 2. Although I highlighted 16 people, information from other participants is crucial to the overall understanding of the background of my fieldwork.

Table 2

Information on Highlighted Participants

	Relationship with WTWIP	Importance	Rank	Sex
Hong	1 st leader Active participant	WTWIP key member	Professor	F
Kim	2 nd leader Active participant	WTWIP key member	Research Fellow (Full Professor)	F
Liao	Active participant	WTWIP key member	Assistant Professor	F
Chen	Active Participant	WTWIP key member	Associate Professor	F
Ng	Active participant	1 st generation woman professor in physics	Retired Professor	F
Wen	Participant	2 nd generation woman professor in physics; Liao's professor	Professor	F
Fang	Participant	WTWIP member in power; university vice-president	Professor	F
Ho	Participant	30 years involvement with feminist movement in Taiwan	Professor (Chemistry)	F
Ying	Participant	Participated in the WTWIP sub-team for graduate students	Graduate student	F
Li	Participant	Participated in the WTWIP sub-team for graduate students	Graduate student	F

Shan	Active participant	WTWIP key member; former secretary-general of the TPA; Li's professor	Professor	M
Koh	Active participant	WTWIP key member, attending the Frankfurt conference	Professor	M
Mao & Tsing	Non-members	Directors of national institutions of science; approved the financial support for the symposium	Professors	M
Wu	Opposed WTWIP	Accomplished professor but disapproved of the organizing themes of the WTWIP	Professor	F
Jing	Opposed WTWIP	Did not want to be seen as a "woman" in physics	Associate Professor	F

Starting from the next chapter, I will highlight the experiences of these participants and the information provided by them relating to what happened in the physics department, the physics classroom and the WTWIP. I use these data to present, in Taiwan, what it meant to be a physicist, what it took to be a woman in physics, how the WTWIP was organized and how an identity reconstruction was possible after this particular intervention.

Autoethnography and Writing Others

As I proceeded to write about my participants' experiences, foregrounding how they were connected to mine, I found that the theory of "autoethnography" was critical in the understanding of my own writing.

Autoethnography

The term autoethnography is used by literary critics (Kamler, 2001) as well as by anthropologists and was first theoretically defined in an article by David Hayano (1979) (according to Reed-Danahay, 1997). It can mean a set of issues relating to studies by anthropologists as “insiders” with full membership, studying their own “people”, or an “anthropological autobiography” in which the anthropologist herself or himself is the autobiographical subject. It can also be a form of writing wherein the ethnographer is the “native,” or it can be a biographical writing method that incorporates elements of one’s own life experience when writing about others through biography or ethnography.

Blending ethnography and autobiography, autoethnography has the dual nature of self-ethnography and autobiographical ethnography. It becomes a post-modern project concerned with representation and reflexivity, a project that aims to disrupt the notions of “objective observer” and a coherent autonomous self. It questions the binary conventions of a self/society split as well as the boundary between the objective and the subjective. An autoethnographer is a boundary-crosser, crossing between the self and the other and seeking the multiple nature of subjectivity.

Francoise Lionnet (1990) describes autoethnography as a genre that “opens up a space of resistance between the individual (auto-) and the collective (-ethno-) where the writing (-graphy) of singularity cannot be foreclosed” (p. 391). Different examples of autoethnography can be viewed as varying in their emphasis on the research process (graphy), on culture (ethnos) and on self (auto) (Ellis & Bochner, 2000). In general terms, autoethnography is a project that relocates the personal into the cultural, the social, the

historical and the political. The “self” is usually the starting point. Ellis and Bochner's (2000) definition of autoethnography clearly depicts this process of relocation:

Autoethnography is an autobiographical genre of writing and research that displays multiple layers of consciousness, connecting the personal to the cultural. Back and forth autoethnographers gaze, first through an ethnographic wide-angle lens, focusing outward on social and cultural aspects of their personal experience; then they look inward, exposing a vulnerable self that is moved by and may move through, refract, and resist cultural interpretations. As they zoom backward and forward, inward and outward, distinctions between the personal and cultural become blurred, sometimes beyond distinct recognition. (p. 739)

Another autoethnography theorist Linda Brodkey (1996) also focuses on the “I.” She uses the phrase “I site” to present a project, following a trend in post-modern geography that historicises the spaces inhabited by the human body:

In theoretical terms, as a post-modern site, the “I” embodies relations between actually lived and socially produced spaces; in empirical terms, the “I” is a site whose memories of lived experiences of social and historical spaces are recounted as narratives of personal experience; and in practical terms, everyone is an “I Site” by definition and either already can or may well wish to explore, in writing, the historicised spaces of their personal narratives. (p. 18)

Such a conceptualization of “autoethnography” resonates with Holland and Lave's theory of “history in person”, as described in Chapter Three, yet with more interest in exploring the researcher's sense of selves through social, cultural, historical and political lenses. It provides researchers, like myself, who aspire to the reconstruction and reinterpretation of their own experiences and identity, with theoretical depth and methodological width, to conduct the voyage of self-authoring.

I hope that my thesis writing is not limited to merely exploring my own identities or, I as “the researcher,” investigating other women's stories. My goal is, through the interviews with my participants and the participatory observation in the WTWIP, to develop a research process and practice that enable both the participants and myself to interject into each other's narratives during dialogues. During these interviews, our experiences are mutually elicited and evoked and our identities are interlaced in the interchanged meanings of our experiences through narrative and dialogue. Through these processes, perhaps both my participants and I are co-authoring each other's selves and developing a kind of inter-identity along a self-other continuum.

Who Is Writing (Authoring)?

In this sense, both my participants and I can be seen as the autoethnographers. My role as an autoethnographer is sustained in my attempt to rewrite my own identities through ethnographic examination of my experiences. The participants also play the autoethnographer's role because, on one hand, they will be speaking about themselves (auto); and on the other hand, they will be manoeuvring to make sense of the conditions initiated by others (ethnography). Upon entering the interview scene, although having some prior

expectations and speculations, the interviewees suddenly step into new circumstances in which they need to make some sense of their situation and speak and act accordingly—the role ethnographers usually play. The participant's role as ethnographer is thus sustained in this sense, with the words they utter being considered as their "ethnography" of that situation.

My research and my writing about these participants thus became a mixture of my autobiography, my participants' autobiographies, my ethnography of their identities and their ethnography of my research. It is *neither* the kind of autoethnography where the insiders study their own people as their researched others, *nor* is it the kind of autoethnography where only the researcher has knowledge of the subject. It is a *both-and* project that attempts to combine both, in which the interviews, the texts and the selves are co-authored and co-presented by the "I" and the "other" in the stories about how the "I" (person; agent) situates and acts in relation to the collective "other" (discursive structures such as physics, culture and society). Therefore, my research becomes a kind of "auto/Ethnography"—with a slash to stress the dual natures. Auto/ethnography can be used to understand the theoretical framework, the methodology and the text of my thesis writing.

CHAPTER 5

THE PHYSICS DISCOURSE

How is physics a discourse? What are the intrinsic values and beliefs of the teaching and practice of physics? How are these values and beliefs connected to the images and interests of those groups traditionally underrepresented in physics? In this chapter, I investigate the roles of reductionism in the discipline of physics, the effect it has on women and most men, and how it contributes to the regulations for producing knowledge of physics and physicists. Identifying signals and practices of what, for the lack of a better word, I call the “physics discourse”, I will demonstrate how discourse theories provide a critical perspective to help understand what has happened, is happening, and will continue to happen in the discipline at several places. I organize my arguments into three sections: Cartesian Reductionism and the Position of Women in Physics; Elite Pedagogy in the Reproduction of Physicists; and Physics as a Discourse.

Cartesian Reductionism and Women’s Position in Physics

Reductionism as the Basis of Physics

Although highly contested and criticized by feminist science scholars (such as, Harding, 1991), physics has been and is still seen as the “pinnacle” of modern sciences. The high position physics enjoys among the sciences originated in 16th and 17th century Europe when a Cartesian mechanism replaced the Aristotelian philosophy of seeing nature as organic, living and spiritual (Capra, 1996). The analytical philosophy of Rene Descartes

viewed nature, the world and human beings as machines and, within this mechanistic view, complex phenomena as a whole could be broken apart into pieces, and the whole could be understood from the properties of its parts. Such Cartesian reductionism has been the episteme¹, in Foucauldian terms, that gives meaning to and generates criteria for the production of western scientific principles, theories, and methodologies. It also regulates scientific practices that are closely and directly related to people's daily lives, such as how western medicine explains the health and the diseases of the human body. It holds physics in high regard and secures for it a crown position in the hierarchy of sciences because, in the division of scientific labour, physics deals with "fundamental phenomena" and "elementary particles", the parts that are most reduced to their essentials. "The supreme position of physics in the hierarchy of modern sciences is clear in a statement of Descartes: "All philosophy is like a tree. The roots are metaphysics, the trunk is physics, and the branches are all the other sciences."

Within such episteme of Cartesian reductionism, physics has indeed occupied an especially prestigious position throughout the development of Western science and its applied disciplines. Such a prestigious view of physics and its reductionist values can be found in the knowledge producing activities and school science curricula and have "trickled down" from the laboratories and institutions to various levels of the classroom. Through the current unequal and unjust global structures of political, economic and military powers, the power of, and the belief in, Western science and science curricula are dominating many parts of the world.

¹ Please see footnote 2 in chapter 3 for discussions about episteme.

With the immense influence of North America on Taiwan's physics education², reductionist values traveled to Taiwan, and became one of the building blocks of the physics discourse that formed the perception of students, regarding the sciences. This was evident in my own experience as a physics student in my undergraduate years. I remember, in the first month of my undergraduate studies in physics, in 1984, a mentoring session was being held by senior students in my department. We first year students were told: "Congratulations! You have made a wise choice by deciding to study physics because all biological phenomena can be reduced to and explained by chemistry, and all chemical phenomena can be reduced to and explained by physics." In Taiwan, high school students are streamed into two pools, the science stream and the humanities stream, and course materials and curriculum structures are chosen and organized accordingly. After passing the university entrance exam, students in the science stream can choose to study "pure/basic" or "applied" sciences. In the pure/basic sciences, students in the same stream have to make a choice between physics, chemistry, and biology. The words of our senior students underscored the value of Cartesian reductionism in sciences and fortified the supreme status of physics in such reductionism. These senior students did not invent those words, but after several years of training, it was within their capacity and responsibility to continue the discourse and convey such beliefs to the neophytes. At that time, as a rare female student in the department who believed that science was neutral and equal for both genders, I felt honoured to be hooked on the physics supremacy in that discourse. At that time, I had no idea that, by

² The vast majority of faculty members in universities and research institutions in Taiwan completed their PhD degree in the US. They are key members serving the textbook committees of the Ministry of Education in Taiwan. Physics professors in Taiwan usually use textbooks by US mainstream authors such as Halliday & Resnick, Alonso & Finn, and Giancoli for undergraduate students. Standards of high school physics are based on the curriculum set by the influential PSSC (Physical Science Study Committee) starting at MIT as early as the late 1950s.

upholding the values of reductionism in sciences, such discourse had fortified not only the status of physics, but also the idea that I, seen as a “woman”, was ultimately not suitable for physics.

Marginalizing Women in the Name of Reductionism

Reductionism tears cells into molecules, molecules into atoms, atoms into nuclei, nuclei into quarks and quarks can then be reduced to certain types of strings and their patterns. The higher the level of reduction, the more the requirement of abstraction and the more complicated the math. Somehow women are not seen as capable of understanding this reductionist task. It is precisely such a perception that has in various stages affected their opportunities in physics, regardless of whether they “really can” or how many of them “can” understand it. Evelyn Fox Keller recalled her graduate studies in physics at Harvard as “two years of almost unmitigated provocation, insult, and denial” (1977, p. 81) because she attempted to study the foundations of quantum mechanics. On her first day at Harvard, it was conveyed to her that “very simply, I was not, could not be, good enough” to study “a pinnacle only the very few, certainly not I, could achieve.” (p. 80) Quantum mechanics is the physical science that deals with the energies and spatial distributions of matter at the atomic level. It requires advanced mathematics and pure abstraction to comprehend and theorize. Keller was not seen as being capable of achieving success in such a field, even with her outstanding academic record from another university. Later in her program, she was queried about her “peculiar ambition” (p.82) to become a theoretical physicist. Constantly being treated as an oddity in Harvard physics, Keller completed many difficult courses with

high marks and changed her research interest to molecular biology, a field where she said she could find respect and congeniality.

Almost four decades later, in Taiwan, in a prestigious Harvard equivalent university, a similar story was being repeated. Li was one of the female graduate students I interviewed in the physics department. She told me that after several classes in quantum physics she pretty much stopped asking questions because, first, the professor only spoke to those thought to be the “brightest” male students in the class and, second, the last time she asked a perfectly valid question, the professor’s comment was: “what are you talking about?” Li felt stupid and certainly not good enough to comprehend the course material. And what made it worse, was the fact that the professor only cared about “the brightest students” in the class. Li told me that once, when the professor was demonstrating some very difficult concept and calculation to the whole class, Li pretended that she understood. Somehow the professor stopped writing on the blackboard and turned to ask “the brightest student” whether he understood. That student did not respond as fast and as positively as the professor anticipated, so the professor said: “If you cannot understand it, how can the other people? There should be at least one student who can understand.” Li told me that she was quite upset to hear that comment from her teacher. She wondered why he was teaching physics. Shouldn’t it be for the benefit of the majority of the students, rather than only for the comprehension of the few bright ones? If only one student, the “brightest” one, was the purpose for his teaching, what was the message this conveyed to the other students? Although upset, Li did not feel strongly enough to challenge the professor because she thought the professor might be correct about who could “really do physics”. In Li’s high school physics class, her male teacher had complained about teaching physics to girls. “I

hate teaching girls physics. Girls are very bad in physics.” This made an impression upon Li and she was somehow convinced by the teacher because, eventually, most of her female classmates gave up physics when preparing for the National Joint University Entrance Exam (Summary of Interview No. 051702).

Women's Position in the Discipline of Physics

Before I interviewed Li, I had already had the opportunity to interview Li's Quantum Mechanics professor, Dr. Shan. Shan was not a blatant sexist at all, rather quite the opposite; he was an advocate for women's rights in the Physical Society in Taiwan. Shan was one of the male professors who brought back the international mandate to form the Working Team on Women in Physics in Taiwan. As the man just below the president of the Taiwanese Physicists Association, he spoke at the annual meeting advocating the cause and importance of such a team. He sought funding and staffing support for this group and attended its organizational meetings. For many key participants of the Working Team, Shan was the guy with the resources, and he was helpful and supportive. When I interviewed him about his incentive to help the Working Team, he told me that: on average, girls had less ability for abstraction than boys because of intrinsic biological differences, and that these differences emerged as the level of schooling ascended; the more years in university, the lower the chances for female students to achieve the first-place awards. Given such disparity in ability, however, there might be some “exceptional” females who could still do high-level abstraction in physics and maths. According to Shan, these exceptional females may make up, say one quarter of the talent pool (i.e., the number of “capable women” is one third of the number of “capable men”), but currently only half of them were represented. Shan

believed that it was because of other reasons, such as discrimination in the working environment, marriage and family responsibility that caused such a female underrepresentation in physics, and that it was worth the effort to identify and eradicate this discrimination (Summary of Interview No. 032202).

Shan's interest in the working team on women in physics was based on a rationale to utilize the untapped female talent pool for the sake of progress in physics. Such a rationale is common in many organizations aimed at increasing women's opportunities in, or eliminating the barriers to, accessing traditionally female-underrepresented careers. For example, general information from the 2002 IAP International Conference for Women in Physics states: "It is widely acknowledged that the global scientific workforce is underutilizing a large percentage of the available talent pool;" and in the conference resolutions: "Currently women can and do contribute to this quest [advancing the understanding of physics] and, through physics, contribute to the welfare of humankind, but only in small numbers; women are an underutilized intellectual reserve". The reason for adopting such rationale may be strategic because, compared to explicit feminist rhetoric, it was less threatening (though just "adding") to the existing physics "talent pool" and could gain more resources and support from the men in power. However, such a rationale certainly does not challenge the nature and practices of physics, nor does it question the presumed necessity to lobby women to ascend the academic ladder.

Shan's attitude was typical among many female and male physicists, including those vocal participants in the Working Team on Women in Physics. When they expressed their concerns about women's underrepresentation in physics, or the leaky pipeline phenomenon in science and engineering, they typically blamed factors outside of physics, such as social

or cultural expectations, an inequitable working environment, marriage and family responsibilities. Outspoken people like Shan usually used the word, and the concept of “discrimination” in talking about women’s rights in physics. What was hardly heard, however, was their doubt in the nature and foundations of physics, such as reductionism, and its link to what could be called “cognitive discrimination” against the image of women. What remains mysterious and under-challenged is why and how this perception, or cognitive discrimination exists, that “on average, women have less ability than men, to handle the abstraction in high level physics and maths”.

The Physicists of Abstraction and the Women of Relationality?

The dissemination of such a perception has to do with the fact that women are *said* to be more relational, emotional, caring and practical while men are more analytical, rational, objective and theoretical. The way people talk about gender differences reflects how society in many ways invests sexualized meanings and associates gendered features with individuals according to their bodily differences. Every utterance starting with “men are...” or “women are...” is a reflection of the perceived gendered differences. It may be a way to serve some analytical purpose, but it is also a way once again to entrench the difference discourse that can shore up these differences. Feminist theories, centering on the value of gender difference, or the so-called “difference feminism”, have then served a double-edged function for this myth about women and physics. It enables scholars to identify the core of cognitive discrimination against the idea of “women” but also, it facilitates the reproduction of such discrimination.

On one hand, difference feminism values the differences between the genders and amongst women and sees the body not as a biological limit, but as a site of meaning construction, where women's special strengths should be recognized and maximized. In the seventies, Nancy Chodorow (1978) developed a women-centred object relations theory to counter Freud's male-centred psychoanalysis. She examined how societies had, on the basis of bodily differences, reproduced the contrast between "the basic feminine sense of self" as relational and connected to the world, and "the basic masculine sense of self"³ as separate and detached. A notion of femininity is thus defined as relationality while masculinity as detachment and objectivity. Such a contrast sparked the growth of difference feminism and has led to the objectivity debate in gender and science studies, in which scholars contest the limits of "weak objectivity" and "autonomy" in western science and the possibility of "strong objectivity" and "dynamic objectivity" in alternative science (Harding, 1991, 1993; Keller, 1985).

However, on the other hand, stressing difference has its counter-effects and can backfire. The public, including women scientists, may or may not follow the feminists' fierce debates about the values of difference. Upon hearing the critique of objectivity and its relation to masculinity, many would confirm associating relationality with women and objectivity with men, and reinforce the dichotomy between femininity and masculinity. Such perceptions have caused practicing women scientists to object to and reject the feminist critique of science, because they see the feminist critics as "accepting stereotypical notions

³ "Feminine personality comes to be based less on repression of inner objects, and fixed and firm splits in the ego, and more on retention and continuity of external relationships. From the retention of pre-oedipal attachments to their mother, growing girls come to define and experience themselves as continuous with others; their experience of self contains more flexible or permeable ego boundaries. Boys come to define themselves as more separate and distinct, with a greater sense of rigid ego boundaries and differentiation. The basic feminine sense of self is connected to the world; the basic masculine sense of self is separate" (Chodorow, 1978: 169).

about women rather than questioning them”, “perpetuat[ing] stereotypes and misconceptions about mathematics and science”, and “discourag[ing] women from entering mathematics and science.” (Longino & Hammonds, 1990, p. 179)

In physics, objectivity, abstraction, detachment and autonomy are bundled together in the training of scientific methods, and they are valued as necessary abilities to conduct reduction when theorizing physical phenomena. Stressing gendered differences and the credits of relationality has, in effect, created a gap that has turned into a conflict between the concept of “physicists” and the idea of “woman,” since women are said to be socially and cognitively relational, while detachment and abstraction are deemed as necessary in dealing with reduction in physics. The gap is considered wider if the required level of reduction is higher, that is, the kind of learning in physics that is seen as “more difficult.” Shan’s belief that the gender disparity in ability for abstraction increases, as their years in university increase, is one explicit example of such an effect.

The contradiction between the concept of “the physicist” and the idea of “woman” has resulted in cognitive discrimination against *the image of women*, and has in fact disadvantaged real women’s participation in physics. Such cognitive discrimination haunts a women’s-right activist like Shan for distancing his female student, Li, from a fair opportunity to learn quantum mechanics in his classroom. Another key participant of the Working Group, female professor Hong, also said that she tended not to ask as much from her female graduate students in lab work as from her male students, because “what am I gonna do if they have an emotional breakdown?” (Interview No. 041402) The perceived image of woman as weak has already affected the kind of training female students can get from their professors, regardless of whether these professors are male or female. In fact, the

conflict between the idea of “woman” and the concept of “the physicist” manifests itself in the training of the “physicist” so that successful trainees, including male professors such as Shan and “exceptional” female professors such as Hong, carry on and practice such perceptions in their teaching and research activities. During these activities, the proper and orthodox training of “the physicist” is the training of objectivity, abstraction, detachment and autonomy which are the essential parts of the curriculum, while the conflict between the idea of “woman” and the concept of “the physicist” characterizes the hidden curriculum. Through this kind of physics education, reductionism is reassured and will be perpetuated in the reproduction of future physicists, along with its conflict with the idea of “woman.”

Elite Pedagogy and the Reproduction of Physicists

Physics for the Smartest

The reductionism episteme generates not only the woman-physicist conflict but also a problematic “elite pedagogy” which functions to “weed out” learners who are seen as “not good enough” to become “physicists”. The former results in an unconscious discrimination, by distancing women from physics, while the latter disadvantages the majority of both women and men. This elite pedagogy is usually found at the higher levels of education. Physics education at the elementary and secondary levels are usually designed and conducted in ways that cater to the majority of students in order to foster basic and necessary scientific literacy. In contrast, tertiary physics education appears to be a process of “spotting the genius”. The symptoms of elite pedagogy usually appear as follows: as soon as the top students in a class, usually less than a handful, “get” the point, the discussion is over and the

instructors move on to the next section, leaving other students to find their own ways to understand the course, or find careers in areas other than physics.

Shan's quantum mechanics class was one of the examples of elite pedagogy, where Li felt alienated by his paying attention to only the students he considered to be the brightest. A similar scenario appeared almost twenty years ago at another university in Taiwan. In 1984, in my first-year undergraduate physics class, the instructor Dr. Wen impressed us with her remarkable memory by remembering all of our names in less than two weeks. At that time, she had a fresh PhD degree in nuclear physics from Caltech; she was the first place student throughout all of her school years; and she had just won a national "Top Ten Distinguished Women" award in Taiwan for her achievement in experimental physics. One day she was writing down a very complicated idea, all over the black board, which the majority of the class did not seem to grasp. She looked around, feeling a bit frustrated, and said: "I know most of you don't understand, but I am only responsible for the top 5% of the students in this class because, statistically, only 5% will become real physicists." We had less than 50 students in the class and I did not think she was talking about me. My classmates and I knew that she was referring to the top one or two students in the class as well as to another three students in the same course she had taught last year. These students were the stars in our department and anecdotes abounded around these "geniuses", such as: last year, Dr. Wen tested the three then first-year students with the "classical physics" exam paper from that year's graduate entrance exam and they all got close to 100%! This type of anecdote was circulated in our department and convinced us that, though there were a couple of hundred students, only a handful of them had the "real strong sense of physics" (words also said to describe the above-mentioned three students) and the anecdote was the clincher.

At that time, a popular chatting topic among the majority of our class was our potential career choices if we could not manage to become physicists in the lab or in the office, handling complicated math problems. General solutions available from our seniors and professors were usually of two varieties: we could become engineers, working in many industries, since physics was the foundation of all the applied sciences and we would have no problem doing that. The other option was, “at least”, we could become physics teachers to disseminate the knowledge gained by the real physicists to the “end-users”—the public.

Streaming Down the Less Smart

The way these two solutions were presented sounded to me somehow like a losers’ choice—losers who could not handle real physics deserved “downstream” careers, down to either applied sciences or educational sciences. Such discourses about physics, as the upstream genius’ choice, and engineering as the downstream easier one, was rampant in our department at that time and was at odds with the educational reality in Taiwan. In Taiwan, in order to get into universities, high school graduates had to take the National University Joint Entrance Exam⁴ that allocated all eligible graduates to various disciplines according to their performance at the exam and according to their preference of disciplines. Based on future job opportunities and income scales, engineering was much more popular and consequently a more competitive choice than physics. Engineering was usually top-ranked on the wish lists of students, and as a result only the “brightest” students managed to get in, whereas physics was among the second tier of the ranking, after most of the engineering-related

⁴ The University Joint Entrance Exam had deeply influenced and vastly dominated secondary education in Taiwan for a few decades and was officially abolished in year 2001. However, the newly implemented “multiple choice enrolment methods” still rely on a joint exam similar to the abolished one. The majority (more than 70%) of high school graduates still take the exam to go to universities and colleges while less than 30% go with a few alternative methods.

disciplines, because it was a “pure science” that had no direct or obvious career implications⁵. In the physics department, the discourse about physics, as the upstream/pure and engineering as the downstream/applied choice, implied that physics was harder than engineering and suggested that physics students should be smarter than their engineering counterparts. It was simply contradictory to the reality of the student distribution in Taiwan’s higher education system, and it revealed the purely reductionist assumption behind such discourse.

To compensate for such contradictions, and to justify the high and upstream status of physics as the hardest science, it demanded genius, an alternate discourse readily available to us first-year neophytes. Also in the first term of the first year, there were anecdotes about certain students, in particular classes, who had put physics as their first choice and had scored much higher than was required for physics in “The Exam.” These students received special attention, expectations and pressure in the department, because they were the “geniuses” who could potentially become “the real physicists”. They were also most likely to become the top 5% in class. Circulation of these kinds of anecdotes conveyed a message that the majority of the students, who entered the discipline according to their score rank, were certainly outside of the 5% and deserved a second tier placement below these geniuses.

Who Become Future Physicists?

In my undergraduate physics department, reductionism had generated the idea of physics as the most fundamental and hardest science, a science that required the ability for absolute abstract thinking, thus only “very smart” people, most likely geniuses, and rarely

⁵ In Taiwan, in general, universities are more popular than colleges and national schools are more popular than private ones. Within the same institution, engineering-related disciplines usually require higher scores than in the physics department.

women, could handle this task. Reductionism had also resulted in an elite pedagogy within which physics education became a process of “spot the genius” and “weed out the incapables,” leaving the educational needs of the vast majority of women and men unattended. However, such elite pedagogy did not successfully prepare its future practitioners nor did it entirely remove all those deemed “weeds”.

Among Dr. Wen’s three genius first-year students who got almost 100% out of the graduate program test, one of them became a stockbroker, one of them became a professional sailor and only one became an astrophysicist. In my class, about a dozen of my male classmates went to the computer chip manufacturing industry with their BS degree in physics, with job titles such as process engineers. Another dozen emigrated to the US and became computer engineers in California. Of the three guys I remember as the bottom students who always struggled to pass, one went on to the PhD program in the same department, two completed their degrees at universities in California, and all three of them became university professors. They told us once at our undergrad reunion that they could hardly follow Dr. Wen’s teaching in the class and that they really regretted having heard the 5% discourse. That discourse almost drove them away from their chosen discipline. After graduation, the top student in our class, to whom we believed Dr. Wen’s 5% statement referred, decided to become a monk. As for myself, even though I was not in the top 5 percentile, my grades averaged in the top 10% and I completed a master’s degree in physics by building a laser. I did not continue with a PhD program in physics but instead became an optical engineer, and then a physics teacher while pursuing other graduate degrees in the social sciences and humanities. Apparently those deemed “elite” in the elite pedagogy did not necessarily stay in physics, nor did the “non-elites” necessarily walk away.

In 2002, when I interviewed Li about how her current learning experience had influenced her future career decision, she admitted that she was alienated by Dr. Shan's elite pedagogy. She was, however, prepared to continue with a PhD program in physics because she remained highly interested in the subject and would not abandon what she had already established for herself.

Factors that contribute to career decisions by individuals in physics are far more diverse than just "genius-or-not." If individuals cannot visualize their future in the world of physics, they are unlikely to be keen on pursuing such a career, even though their ability to succeed in the field is recognized. On the other hand, even if an individual has to struggle in their study of physics, if they have a vision of themselves as a physicist, they will overcome their difficulties and manage to find a way to reach their goals. Therefore, becoming a physicist or not, is not entirely a matter of genius or ability, but also a matter of management and identity. The identity of an individual, whether as a physicist or not, is shaped through the interaction of his or her biographical path and the pedagogy discourse he or she encounters. It takes shape in a discursive field where various discourses are presented, some of which push them to one direction or another. The often seen scenario of struggling male students staying on course and becoming physics professors with successful female students opting out and choosing other paths, may well have to do with the discourses of man-the-bread-winner and woman-the-secondary-income-provider. Such discourses need to be examined along with the elite pedagogy in the classroom.

In the above cases, elite pedagogy was neither equitable nor efficient in preparing future physicists. It appeared as if it was for the brightest students, while in fact the brightest students did not necessarily stay, while the vast majority often had to suffer and were left to

their own devices. Elite pedagogy in university level physics in Taiwan was and is commonly found in two different universities, twenty years apart. It is problematic and inefficient and has never been challenged. Given its inefficiency in either preserving the geniuses or weeding out the “incapables,” its longevity and tenacity of existence in physics classrooms is intriguing.

Perpetuating Physics as the Hardest Science

Pondering the question as to why this is happening, I suggest that elite pedagogy in university level physics in Taiwan is less concerned with educational interests than with a conceptualization about physics. It is less about what is the best educational practice for the teaching and learning of physics than it is about how physics itself as a discipline should be perceived. The things the physics instructors say to the students, and our assumption that it allows them in their comfort zone to say such things, including all the anecdotes that get circulated inside the department, have little to do with the educational or career interests of those involved, but rather constitute a discursive practice to secure the image and status of physics as the hardest science.

Within such discursive practice, the elaboration and explanation of certain concepts by the course instructors stops as soon as the top students are up to speed, leaving the others to rely on the willingness of the top students to tutor their classmates. The course instructors, on the other hand, are under pressure to present more difficult, more complicated, more recent and more advanced theories and findings, in order to feed their genius students who are always following close behind. Educational activities involved in such pedagogy may be as minimal as recognizing the hottest topics and the top-down authority, while missing all

other interactions and interpersonal responsibilities such as discussion, debate, care, exchange and challenge, not to mention fostering the critical thinking abilities of the students. Students trained through such pedagogy, if they choose to become science teachers, are likely to present authoritarian behaviours and reproduce authoritarian ideology in their teacher education programs and future classrooms, as I observed in a recent teacher education program.

In 2002 I visited a secondary teacher education program for future science teachers in the Vancouver area of Canada. Students mostly held a bachelor degree in science and were completing the requirements for their education certificate. One of the class activities the instructor asked students to participate in, at every class, was to break the class into groups of four or five to solve an assigned physics problem and then to discuss with other group members, the different ways of teaching students how to solve the problem. There were three men and three women, including me, in my group. Within 5 minutes, one male in my group announced that he had solved the problem. He waited for a few minutes for the rest of us to come up with *the* solution. However, the situation became such, that each of the others asked him how to solve it. After that, we were supposed to discuss how our future students might solve the problem, and how we as teachers might guide them through this. Our group did none of this. My group members seemed to have reached a consensus that if they knew how to solve the physics problem, they also knew how to teach it, or at least that they knew all they needed to know for teaching it. In the next fifteen minutes, the male who solved it first was apparently so bored that just for fun he provided a coin-measuring conundrum for the rest of us to solve. When the course instructor called time, people in my group unanimously appointed the "brightest" guy to represent our group. He stood up,

walked to the blackboard, demonstrated to the class how to *solve* the physics problem, not how to *teach solving* the problem. As I sat through the group activity I could hardly see it as a teacher education classroom, instead I was constantly being reminded of my undergraduate classroom experience, digging to unearth the brightest for physics. Suddenly an image flashed into my mind that so crystallized for me the elitism, the “geniusism,” and the authoritarianism in the conceptualization of physics—an image so pervasive in the labs, classrooms, textbooks, even in restaurants, on T-shirts, and as “Man of the 20th Century” on the cover of Time magazine: Einstein, the White man, the genius physicist.

Physics as a Discourse

It is probably appropriate now for me to recall Stuart Hall’s (1997a) definition of Foucauldian “discourse”, as it is most applicable to what I have observed in physics as a disciplinary practice. Hall says:

Discourses are ways of referring to or constructing knowledge about a particular topic of practice: a cluster (or formation) of ideas, images and practices, which provide ways of talking about, forms of knowledge and conduct associated with, a particular topic, social activity or institutional site in society. These discursive formations, as they are known, define what is and is not appropriate in our formulation of, and our practices in relation to, a particular subject or site of social activity; what knowledge is considered useful, relevant and ‘true’ in that context; and what sorts of persons or ‘subjects’ embody its characteristics. (p. 6)

Western science has developed along a Cartesian reductionist route and has assigned physics a prestigious status as the model of sciences. Values derived from reductionism, such as detachment, objectivity and abstraction, have become the key criteria that regulate the production of knowledge in physics and the training of physicists. In Western societies as well as in Taiwan, discourses about women being more relational and men being more detached, have caused myths about women's inability to handle highly abstracted physics and have cost women good opportunities and fair treatment in the pursuit of higher physics. Reductionism founded the myth that physics was the hardest foundation and that it was above all sciences, and that engineering was the easier application and downstream choice. This has generated elite pedagogy, and discourses around such pedagogy, that alienate both women and men. Its effects, however, serve neither to preserve the "geniuses" for the disciplines, nor function to exclude the "incapables," but demonstrate, instead, a discursive practice to uphold the image and status of physics as the hardest male science.

The words, statements and discursive practices about physics, sum up what I call "the physics discourse." It is manifested in the production of the knowledge of physics and the reproduction of physicists where the beliefs and values of abstraction, detachment, objectivity and reductionism are upheld. It is manifested in the myths that most people, certainly ordinary women and most men will never be good enough to handle the absolute abstraction of advanced physics. It is in the words used, consciously and unconsciously, by people successfully trained in physics—genius students and/or professors. It is in the different needs of students, needs that are misunderstood or unattended to. It is in the types and frequencies of certain anecdotes that get circulated or not circulated. It is in the sorts of

classroom activities that are missing. It is in the tireless searching for the desired geniuses, in the dreaming of becoming another Einstein and in the conceptualization of physics as the hardest science and the tougher career choice.

The physics discourse regulates reproductive practices—it reproduces the knowledge, the physicists, and the criteria—inside the discipline; it governs the criteria under which certain topics count as physics or what is relevant and what is not; it frames conceptual space within which particular ideas are accentuated; it directs the public's understanding and conceptualization of that discipline and that career; it gives meaning to the feelings of inclusion, exclusion, accomplishment, frustration and alienation of its participants; it sets boundaries for an individual's imagination as to their future identity as a physicist, or not. The perceptions of individuals about themselves, who they are and who they are not, who they can be and who they cannot be, who they want to be and who they do not want to be, come out of the intersection and interactions of the past discourses they have lived through, the discourses that have formed their sense of identity and the current discourses they are coping with. As the physics discourse does not speak to, or speak against, the images of women and those deemed "incapable," the identity formation and transformation of women and the "incapables" who choose to stay in physics becomes an intriguing issue. In the next chapter, I will elaborate on a "woman's discourse" that is directed to, performed by, and carried out by women who chose to go into physics. I will examine the meaning of their being "women" in their departments, in the broader academic and societal spheres, and in relation to the physics discourse. I wish to see how both the sense of self and the choices of career are contested alongside the clashing and meshing of competing discourses, and how individual agency can be understood within such contestations.

CHAPTER 6

THE OTHERED WOMEN WHO OTHER¹

Discourses about “ordinary women” and “normal physicists” are forces that push and pull the identity construction of “women in physics.” These pulling and pushing forces shape conceptual and practical spheres and influence individuals’ ideas and choices regarding gender and physics. In this chapter, my analysis will focus on two parts: 1) how the discourse of “ordinary women” translates into practical barriers that prevent women’s participation in physics; and 2) how women physicists use the discourse of the “normal physicist” to distance themselves from other women. I explain the processes through which physical “woman” and the abstract idea of “Woman” are both othered in the practical sphere of physics. I also describe how some women physicists are Otherizing or distancing themselves from “ordinary women.” The outcome of such double Otherizing, I argue, preserves the existing power structure within the discipline of physics and creates a slippery terrain for identity politics and what it means to be a “woman in physics.”

Theoretical Underpinning

Subject Positions for “Women in Physics”

I was amazed at how, early in childhood, discourses about women have already been constructed in opposition to the discourses about physics. In August 2000, in the biggest city

¹ In this chapter, the terms “Other” and “other” are used as both nouns and verbs. The uppercase “Other” and the lower case “other” are different although often used interchangeably. I follow postcolonial studies theory to distinguish these two terms and adopt Gayatri Spivak’s (1985) usage of “othering” as a verb. Details are given in the section of “The Uppercase and the Lowercase” in this chapter.

in Taiwan, a distant relative's family was invited to have dinner with my family. The father was a professor, the mother a housewife; the son was an undergraduate physics student in a prestigious university and his ten-year old sister was in elementary school. During that dinner the young daughter always leaned against her mother. We started with some small talk about each other's backgrounds. When I told them that physics was also my undergraduate major, the mother said: "Oh! You must be so excellent! You study physics!" I was not quite sure about the meaning of her compliment. Was it because physics was hard to study, so its disciples must be excellent, or was it because physics was an unusual choice for a woman? Certainly, keeping quiet without returning such courtesy was rude. Therefore, I briefly replied by copying her discourse: "Your son is excellent, too. He studies physics." "No! That's different. He's a boy!" she commented without hesitation, speaking to both her son and her ten-year old daughter. Our conversation ended there, but I could not help pondering: what exactly was different? Was it that studying physics is natural for men but rare for women? Was it that women and men bear different abilities for physics? Or was it that women and men have different chances to become physicists? Regardless of the answer, one thing was certain in that conversation: excellence was attached to physics, and physics was presented as masculine—men were the norm and women the exception.

It is remarkable that, in the year 2000 in contemporary Taiwan, the mother's view about the asymmetric and gendered relations of men and women to physics was so naturally reproduced and spoken into existence in front of her son and daughter. This is a process of Althusserian "interpellation," as discussed in Chapter Three. While such interpellation provides the son a taken-for-granted "men the physicists" subject position, it "hails" the ten-year-old girl into two others—a "different" and excellent woman who can handle physics, or

an “ordinary” woman who has less affiliation to physics excellence. Apparently another subject position in such discourse is missing: the smooth identification of *ordinary* women with physics as their *normal* choice.

Discourses about women provide subject positions for individuals to identify themselves as “women,” or not as women; as a particular “kind” of woman and to constitute for themselves the meanings of being “women.” When discourses about women are constructed and evolve to be incompatible with discourses about physics, individuals who identify themselves as both women and physicists are constantly facing tensions arising from the antagonism between these two identities. So called “women in physics” is a hybrid identity, with inevitable internal conflicts that grant no subject position of either “normal physicist” or “ordinary women.” With the excellence attached to physics, “women in physics” are usually referred to as “exceptional women”—a term that signifies several Otherizing processes. This also opens up new terrain for contesting meanings of gender. What it means to be a “woman in physics” is, thus, constantly defined and re-defined within the discursive practices of what it means to be a “normal” physicist and what it means to be an “ordinary” woman.

Stereotyping for Otherizing

Stereotyping is a common means of othering. As Stuart Hall points out, “Stereotyping reduces people to a few, simple, essential characters, which are represented as fixed by Nature” (1997b, p. 257). It constructs “otherness” to exclude, and to perpetuate, a hierarchy of power. Hall draws from Richard Dyer’s (1977) important distinction between typing and stereotyping. According to Dyer, typing is essential in the production of meaning

because people put things into existing or familiar types to make sense out of them. We assign people to the membership of different groups according to class, gender, age group, nationality, race, linguistic group, sexual preference and so on. "A type is any simple, vivid, memorable, easily grasped and widely recognized characterization in which a few traits are foregrounded and change or 'development' is kept to a minimum" (Dyer, 1977, p. 28). Bodily difference is one of those traits. When these traits are grasped, then exaggerated, simplified and emphasized, they are used to reduce everything about a person to these traits. When the exaggeration happens, it becomes a procedure of "stereotyping." In Hall's words, "stereotyping reduces, essentializes, naturalizes, and fixes 'difference'" (1997b, p. 258).

Stereotyping contrasts and highlights differences and deploys a strategy of "splitting" to divide the normal from the abnormal, the ordinary from the extraordinary, the acceptable from the unacceptable, and the standard from the exceptional. It serves to maintain clear-cut, fixed boundaries of accentuated types to preserve and perpetuate normalcy. It is a practice of closure and exclusion to maintain the social and symbolic order and the social and symbolic power bestowed upon such order. The strategy of splitting creates a binary opposition between what belongs, and what does not belong or is the "Other." In conceptualizing Us/Them, according to Derrida, "we are not dealing with...peaceful coexistence...but rather with a violent hierarchy. One of the two terms governs...the other or has the upper hand" (1972, p. 41; as cited in Hall, 1997b, p. 258).

In the research data explored below, I show how the concept of "exceptional women" in the discursive field of physics partakes of two o/Othering processes. First, I will show how stereotyping of "ordinary" women and "normal" physicists is used in my interviewees' words and in the discursive practices in physics departments to create the

Othered position of “women in physics”. Second, I will also show how such stereotyping is used by my participants to distinguish/other themselves from “other women.” Then, I discuss whether such othering processes have challenged or maintained the social and symbolic power structure in physics departments and in the conceptualization of physics.

The Uppercase and the Lowercase

The title of this chapter “The Othered women who other” includes both the uppercase “Other” and the lowercase “other” and can be understood as “The o/Othered women who other.” The distinction between “Other” (“Autre”) and “other” (“autre”) is characterized by Lacanian notions of the “two modes of otherness”:

“a” [other] tends to represent an other that is not truly “other” but a projection or effect of the ego, the prototype being the specular image with which the subject identifies in the alienation of the mirror-stage... “A” or the “big Other”, refers, in contrast, to the symbolic and to language itself insofar as they are orders that are quite alien to and inassimilable by the subject, but into which the subject must be inserted or inscribed if it is to be able to speak and exist as a human being. (Macey, 2000, p. 286)

In general terms, the “other” is anyone who is separate from one’s self. In recent postcolonial studies, it has been identified that the existence of others is crucial in defining what is “normal” and in locating one’s own place in the world. The relations between the colonizer and the colonized can be described thus: “the colonized subject is characterized as

'other' through discourses such as primitivism and cannibalism, as a means of establishing the binary separation of the colonizer and colonized and asserting the naturalness and primacy of the colonizing culture and world view" (Ashcroft, Griffiths, & Tiffin, 1998, p. 169). Gayatri Spivak (1985) has further coined the term "othering" to refer to the process by which imperial discourse creates its "others." The distinctions between the uppercase "Other" and the lowercase "other", as well as the process of "othering," can be thus understood in postcolonial studies as:

Whereas the Other corresponds to the focus of desire or power (the M-Other or Father – or Empire) in relation to which the subject is produced, the other is excluded or "mastered" subject created by the discourse of power. Othering describes the various ways in which colonial discourse produces its subjects. In Spivak's explanation, othering is a dialectical process because the colonizing Other is established at the same time as its colonized others are produced as subjects. (Ashcroft, Griffiths, & Tiffin, 1998, p. 171)

While Spivak faithfully adheres to the Lacanian distinction between "Other" and "other", many critics use these two terms interchangeably in that the construction of the O/other is fundamental to the construction of the Self.

In my analysis, I follow the Lacanian distinction where the uppercase "Other" refers to the symbolic, the conceptual, and "the ideas" of the others, whereas the lowercase "other" refers to the actual existence of the others. I also use o/Other and o/Othering interchangeably because, in physics discourse, the term "Women" sometimes indicates the focus of desire,

while at the same time the real “women” are the excluded or marginalized others. The purpose of this chapter is to discuss the o/Othering of women in physics at both the personal and the symbolic levels. I use the uppercase and the lowercase and also extend its implications to other words such as “women” and “physicists.” I use “women” and “Women”; “physicist,” and “Physicist.” On occasions when my focus is on the conceptual and symbolic level, I use the uppercase; when my focus is on the personal level, I use the lowercase.

In my analysis, I distinguish two phrases—“the Women amongst physicists” and “the Physicists amongst women”. The capitalized “Women” indicates a symbolic category that systematically and constantly calls the individuals into particular identifications of womanhood and speaks them into existence. It refers to “an idea of women” rather than real women. Similarly, the capitalized “Physicists” in the phrase “the Physicists among women” indicates a symbolic category that systematically and constantly calls individuals into particular identifications of physics and speaks them into existence. It refers to “an idea of physicist” rather than real physicists.

With their rare existence in physics departments, women’s difference in appearance from men is most visible and can trigger a stereotyping process to highlight the “Women” amongst physicists. In such a process, they can be othered in some decisions and practices inside their discipline and departments. However, when they are compared with other women, their competence to “handle” physics is highlighted and contrasts them as the “Physicists” amongst women—the exceptional/excellent cases that are different from “ordinary women.” In such comparisons, they other themselves from the women category or they other women who are not doing physics. It is important to ask when, how and for what

purpose this othering is taking place, who is assigned the upper hand and whose power or what kind of power structure is preserved.

The “Women” Amongst Physicists

In this section, I argue that women’s existence is othered in physics departments in four aspects: femininity, motherhood, sexuality and attire. Such othering processes distinguish “women physicists” from the “normal” subjects in the department and highlights them as “Women” amongst physicists.

Femininity

Here I use “femininity” to indicate an essentialized sense of feminine traits and “natures” that are said, or discoured, to be born with/in a feminine body, namely inherent care, patience, and maternity. Discourses about femininity and about the lack of it, are used to justify particular allocations of work to females or to give particular explanations of their achievements.

Ying was permitted to do her research project because it was said, and she agreed, that women could do a better job in the lab work that required extreme care and meticulousness. I interviewed Ying when she was approaching the end of the first year in her graduate program. Ying received her undergraduate degree from the same physics department, so she had earlier opportunities to match her interests to those of some of the professors. From the beginning of her graduate program, she had begun doing lab work with her supervisor in the research field of the single molecule. Their work involved using an Argon laser to break clusters of molecules, such as protein, into single molecules. Her work

was to isolate and freeze one single molecule so that other people in the lab could work on the next steps.

Ying was also a graduate student member of the WTWIP (Working Team on Women in Physics). She told me that her reason for joining the group was to seek companions and advice. Although she was half way through her graduate degree and planning her future career, she felt that it might be time to change her career track because she was so tired of her current work. Ying said:

After I entered the Master's program, I felt so tired, so lost, so pressured. Time is always fragmented and I have no clear advice to follow even though I have talked to classmates, senior students, and professors. I feel that this is reaching the limit of my ability and maybe I should do something else. (Interview No. 040702)

Ying told me that the WTWIP was a good cause as it could help her meet others like herself and exchange experiences, problems, ideas and advice. She also felt that the WTWIP was a great place to help her examine her own gender values. I asked her how many people were in her lab and how she was assigned to do her current work. She said:

We are physically weaker than guys when it comes to carrying heavy stuff. On the other hand, women are more careful and attentive in detailed procedures. A single molecule is extremely small; its separation process requires extreme care, which guys usually have trouble with. Right now I am doing it with a senior female student

in the lab because my supervisor asked her to guide me through the operation.

(Interview No. 040702)

In Ying's supervisor's lab, there were a couple of research groups. In the single molecule group, there were five women and two men, 71% female. Compared to the less than 20% of females in the overall student body of the department in recent years², this percentage was very high. Ying expressed her frustration in conducting the tedious, repetitive, and attention-driven procedures. She also expressed the lack of her sense of achievement because a small mistake in the last 1% of her work meant that the previous 99% was in vain.

Ying's experience reminds us of Margaret Rossiter's (1995) study of women's participation in science in the US after World War II. Rossiter points out that between 1954 and 1955 there was a sudden explosion of articles urging women to study science, primarily in order to become laboratory workers or public schoolteachers. One of the articles stated that "women are most successful and appear happiest in the position of technical aide to scientists and engineers...they are more willing than men to do routine, repetitious work. They are patient, faithful and dexterous." (As cited in Rossiter, 1995, p.56). At that time, in the US, women were welcomed as a new source of science workers; however, their roles were restricted and minimised. Within this discourse, as Rossiter said, any increase of scientific womanpower could be "safely channelled into traditionally feminized roles where they would reinforce rather than threaten existing sex segregation" (p. 57). Rossiter's

² For example, in 1999, overall, female students comprised 17% of the student body in this department, with 20% undergraduates, 14% in Master's programs and 10% in PhD programs. In 2000, the percentages were 15%, 19%, 13%, and 6%. Statistics are drawn from the university's yearly statistical reports available on the Internet. Its URL was reviewed by the thesis supervisor but not released here in order to preserve the anonymity of the institution.

insights resonate with research findings from studies of the history of computers. Before the first Integrated Circuit computer was invented, precise trajectories of rockets or bombs had to rely on enormous, repetitive, careful, manual calculations of similar equations with only one slight change in the parameters each time. At that time, women, many as scientists' wives and part of the secret circle, were recruited to do such work because they were believed to bear the required extreme care and prudence. These women were called "computers" (Light, 1999; Rossiter, 1982).

In Ying's case, Rossiter's analysis, and the "woman computer" example, particular traits of femininity were selected and highlighted to describe or justify women's participation in science. Women's abilities had to be put into types, which matched particular traits of femininity. These were then simplified, accentuated, exaggerated and naturalized—that is, stereotyped, so that in science, the different appearance of women from men would make sense in the existing discursive structure. In Ying's laboratory, gender stereotypes buttressed the gendered division of labour in an alleged gender-neutral discipline.

Such stereotyping of women is also used to describe the famous woman physicist Dr. C. S. Wu in her professional and personal life. Dr. Wu was an experimental nuclear physicist. She was considered a "should-be" Nobel Laureate because she conducted the experiment to prove the hypothesis of two theoretical physicists, Lee and Yang, that the law of parity could be violated. The outcome of this experiment won Lee and Yang the 1957 Nobel Prize, but Wu was left out of the list. This sparked debate among theoretical and experimental physicists about whether experimental innovations count as profound contributions to physics. Wu's story is also used as a common example for the study of women and science. Her credit in this event, though, is usually addressed in different terms

from those used for Lee and Yang. While Lee and Yang are praised for their originality in conceiving ideas, what is attributed to Wu is her determination and ability to achieve “precision” in those “extremely difficult” experiments that require tremendous caution and enormous patience to overcome the tedious and repetitive procedures.³

Stereotyping selects particular traits, presses them into existing types, reinforces the existing discourses and reproduces the existing power structure. When any new, odd, extraordinary events happen, the stereotyping process is activated as the most convenient way to make sense and generate meaning. It is not surprising that, in contrast to Wu’s superb achievement in the lab, words about her inadequate attention and insufficient care to her son also circulated⁴. Similarly, Wu’s nickname, “The Dragon Lady,” acquired in her time at Columbia University, signifies both racial and gender stereotyping processes for Othering.

Motherhood

Discourses about motherhood generate another aspect of gender stereotyping in physics. Such stereotyping affects students’ chances to obtain attention from professors and the kind of research projects they may receive. It also affects faculty members’ social power and academic production.

Dr. Ho’s words were not totally new to me but they still struck me when I interviewed her. She is a senior chemistry professor who has long been an important figure in the feminist movement in Taiwan. She was also the WTWIP’s liaison for women in

³ See in McGrayne (1998, p. 268) for author’s quotation of another Nobel Prize winner William A. Fowler’s compliments for Wu. Such a “compliment” was also commonly heard when I was in my undergraduate physics program in Taiwan.

⁴ See McGrayne (1998, p. 270) for Wu’s students’ comments and the description and reference about Wu’s son Vincent. Dr. Koh, a male member of the WTWIP, when mentioning Wu to me in an interview, also repeated these comments as one of the two points he quickly brought to mind, concerning Wu.

chemistry. Being a female science professor in Taiwan for more than a quarter century, Dr. Ho has heard and has been told many stories about women's participation in science and engineering in both the universities and industries in Taiwan. She shared her observations with me:

Professors usually do not like to take female graduate students because they think that these female students will eventually become mothers or housewives. Even if they stay in their professions, their chance to occupy important positions is slim. Male students have more opportunities and actually have a higher percentage of holding influential positions. Genealogy matters from university to industry. It matters to ask how many students of yours are chairs, managers and program directors in grant-distributing offices, laboratories, factories and their co-ops. Large and strong genealogy guarantees profitable cooperation with your past students, smoother transitions from school to career for your current students and the continuity of future students for your research empire. Think about it, how many women are in these positions? There you go. It becomes a vicious circle. If you ask these professors, they will never tell you the truth. If they want to turn down a female graduate student, they simply say 'Sorry, I've already taken too many students.'... Men's and women's distinct social patterns also contribute to this vicious circle. Women get together and talk about kids and family. Men get together for sports, drinks and exercise. They simply do not merge together. (Interview No. 033102)

Dr. Ho's words need further research for validation, including a comparison between female and male students' experiences in finding supervisors and a lineage study of their professors' research activities. Her words, however, do resonate with what I have witnessed during some interviews. I have witnessed how male professors' networking was built through informal and casual events and how it might be built on the privilege of escaping from housekeeping and parenting.

When I started my interview with Dr. Shan, it was already 4:30 in the afternoon. He was very nice to promise me several hours out of his busy schedule. As the time approached 7 p.m., I forced myself to stop the interview even though I had not gone through all the questions on my list. I said: "I guess I should stop. Maybe your family is waiting for you to join them for dinner." "Don't worry about it." he said, "Oh, would you like to join our daily coffee break?" "Coffee break at this hour? These professors must work very hard," I thought. He led me next door. Already there were three other professors chatting inside, making coffee. All were male. Shan introduced me as a guest to this coffee club; I was the only female present. They praised my attire, commented on my look and one of them said: "Welcome. It's very rare that we have a pretty woman visitor." Then the young department chair joined. He had been Shan's former student in the department. He started to report and complain about what had happened in the university meeting he had attended earlier that day regarding some financial issues in the department. Then these professors gave him some ideas and also commented on other departmental administrative issues. Then, Shan said that it was his time to go home. I looked at my watch; it was close to 8 pm. At this moment, other words of Dr. Ho came back to me:

Have you heard about the 8 o'clock rule? Male professors all know that they should never go home before 8 o'clock. If they go home before 8, food is not ready; kids are running around; their homework is not done. After 8, food is ready; kids are settled; everything is neat but waiting for them to join dinner. (Excerpt from Interview No. 033102)

I do not think that this 8 p.m. phenomenon necessarily applies to every male professor I met in the coffee club. However, the fact that they—to my knowledge, at least four out of five were married—were able to spend those hours in a coffee club is a career privilege. It implies that they had longer working hours compared to their female colleagues who were engaged in household responsibilities at that moment. Staying until the evening makes professors look hardworking and provides a longer time period for student contact. This daily coffee shop was also a place to socialize and to exchange ideas for both administrative and academic purposes. The only female professor in this department never joined the group.

How to balance family and career is always a major discussion topic among women scientists and engineers. It can be found in conferences organized by women scientists and engineers, but not in those typical physics conferences with predominantly male participants. Long and demanding working hours in the lab are a serious commitment for women who are considering careers as scientists or engineers. The burden of traditional feminine roles and motherhood has not eased for these professionals just because they have chosen a “non-traditional” career. Discourses used to recruit females into the talent pool of science and engineering are not accompanied by compatible discourses to recruit males to take on

primary responsibility in household and care-giving work. These women scientists and engineers are in a situation where they must balance their careers and families and their success is at the mercy of their husbands' good will. Such situations manifest in the phenomenon that many successful women⁵, when describing their career progress, will express their appreciation for their husbands' "helping" them with family responsibilities.

It is scary to think about this double burden for heterosexual women who want children. Women scientists' difficulties in balancing family and career translate for young women into obstacles for "having a life." In the survey made by the WTWIP in 2001 on Taiwanese women physicists' marital status, 65% of the respondents were not married, and 65% of the married women did not have children.⁶ If women's motherhood and family responsibilities are still put aside in the departmental agendas, if women's difficulties between family and career remain marginalized or invisible in their departments, physics cannot yet be a straightforward career choice for women. There are reasons why many women and their concerns are absent in the coffee club.

Sexuality

When Ying started her undergraduate program in the same department where she had taken her graduate program, her class⁷ was already matched with a "peer class"—the first-year class in the Department of Economics. This kind of unofficial program is quite

⁵ Many of my interviewees have expressed such appreciation, including Ho, Hong and a female professor at the University of British Columbia. In the concluding report made to the assembly at the international conference in Frankfurt, the organizer gave similar remarks.

⁶ Sixty-five questionnaires were sent out for this survey. Twenty-six recipients responded to these particular questions. The total number of women physicists listed in the *Personnel Resource Book* published by the Physics Research Promotion Centre at the National Science Council in Taiwan is 63.

⁷ In Taiwan, most departments in universities offer curricula that are designed for yearly progress with many required and a few elective courses. Students who enter in the same year are expected to take mostly the same courses every year with those they see in the first required course—thus forming a class.

common in universities in Taiwan and was also present when I was in my undergraduate physics class. Peer class is a tradition where a male-dominated class, usually in science and engineering, will be matched with a female-dominated class, usually in literature and social sciences. Such matching is designed to even out the gender disparity in student numbers in each class and to promote heterosexual social activities. It is not designed by the universities, but initiated by students themselves. Usually the contact men in the male-dominated class will *approach* the contact women in the female-dominated class for cross-class parties or trips. It is a typical sexist and heteronormative male-proactive versus female-reactive pattern. If the female-dominated classes “run out,” that is, the number of female-dominated classes is less than the number of male-dominated classes, especially in a science-technology oriented university, a male-dominated class with no match would find a female-dominated class in another university for occasional social activities.

In my undergraduate days, there were only three departments in literature and social sciences and more than a dozen in science and engineering in my university. The Department of Electronic Engineering matched with the Department of Chinese Literature; the Department of Power Engineering matched with the Department of Foreign Languages; and the Department of Industrial Engineering matched with the Department of Economics. The men in charge of social activities in my class found different “matches” from other universities for every summer break. At those times I never joined in any of the activities, simply because the overtly obvious purpose—to optimize the matching pool for the dominant sex in my class—did not cater to my interests and I never heard of any men from the female-dominated classes ever attending these activities. I think those minority males perhaps felt the same way I did: alienated and othered as a sexual object for my classmates.

The process of othering female students as sexual objects in my physics department was activated as soon as, or even before, the first semester started. Dr. Liao, one of the junior active members of the WTWIP, also my undergraduate classmate, recalled to me that in our class, she was the only female student who, intentionally, had no romance throughout the four years. She witnessed one third of the girls (3 out of 9) “settled” into relationships in the first semester, while the others struggled through romances for the rest of their program. In Taiwan, sex segregation before college education is still common. Therefore, university classrooms are the first legitimate venue allowing male and female social activities to suddenly become available for these high school graduates after a long period of sex segregation. In a place with extreme gender disparity in female-male ratios, young women are easily viewed as the rare mating resources for heterosexuals. The most outrageous scene, as Liao and I recalled, was when two female classmates had to jump out of the classroom window to escape their male student-seniors’ chase⁸.

My male classmates once complained about our male student-seniors. In the classes of the second, third and fourth years, there were only one, two or sometimes no female students, out of about 50. As our class suddenly had nine girls, it was unusual and attracted attention from other classes in the department. The males in our class complained that the males in the senior classes chased after the girls too fast and too hard, so that they were left with very little chance. Somehow that was true because the three “early-settled” girls were all dating male student-seniors. When these girls had questions about course materials, their classmates would expect the boyfriends/male student-seniors to take care of them. For these

⁸ “Student-senior” or “student-junior” is another system initiated by students and also encouraged by their universities. Students who enter the universities in different years but share the same seating numbers in a class are student-seniors and student-juniors. Student-seniors are expected to take care of or guide their student-juniors. Following such lines, a student kinship may develop. Students in the same “family” will have more chances to interact with each other.

girls, male students became boyfriends *and* convenient study consultants. For others, if a girl asked questions of them, it might be regarded as a sign of sexual or romantic interest.

In a private conversation, a Taiwanese friend of mine, who was a computer engineer working for IBM, recalled for me similar situations during her undergraduate program. She expressed frustration in finding study pals when she was doing her Bachelors' degree in engineering. If she made appointments with male classmates to discuss course materials, they thought she was interested in or attracted to them. After she explained her lack of interest in romance, her male classmates were offended and had no further conversations with her. They, then, spread words about her "dating around but not being committed".

As a small minority treated as heterosexual objects, young women in physics departments can hardly acquire the subject position of a "normal physics student." The image of a normal physics student is male, interacting with pals for genuine academic interests and desiring a possible, heterosexual mating partner. As desire can never be disentangled from o/Othering⁹, the "normal" physics students' (males') constant desire for romance mates places the "exceptional" physics students (females) into a heterosexually othered position.

The image of the minority is often a projection of the majority's desire. When a young woman shows up in her class and her department, her bodily image immediately is

⁹ Deriving from Freud's theory of the object and meditating on the theme of the "other," French psychoanalyst Jacques Lacan developed concepts of "object (petit) a." From the 1960s onwards, "object (petit) a" came to mean an object of desire that can never actually be attained. It can be viewed as the cause of desire rather than a concrete object that is actually sought after by sexual drives. The "a" stands for "autre" (other) and the use of the lower case marks the distinction between this object and the "Big Other" symbolized by the capital A[utre]. Lacan uses the notations of "o[ther]" and "O[ther]" to describe two modalities of otherness. The lower case "a" designates the specular image of the mirror-phase and the "A" designates the unconscious or the symbolic. Please see Macey (2000) for further discussions. In my argument, the "o" points to the individual level and stands for the bodily imagery from male-subjects upon female-objects in the physics department. The "O" points to the symbolic sphere and stands for the discursive structuring of the department that facilitates such imagery to happen.

read as a sexualized other that reflects the subject-reader's desire. To avoid such reading and positioning, individuals can curtail their involvement in any romance, like Liao did, or simply reject such othered sexual objectification by opting out of this discipline.

Attire

Women's attire is another aspect of the othering process in physics departments. On many university campuses in Taiwan, attire was and still is used as an important and easy indicator to distinguish women in science and engineering from women in literature and social sciences. It is said that the "science women" hardly ever wear make-up and appear to be wearing casual/sporty clothes all the time while the "literature women" appear to be investing more time in their dressing styles and facial appearance. Sometimes the science women take pride in their "lack of style" because, in the discourses available in their departments, extensive care of how one looks simply indicates less commitment to the demanding discipline or less seriousness toward their study. Such stereotyping is often used to "spot" the science or literature women on campus and is adopted by science women to distinguish themselves from the literature women. When Ying described her attire, she said: "I usually dress neutral. Even when I wear skirts, I wear less fancy ones than the literature women's skirts. If I wear skirts to the class, my male classmates will boo as soon as they see me." (Interview No. 040702)

For women who work in the labs, there is at least one reason, a very practical one, for them to wear shirts and pants: to work more easily with and under the lab set-ups. The usual shirts-and-pants combo simulates the science men's daily wear. It is a default dress code and makes the women look "neutral" or "like men." Ying described the day-to-day

interaction in her class and lab: "They do not see me as a woman; they treat me almost like a man." (Interview No. 040702) The fact that "neutral" style is akin to men's daily wear and the fact that it is the proper way to dress and work in the labs reveals that the default sex in labs is male and the working environment is designed around this default. Such a default has the power of gaze that regulates the proper look in the labs and triggers science women's self-censorship of their own clothing styles. Such a gaze can only be dismissed or overthrown when the women acquire more power in their lab or department. An Austrian representative reported to one of the workshops in the IAP conference at Frankfurt that she dared not wear womanly attire in her graduate program and only started to wear make-up after she got her PhD (Field Note No. 0307-6). Dr. Hong, a leading member in the WTWIP, finally felt comfortable enough to wear skirts in her own lab after she became a full professor (Field Note No. 0526).

While "neutralized" (or masculinized) under such gazing power, many science women also use the most conservative and obviously feminine, or what is called "girly", style to mark their femininity in the physics departments. In Liao's and my undergraduate years, putting on long skirts or womanly dresses and doing "good-girl" hairstyles or simply keeping hair long were the most common measures to replace our everyday neutrality (or manlike-ness), with the clearly-stated femininity at parties or on special occasions. The matrix relationships of skirts-and-make-up versus short-hair-and-pants and literature women versus science women are intriguing. While the literature women could rebelliously use skirts and make-up to experiment with notions of femininity, science women's skirts and make-up could hardly escape the interpretation of "girly." While stylish short hair and fashionable pants may still grant a literature woman a provocative feminine look, science

women's short-hair-and-pants combo can be taken as simply "manly." Perhaps, the conservatively feminine style is more obvious and easier to recognize for the science men in classrooms and labs if the science women want to make an instant and effective statement of femininity. In the attire of my interviewees across three generations, Ying has "less fancy" skirts; Dr. Hong has kept her straight long hair for 15 years ever since she was a PhD student. Now, in her fifties, Dr. Wen (see Chapter Five) has maintained her straight long hair since her early thirties (when Hong was a PhD student in the same department).

"Manlike" and "conservatively-instantly feminine" are the two recognizable and acceptable stereotypes that leave little room for science women to play between their gender identities. If a science woman stands out with distinct fashion and fancy make-up, her appearance tends to be commented upon. The reason for this is mostly because she does not look like a serious physicist, whose image is male; nor does she look like the recognizable woman in physics, whose style should be conservative. A good example is a conversation that took place between Dr. Hong and Dr. Koh during their trip to the IAP Frankfurt conference. Both Hong, female, and Koh, male, were active members of the WTWIP. In a poster session, they were talking about physics losing students and the currently less prestigious status of physics, compared to the good old days. Hong said that these days, men who chose physics were usually labelled "scientific weirdos" and women, unfashionable; but in fact, many women physicists were good dressers; they just did not dress well everyday because it was inconvenient for lab work. Koh replied with:

But Professor Ning is an extreme example. As the only female physicist in her prestigious institute in the US, it is understandable that she has developed a very

aggressive working style. But her fashion style is just too much. I saw her in a conference. She put on heavy make-up and changed shoes three times a day. She is overdoing it. She is just overdoing it. (Excerpt from Interview No. 030703-7)

Other than the two extremes, “manlike” or “conservatively-instantly feminine,” it is puzzling for some male physicists to comprehend the attire of their female colleagues. These two extremes, as the accepted look for women in physics, are the two ends of what Stuart Hall calls “the binary structure of stereotype”. Drawing on the previous research of other scholars, Hall (1997b) demonstrates how power circulates within the stereotyping processes. Hall argues that, forged through the histories of slavery, colonialism and imperialism, the representation of black masculinity has trapped blacks with the binary images of both “childlike” and “oversexed.” During slavery in North America, black adults were deprived of the attributes of adulthood and treated as children; and at the same time, alleged rape was the principle justification advanced for the lynching of black men in the Southern states of the US. Such infantilization and over-sexualizing processes have left legacies in the contemporary presentation of “blackness” that play a significant role in the construction of black identities. As Wallace (1979) points out, in opposing responses to such infantilization, black men sometimes adopt a sort of caricature-in-reverse of the hyper-masculinity and super-sexuality, that is, the opposite end of childishness to challenge the stereotype that they are childlike. However, a “macho,” aggressive masculine style in turn confirms black men fit into the “oversexed” fantasy in the deeper structure of the stereotype. The othered victims “can be trapped by the stereotype, unconsciously confirming it by the very terms in which they try to oppose and resist it” (Hall, 1997b, p. 263). They “are trapped in the binary

structure of the stereotype, which is split between two extreme positions—and are obliged to shuttle endlessly between them, sometimes being represented as both of them at the same time” (Hall, 1997b, p. 263). The “oversexed” fantasy about blacks characterizes what whites have both feared and secretly envied.

The “proper” looks of women in physics—manlike or/and conservatively-instantly feminine—are the two ends of the binary structure of attire stereotype for women in physics departments. As the figures in physics that science men both feared and secretly envied, science women are othered through a “neutralizing” process that discounts their difference from the majority—they are almost men—so they are less threatening. In responding to such neutralizing, some of them take the instant and effective measure to clearly state their femininity—using a conservatively feminine style—to mark their difference in order to facilitate constructing an identity as women in physics. Science women’s shuttling between these two ends indicates the fact that they are the othered sex in their departments.

Women the o/Othered—Male “Normalcy” in Physics

Once present as a minority in physics departments, women’s existence immediately activates prevailing discourses of the idea of Women. The idea of Women and real women are both othered through discursive practices in four aspects: stereotypical femininity, motherhood, sexuality, and attire. Some of these practices conveniently translate into unwritten rules and expectations that perpetuate the inequitable gender power structure inside those departments. Women’s research options, departmental participation, peer interactions and bodily appearances are limited to gender-laden choices and roles, and are narrowly defined in relation to the “normal” physicist—the male. The othering of women in

physics minimizes any disruptive potential of the “difference” that w/Women may bring into such a discipline and it safely converts womanpower into a non-threatening and substitute “manpower.” That is, through discursive practices, when necessary, the Women part in the identity of “women in physics” will be highlighted and an othering process activated so that the existing power structure of physics—male “normalcy” in physics—is maintained.

The “Physicists” Amongst Women

Although seen and othered as the w/Women amongst physicists, women physicists, however, do not identify themselves as ordinary “women” but as exceptional cases. When distinguishing themselves from the “other” women, they highlight their physicist subject position to address their particularity/superiority.

Nu-Jong-Hau-Jieh

“Nu-Jong-Hau-Jieh” (literally the gallant and dauntless amongst women), which refers to very rare women during the imagined chivalrous era, is a common term of praise in Chinese to describe women in non-traditional careers. It also refers to famous heroines or women warriors in Chinese history. As women are rare in physics, those who choose it are sometimes referred to as “the gallant and dauntless amongst women.” For example, in the opening session of the WTWIP Symposium where 42 women in either physics or chemistry were present, one of the otherwise-majority three male physicists carefully addressed his respect to the then-dominant sex in his self-introduction:

Thanks for letting me be here. I am from Beijing University, and I am very glad to see so many heroines gathering in one hall. In my university, women in chemistry may have held up half of the sky, but women in physics are still very rare. In the ancient times, the chivalrous were predominantly male, but there were still a few women such as Muh Kueiying.¹⁰ I am very glad to see so many Muh Kueiyings of Taipei here, now. (Field Note No. 0525)

After his self-introduction, another male participant expressed his awkward feelings of being a member of the small minority in any physics-related meetings. The “Muh Kueiying” analogy has marked the nature and themes of such a symposium with clear implications that those women present were all Nu-Jong-Hau-Jieh. The fact that the concept of Nu-Jong-Hau-Jieh, even though showing approval, is used to describe women in physics shows that physics is seen as a highly intellectual challenge and women are less commonly found within its walls. Interestingly, such a chivalrous metaphor is picked up and used by women physicists themselves, to distinguish their “work on women” (organizing WTWIP) from their “work on physics” (research activities): “Doing work on women is unlike doing hard science, which is blade against blade; sword against sword.” (Interview No. 043002) Liao said, when she explained to me how working on women issues should be different from working on physics questions. In these words, Liao seemed to present a split identity. She is *both* a women and a physicist, but the physicist in her seemed to have some abilities in wielding blades and swords that the woman in her could not.

¹⁰ In Chinese folklore, Muh Kueiying was a famous woman warrior who was believed to have tremendous ability in the martial arts and outperformed her husband.

The Hard Route

On other occasions, Liao summarized for me how several main characters in the WTWIP took their physics training, especially those with their PhDs in physics, as the major factor that distinguished them from “other” women, such as me. In a conversation I had with Liao, she was nice enough to explain to me why my membership in the WTWIP did not confer equal recognition. She said that, in the beginning, the WTWIP wanted to invite a social scientist to participate in the survey of the current status of women physicists, but eventually they decided not to. The main concern was that, for them, social scientists seemed to work with very “different styles” from those of natural scientists. Social scientists seemed to “judge a lot” before hearing the words from women physicists. The example Liao gave me was that Dr. Hong’s close friend in social science, who was very eager to conduct the survey, always preached to Hong that she should feel oppressed as the only female among her male colleagues. Hong did not trust her friend’s judgement, so she would rather have someone with both a natural science and a social science background participate. I have both backgrounds, and I happened to contact Hong at the right time. She remembered me doing an M.Sc. degree in physics when she was doing a PhD in the same department. She also expected that I could contribute to the WTWIP with my social science skills.

Throughout the course of my participation in the group, though, not everything was perfect or pleasant. I am still not sure what the main reasons were to cause the uneasy feelings some of them had toward me. I am unsure whether it was because natural sciences and social sciences are truly two incompatible cultures, even though I have tried to bridge the gap; perhaps my social science training reminded them of the differences between us; or perhaps it was simply because I did not perform well as a researcher. The fact that, during

the study, I was still a physics lecturer and also a member of the Physical Society in Taiwan did not seem to register deeply in their perception of the reason for my participation in the WTWIP. The underlying scepticism was often incarnated under the name, disciplinary differences, and marked my awkward membership in the group.

Liao once shared with me: “Honestly, one of the key members feels that your existence spoils this group.”

“Spoil? Do you mean spoil the purity of this group? Why so?” I asked.

“I think it is a general feeling,” Liao replied, “it is a general feeling that you are different because you did not take the hard route.” She meant, I did not continue with a PhD in physics.

Like most of them, I have completed a BS and an MS degree in physics and was teaching physics at college level. Unlike most of them, I did not pursue a PhD degree in physics. Indeed, I was the only one who had a “social science touch.” Thus, I was “different” from the other members. The reasons why they had uneasy feelings about me, and some impulse to marginalize me, may be complicated or strategic. (This would be a good topic for another paper.) Upon hearing her words, what caught my attention was that when it comes to distinguishing them from me—the other woman, the “route” difference was highlighted and the physics route was given superiority as “the hard route.” That is, when it comes to distinguishing them from other women, the physicist in each of them is highlighted, and they see themselves as the “physicists” amongst women.

We Can Never Go Back

After the symposium, Dr. Liao and Dr. Wen, who was Liao's professor in her undergraduate years, had a chance to have a cross-generational talk about the issues of being a woman in physics. Liao told me that she shared Dr. Wen's deep feelings about juggling the roles of "a successful woman" and "a successful physicist." What Liao meant by "a successful woman," as I understood it, was a woman who could commit a generous amount of time to physics and still take good care of her family in a fairly traditional manner. "A successful physicist" would refer to long lists of publications, grants, industrial co-ops and student names, former and current, in what Wen once said in sarcasm: "In total, I only have a handful of students. You can count them all with one hand, unlike my husband whose 'Thanks-to-Professors' banquets always involve at least two round tables (ten people per table)" (Field Note No. 0423).

Liao is now a newly hired assistant professor, and Wen is a senior professor. The twenty years between them that Wen had walked through prompted her to mention to Liao the commitments attached to their career choice. When Liao described to me their conversation, I could clearly see how much Liao was imprinted by the line Wen used to express her sense of what it meant to be a "woman" in physics: "We can never go back, you know? We can never go back"—go back, if I may add, to what they think society expects them to be as "women."

The comment, "we can never go back", also indicates an identity quandary for women physicists. They are stuck in between the two subject positions of "woman" and "physicist." Sometimes, they are both women and physicists but, at other times, they are neither women nor physicists. Liao's husband had told her: "You can only be a 60% mom and a 60% physicist." (Interview No. 060302) Liao resented the fact that a capable woman

such as Wen, who had the ability to, and did in fact, perform 100% quality work in whatever she did, was forced to perform at only 60% just because she was seen as transgressing the gender boundary. With the unchallenged criteria of who counts as a physicist, and the unchanged meanings of who counts as a woman, women in physics can experience uneasy identifications with the subject positions of “normal” physicists and “ordinary” women.

The Women Who o/Other—The Cognitive Superiority of Physics

Many women physicists identify themselves as both a woman and a physicist; but exactly because of the physicist identity, the woman they identify with is never the same as for non-physicist women. In the cases presented above, the ability to do physics triggers the o/Othering process *by* women physicists—they other ordinary women and see themselves differently from the “other” women. That is, they see themselves as the “physicists” amongst “women.” In such an o/Othering process, women physicists’ connection to other women is diminished. This may lead to some women physicists’ alienation from other women’s concerns, including “the feminism” advocated by female scholars in social sciences and humanities.¹¹

Such a process also confirms the perception that “normal physicists” and “ordinary women” are incompatible and reconfirms physics’ high status as the “hard” science. Its outcome has similar effects as the othering of women in physics mentioned before, where women are othered in at least four aspects. Women physicists’ o/Othering “other” women, minimizes the disruptive potential of the “difference” that w/Women may pour into such a discipline and safely converts womanpower into a non-threatening substitute “manpower”.

¹¹ More details are provided in the next chapter.

discipline and safely converts womanpower into a non-threatening substitute “manpower”. That is, through discursive practices, when necessary, the Physicist part in the identity of “women in physics” will be highlighted and an o/Othering process activated so that the existing power structure of physics—the cognitive superiority of physics—is upheld.

What Does It Mean to Be a “Woman in Physics”—Identity Politics

Disruptive Potential Matters

The identity of a “woman in physics” is contested between the physics discourse and the woman discourse, with the two discourses often seen as antagonistic toward each other. For “women in physics”, neither the subject position of “physicist” nor the subject position of “woman” is smoothly available and straightforward. In physics, the meaning of “women”, or specifically, of “exceptional women”, is defined in relation to the male normalcy in physics and the cognitive superiority of physics. “Women in physics” are othered by male normalcy in physics in many aspects. On the other hand, they have also othered “other” women by maintaining they carry the cognitive superiority of physics. However, as illustrated above, if being a “woman in physics” merely means to be o/Othered in the discipline and to o/Other other women, women’s existence in physics not only lacks the disruptive power to challenge such male-dominated disciplines but also perpetuates the very discursive structure of physics that regulates its power distribution and perceptions about “women in physics.”

The identity politics of “exceptional women”—usually referred to as “role models”—is thus one of inevitable struggle. Supposedly, the appeal of “role models” for

minorities in groups (e.g. physics) indicates some imbalance, injustice or inequity in these groups. However, through the journey to acquire legitimate membership in a group dominated by others, role models often have to follow existing rules and sometimes internalize them more strictly than their counterparts, in order to fortify their good-citizen membership. At the other end of this journey, models appear that are often for the original group, with fortified rules, rather than for the minority. This is a process through which a role model becomes a mainstream substitute. In the case of “women in physics”, the glorified exceptional women can become substitute men. If the existence of role models bears no potential to challenge or change the original group, one can hardly justify advocacy for the inclusion of more women in physics.

Affirmative versus Transformative

Disruptive or radical potential is thus the required feature to legitimate the existence, and to foreground the identity transformation, of “women in physics”. My appeal to a disruptive or radical potential resonates with Nancy Fraser’s (1997) call for deconstruction as the goal for transformation. On analyzing identity politics involved in different types of remedies for injustice and inequality, Fraser contrasts “affirmative remedies” with “transformative remedies”. As Fraser states,

By affirmative remedies for justice, I mean remedies aimed at correcting inequitable outcomes of social arrangements without disturbing the underlying framework that generates them. By transformative remedies, in contrast, I mean remedies aimed at

correcting inequitable outcomes precisely by restructuring the underlying generative framework. (p. 23)

Borrowing Nancy Fraser's (1997) terms, I argue that simply adding women into physics and forming a women's group are projects of affirmative remedies. Affirmative remedies involve two kinds of projects: "affirmative redistribution" and "affirmative recognition". "Affirmative redistribution" is a liberal approach for surface reallocations of existing goods to existing groups. Such a criticism echoes Evelyn Fox Keller's (1989a) critiques on a liberal approach to equity, as mentioned in Chapter Two. To assure women's participation rights in physics is to seek this kind of affirmative redistribution without critically challenging the existing structure. "Affirmative recognition" is a mainstream multiculturalist approach for surface reallocations of *respect* to the existing identities of existing groups. In my opinion, to form a WTWIP internal group in physics and to demand recognition for women's contributions is to seek respect and to assert a different identity—a measure that fits into the category of affirmative recognition. Although an affirmative approach aims to redress injustice and inequity, its limits lie in the intact deep discursive structures that generate gender disadvantage and may cause unexpected problems. As Fraser points out:

Thus, it must make surface reallocations again and again. The result is to mark the most disadvantaged class [or gender] as inherently deficient and insatiable, as always needing more and more. In time such a class [or gender] can even come to appear privileged, the recipient of special treatment and underserved largesse. Thus, an

approach aimed at redressing injustices of distribution can end up creating injustices of recognition. (p. 25)

Fraser's observation applies to the development of "girl-friendly science" and the GIST program, mentioned in Chapter Two, as it explains the suspicions and perceptions many women and girls have about such special projects designated for women and science. In the data collection period of my research, these kinds of suspicion and perception have occurred among some women physicists, as depicted in the next chapter, but have not yet been found in the attitudes of the WTWIP's financial sponsors—mostly male colleagues in institutional power. This may well be because the WTWIP was in its initial stage and only asked for financial and institutional support once or twice, and the WTWIP was appealing as a politically correct cause that was difficult to reject. In the long run, after the women's group has asked for "more and more,"¹² how the dynamics change between the WTWIP and its financial and institutional hosts, indicating how far the affirmative approach of WTWIP can go, remains to be seen.

Identities for Transformation

If role models are not to become substitutes, the ultimate goal is to aim for "transformative redistribution" and "transformative recognition." In Fraser's definition, "transformative redistribution" is a social justice project aiming for deep restructuring of the relations of production. "Transformative recognition" is a deconstructionist project aimed at

¹² In my recent contact with one of the WTWIP members, she mentioned that the "Working Team" had upgraded to an official "Committee" directly under the president of the physical society. As the "Women Committee" had been asking for more resources, the response from their male colleagues in the society had caused a split in the committee members' strategies as how to proceed with their goals in the physical society.

deep restructuring of the relations of recognition and destabilizing group differentiation. In the question of women and physics, transformative redistribution should involve a deep scrutiny and a disruptive reorganization about who is in power in setting terms and conditions of how to produce physics knowledge and how to reproduce future physicists; who is in power to other non-conformists. Transformative recognition should involve a radical re-conceptualization of what counts as physics knowledge (dismantling Eurocentrism in the current physics curriculum) and who count as physicists (destabilizing gender and institutional restrictions).

For women already in the discipline of physics, forming a group for women inside the physical society is already a first step to collectively address differences and to mingle with the double o/Othering processes. What impact such collectives can address depends on the organizational goals and strategies of the group members and where they see the problems and resources as being. In the next chapter, I depict the goals, strategies, challenges and conflicts involved within several aspects of the WTWIP organization effort. In Chapter Eight, I describe the identity change of women through the organization of such a group and I explore the potential and conditions for the birth, beyond affirmative recognition, of transformative recognition.

CHAPTER 7

ORGANIZING A WOMEN'S GROUP IN PHYSICS

In Chapters Five and Six I argue that physics is a discourse within which women are undergoing a double o/Othering process. In many aspects, women and the image of Women are disadvantaged in the perceptions about, and practices of, physics. In this case, how is forming a women's group in physics possible? What kinds of goals, challenges, and difficulties might be involved? Would the organization of a women's group in physics make any difference?

In this chapter, I describe the organization of the Working Team for Women in Physics and the internal and external challenges faced by this group. These challenges include: 1) challenges from within, such as issues of seniority and power and the tension these caused among participants of the group; 2) challenges from other women physicists, such as differences in how they present their own images as women in physics, and the subsequent opinions they had about the legitimacy of the group; 3) relations with the feminist movement in Taiwan, including the existence of a generation gap in their attitudes towards issues of "gender," and their distance from other influential feminist groups; and 4) challenges posed by their male colleagues, such as their hurt feelings and lack of understanding. In the end, I argue that these challenges, along with other opportunities, form a "field of negotiability" where the meanings associated with being a woman in physics are negotiable and where an identity change for women in physics can take place.

Challenges from Within

Qualifications of the Leader

My working relationship with the Working Team for Women in Physics (WTWIP) began when I met my key informant¹ of the WTWIP in early 2002. At that time, I had already learned that not all women physicists in Taiwan were happy to be part of this women's group in physics.

Dr. Hong was the first woman physicist to take on the task of organizing such a working group on women in physics. Although she was already a full-professor, she did not consider herself senior enough (she completed her PhD in 1988 and obtained full-professorship in 1998) to lead a group focused on such a "sensitive" cause. I felt the sensitivity of this cause because, in the first ten minutes of our conversation, Dr. Hong stressed to me why seniority and academic achievement were important factors to the position of the leader. In the beginning, when Dr. Shan brought back the task of forming the WTWIP and Dr. Hong agreed to help in its establishment, she was looking for another "really" senior woman professor to be the chair. In Hong's opinion, Dr. Wen² would be an ideal candidate because Wen was already a professor when Hong received her PhD degree from the same department. Another ideal candidate would be a retired professor who was in the same generation as Dr. Wen's supervisor. In Hong's opinion, the chair of the WTWIP must be a "role model" (Interview No. 022102) to qualify for this position and, indeed, a role model's role model would be even better. In other words, academic prestige could help

¹ The term "key informant" may have other connotations in other disciplines. However, in cultural anthropology, it usually means the first person the researcher contacts when she or he enters the field of research. This person also serves a key role in providing the researcher with resources, help, and connections to other interviewees.

² Dr. Wen was mentioned in the previous two chapters.

to justify the establishment of this team. Other factors concerning Hong include academic reputation and research resources. She thought that the woman who would run the Working Team must have adequate academic qualifications otherwise her credentials would not be persuasive enough to allay any suspicions or objections. She did not consider herself accomplished enough because, by her own admission, she had made a career mistake in choosing a university in the southern part of Taiwan.

Most of the research resources are in the north. In the south, I did not have a good networking system to be able to mobilize those resources. If I had chosen the north, my academic productivity would have been much greater. It is just not convincing for a southerner to lead the group. (Interview No. 022102)

For some reason, these senior women professors did not express enthusiasm for the post. Hong did not intend to take the chair position at that time, but since no other woman physicist responded as positively as she did to the call to organize the WTWIP, she became the first chair.

In our conversation, I sensed that her concern about the leader's seniority and achievements was not just conventional thoughts about electing a leader or president. For her, these issues were particularly important because she was organizing a "women's" group—making gender visible—an unprecedented measure in the history of physics in Taiwan. The leader had to be a well-accomplished and eminent female, so that people (mostly her male colleagues) would not pick apart their academic records. Otherwise, it would look as if these women in physics were just finding excuses for their under-

achievements. Moreover, if this female was well accomplished and eminent, she would very likely have supervised many currently powerful male physicists during her career, and would thus have better access to resources and networking groups.

Hong had two goals for the working group: including more women in physics and building a supportive network for women in the field. To all appearances, it looked as if she was working on some kind of feminist project; however, in as many instances as possible, she literally rejected the label of “feminist group” or “women’s rights group” for her organization, and made sure that her group included at least some resourceful male members³. On several occasions, she showed a clear inclination to utilize, as well as reinforce, the existing power structure of academic physics.

Reinforcing Hierarchical Power Structures in Physics

In a preparatory meeting for the local symposium for women physicists and chemists, when group members found that they were unable to cover all of the expected expenses, Hong’s first and last move was to request the necessary funds from Dr. Mao—a renowned physicist and the director of the National Science Council. The National Science Council distributes all government research grants in Taiwan and Hong had the chance to contact Mao personally because they were in the same research field. Hong viewed Mao as the WTWIP’s biggest supporter and her move was consistent with other actions such as asking Mao to fund the WTWIP members’ trip to Frankfurt. In return, Hong stressed to other meeting members that Dr. Mao’s secretary, who held a Bachelor’s degree in physics, must have a spot in the funded trip during the Symposium for Female Scientists. Dr. Kim, the

³ Supporting details to this description can be found in the section about Dr. Hong in Chapter Eight.

designated organizer of the symposium, was not comfortable with Hong's strategy and felt it was better to minimize the roles and footprints of male physicists in the WTWIP. In the end, Dr. Kim offered to use her personal savings to cover the shortfall.

Another instance involved a seating arrangement during the Frankfurt trip. On the banquet day of the international conference in Frankfurt, the conference organization committee had pre-arranged seating for presenters and delegates from all countries. All of the Taiwanese delegates were seated at the same table except for Dr. Mao who was seated elsewhere. We were not aware of the reason for this, but suspected that it could be either because his secretary had registered him earlier than the others, or because his rank of title was higher. Before the banquet started, Dr. Mao approached our table, which was already full, and stood talking beside Hong. It was quite apparent that he wanted to join our table. I sensed some pressure being put on me to do something but I decided, nevertheless, to assume nothing. Finally, from across the table, Dr. Hong said to me "Why don't you switch seats with Dr. Mao?" I felt that I had no choice but to agree to her request, although I was the newest WTWIP member, a "social scientist" amongst physicists, and the latest to join the delegation. After we returned from Frankfurt, we began the preparations for the Symposium. On the invitation letter to be sent out broadly, Hong decided to call other people "Members of the Organizing Committee" and call me the "Executive Secretary."

In my opinion, Hong's way of running this group was very strategic and consistent with her lack of interest in feminist reflections on power, seniority, and institutions. Her many gestures to connect the WTWIP to powerful males are symptomatic of the fact that while her organization looked "feminist," she had no intention of pursuing an avowedly feminist agenda. The fact that she reinforced the existing power structure, stressing seniority

and credentials, generated pressure on junior faculty members in the working group such as Dr. Liao.

Dr. Liao was the most, perhaps the only, active group member at the assistant professor level. Her participation in this group was particularly sensitive not only because she was making women visible in the discipline of physics, but also because she was “just” a junior who had yet to build an impressive academic record. Her participation therefore made her look “bad” in many ways: she was either not doing her research, she had too much free time or she was seeking some excuse to justify limited research productivity. Other junior women physicists from various universities were generally receptive to the WTWIP’s cause, but very few of them dared to take part in the direct operation of the group. The pressures Liao faced, and the stigma attached to her participation, prevented many young women physicists from showing enthusiasm and associating themselves with the group. At one point Liao was experiencing extreme pressure and was about to quit the group. She told me:

I want to talk to Hong. I have to talk with her about the issues of seniority and hierarchy in this group. Look, I am the only assistant professor. If we do not deal with such issues, how can we attract more assistant professors? Every time I talk to them and try to include them, they all say that the members should be full professors! Sisterhood alone cannot run this group. (Interview No. 042102)

Challenges from Other Women Physicists

Commanding Presence versus Trustful Sharing

The pressure Liao faced could have been worse, considering the sharp objection to the WTWIP voiced by a senior woman physicist, Dr. Wu. Compared to all the key members in the group, Dr. Wu was considered the most senior and was very accomplished. She was a full professor in a renowned university in the north. She had been with the faculty for 20 years. She held many patents from research work she had done. Her past service records included serving as the Department Chair, as well as membership on the Board of University Affairs and the Board of Gender Equity at her university. She also took charge of the Board of Finance in the Taiwanese Physicists Association. At the time I interviewed her, she was heading a high profile and commercially profitable research project funded by the National Science Council. She ran a big lab and supervised many students whose work with her would amount to more than ten publications a year. She even organized the "Gender Issues" course for university-wide students and offered the "Gender and Science" course. It was this kind of background that made her objections to the working group even more phenomenal.

In the beginning, Dr. Wu was a founding member of the group. She attended the first group meeting, but after the second meeting, she decided to withdraw all parts of her participation in the group. When I visited her, as soon as I explained my research interests and my relationship to the working group, she stated her objections up front:

I don't like their tone. It is a loser's tone. Some guy in your class says one line to hurt you, and you let the damage last for the rest of your life? Come on! Stop

blaming others for your weakness. It just indicates low self-esteem and pathologic mentality. This group should address more encouraging and positive things; it should not be used as an excuse for poor achievement. The young woman from the Rainfall University is particularly negative. What she heard from her male classmates was not discrimination; it was merely personal opinions. Men have their own problems with social and cultural expectations too. And women should not find excuses. Some women just look too wimpy—they make others feel they have to bully them!

(Interview No. 051302)

I consider the last line in her words a very strong opinion against the young woman from the Rainfall University. Dr. Liao was the only WTWIP member who was from that university. In the instance Wu was referring to, I supposed Liao was simply sharing her gendered learning experience with members in the group, but her sharing registered in Wu's mind as a loser's moaning. As mentioned before, most of the group members, including Hong and Liao, hold two goals: to encourage more women to enter the field and to build a support network for women in physics. Wu, however, only approved of the first goal and took offence at the second goal. She believed that women had to be tough in order to survive in physics—a principle that was applicable to any minority. "We must work harder to achieve equal recognition. It is because we are a minority, not because we are women"

(Interview No. 051302).

Wu said that she stepped out of the meeting room in the middle of the second group meeting as a form of protest, and since that time, even though she was still included in the group email list, she simply ignored any news or messages about the group. "I have no time

to waste on their moans”, she said. She could not tolerate the sharing of problematic experiences because, for her, that kind of sharing only spread negative feelings and did nothing constructive. In her opinion, the working group should come out with stronger, more positive aspects for their colleagues and students. The Taiwanese culture, in her understanding, only taught girls to pick easier routes and to give up their goals whenever they encountered difficulties (one of the reasons she preferred male over female students). She understood that her culture and society was a long way from having gender equity, but the only way out, she said, is “to cope with it, not to fight it, hate it, or moan over it”. “You can not stop people being unfair to you. You can only keep moving ahead and prove yourself. You have to prove that they are wrong and you are strong”. She continued:

Before the whole society solves this problem for women, women have to manage. Balancing family and career? No excuses. I did all the management work. I took care of my sick kids and I did laundry in the middle of the night. You save a lot of time doing housekeeping by yourself rather than teaching your husband how to do it. If you take that [gender inequity] as a big issue, you are not going anywhere...I don't like feminism. It just teaches women to ask for more and more, without reflecting on their demands. Confidence and commanding presence are the most important...Thank god I am a woman; otherwise she [Dr. Liao] would say I bully her in those meetings. We ought not to always mention gender when there is a problem. Who are you to represent all women? (Interview No. 051302)

Betraying the Image of "Chinese" Women

Dr. Wu's beliefs and pride in women's strength and toughness are also found in the opinions of a retired professor, Dr. Ng, from the physics department at the prestigious, Harvard equivalent university in Taiwan. Perhaps because I introduced my research interest as gender and physics, she felt pressured to stress how capable a woman she was. In our three-hour interview, she mentioned four times that she was educated to be a "standard Chinese woman". "Raised with Confucianism," she said she could do all the "women's work including cooking, cleaning, tailoring, nursing...etc. This was just to name a few" (Interview No. 032102). She believed that it was the proper way to train women, before they could handle other things such as physics. In her opinion, "Chinese women are too capable; you have to bind their feet to cripple them" (Interview No. 032102).

Dr. Ng's attitude reminds me of another senior women physicist in the south, also in her sixties. I met her in a conference in 1999 and we sat together with other people at a lunch break. When the topic turned to how much she had accomplished during the 40 years of her service in the physics department and for the university, she proudly announced the most satisfying thing in her career: In those 40 years, while doing physics, she did all "the women's jobs" and never asked her husband to "even get himself a bowl of rice at dinner" (My memory of her impressive words). For women physicists of their generation, I felt that it is almost insulting to mention "gender" in their work. Perhaps feminists in Taiwan should first advise their women to be less capable.

Although believing in the need for toughness, Wu did not uphold the existing power structure of seniority and institutions as much as Hong did. In fact, Wu was proud of fighting against the biased distribution system for government grants and of pushing the

government to establish a more equitable and “ethical” (her word) system. When she had just started her career in the normal university where she was hired twenty years ago, government research funds were mostly channelled to a handful of top research-oriented national universities in the north. As for the private universities, unlike those in the US, they were almost totally dependent on their own budget. Wu’s university, even though it was at the top of the national normal university system, was considered “teaching-orientated” and possessed very little research power, thus attracting only a limited portion of available grants. Ignoring the dissuasion and worries from her male colleagues (“You could die an ugly death”), Wu fought the National Science Council and the handful of universities behind the Council, and pushed them to finally establish a new system that granted funds on the basis of an applicant’s merit rather than the reputation of their university. When on occasion people addressed her as “power-woman” (paralleling “power-man”) or “female professor”, she was usually very cautious because she believed she “was hired for my expertise, not my sex” (Interview No. 051302).

If the pressure from Hong on young faculty in the group was about seniority and hierarchy, the pressure from Wu was that she only approved of one image for women physicists: tough, enduring, and resilient. Indeed, she only endorsed the identification of women physicists as those with such characteristics. For women like Wu, betraying this image was almost like betraying the virtue of being a woman physicist. Dr. Wu and these two other senior women physicists represent a certain generation of women physicists in Taiwan. They have served in their positions for at least twenty years. They were mostly hired before or during the early eighties when North American feminism had just been introduced to Taiwanese society and was the subject of major criticism and suspicion. They

constituted a tiny minority in their departments and refused to present an image of women physicists who were encountering difficulties. For them, to mention gender was to take away or to reduce their “human rights” in participating in their discipline. In her depiction of Barbara McClintock, Evelyn Fox Keller (1985) noted that “most women scientists would be appalled” (p. 173) at the mention of gender because they were hoping that, in the ideal world of science, “the matter of gender drops away” (p.173). But precisely because of the way these Taiwanese scholars talked about gender in relation to the physics they did—that is, the “power women” fulfilling their “women’s jobs” without it interfering with their physics work, the demarcation and tension between the “women” and the “physicists” were clearly shown. “The matter of gender never does drop away” (p.174) and was, in fact, silenced in the work domain of physics.

For women raised within the traditional Chinese culture, such silencing is even more acute. Confucianism, Taoism, and Buddhism are the three major foundations of traditional Chinese culture. These tenets accompanied immigrants from China, travelling across the Taiwan Strait and reaching the island of Taiwan. Confucianism requires men and women to tailor their roles to the dichotomized public and domestic spheres. Failure to fulfill their respective responsibilities in such roles disqualifies them from their gender identity. A particular interpretation of Taoism has also strengthened the dichotomy between female and male as “Yin” and “Yang”. In the era before the early eighties, when Taiwanese women were taking on paid jobs *in addition to* their domestic work, there was hardly any public discourse about pushing men to take on domestic work at home. Women transgressing the spheres ended up taking on double loads and demonstrating exceptional competence, especially in a discipline as demanding as physics. The idea of “standard Chinese women”

has transformed the Taiwanese women physicists of this early generation into superwomen. However, these superwomen are powerful in managing their lives but invisible in challenging the domain of physics.

Is Gender a Legitimate Topic in Physics?

Generational Differences and the Feminist Movement in Taiwan

The superwoman image and the narrow identity of standard Chinese women also work to silence the primary concerns of other younger group members: how to balance career and family. Dr. Chen started her employment in 1992 and was an associate professor when I interviewed her. In the first two group meetings of the WTWIP, she shared her major career challenge of balancing family and work and sought input from other members. She also attended the international conference in Frankfurt and volunteered to join the workshop on family and career. While other meeting members, such as Hong and Liao, welcomed such sharing, Wu considered Chen's concern as looking for "excuses" and speaking from the position of "loser". Liao started her post-PhD employment in 2001. Compared to Chen, her claim to gender equity was even stronger. Chen approached the family and career issue by taking sole responsibility for the care of her two daughters and simply sought advice on how to balance her family and career responsibilities. Liao, on the other hand, approached this issue by insisting on equal parenting duties with her physicist husband and she also fought with him for equal time in her lab.

In comparing the various stances of Ng (30 years of post-PhD employment), Wu (20 years), Hong (15 years), Chen (10 years), and Liao (1 year)—all of whom were active

members in the WTWIP, including Wu before her withdrawal—it seems that the younger the generation, the clearer the desire to make gender visible in physics. The generations hired before the early 1980s (Ng, Wu) are far more reluctant than those hired in and after the early 1990s (Hong, Chen, Liao) to view gender as a legitimate issue in their workplace. Such differences, I maintain, correspond to the political changes and the corresponding development of the feminist movement in Taiwan. It is particularly relevant to the general uproar of social and political power in the late 1980s, when the local feminist discourse started to grow and become accessible in Taiwan.

It is generally believed that North American feminism was first introduced to Taiwan in 1976 by Annette Lu, then a fresh Harvard PhD and now a Vice President, through several newspaper articles. Her then “controversial” articles advocated the rights of Taiwanese women to higher education and opportunities in the public workplace. At that time, Taiwan was still under the authoritarian rule of the Nationalist Party (KMT) backed by the long-enforced martial law since 1949. The efforts of Annette Lu and her successors, to raise gender consciousness through newspapers and magazines, achieved only minor success during this period until the lifting of martial law in 1987. After almost 40 years of oppressive government, the lifting of martial law suddenly restored long-suppressed civic rights, including freedom of speech and rights to assembly. With these human rights as the vehicle, a long suppressed social and political momentum burst forth into all kinds of parades, protests, movements and even some chaos, which destabilized the old socio-political structure and pushed for the birth of a new government. Shortly after 1987, the feminist movement in Taiwan finally expanded from running publishing houses to organizing social service groups. Organizing social service groups not only broadened the

coverage of gender issues but also acknowledged differences amongst women of various classes, ethnicities, and professions. These groups included The Association for the Protection of Victims of Forced Prostitution, The Women's Rescue Foundation, The Housewives' Union, The Pink-Collar Foundation, The Women Labourers' United Front, and The Feminist Scholars' Association. In 1994, after the candidate of the newly established opposition party (Democratic Progressive Party, DPP) took over the city government of the capital Taipei, feminist and women's groups for the first time had access to policy-making at the government level. It is fair to say that feminism in Taiwan gradually raised its public profile after 1987 and grew stronger after 1994. The recently elected DPP central government has offered a great opportunity for feminist policy making because it owes so much to local feminist groups who campaigned on its behalf (Fan, 2000).

The development of the public feminist discourse in Taiwan may have contributed to the differences between women physicists hired before the early 1980s and those hired after the early 1990s. The generation of Hong, Chen, and Liao completed degrees and acquired employment at a time of public feminist discourse. For the generation of Ng and Wu, feminist discourse appeared decades after their own early and lonely struggles. It is therefore hardly surprising that the younger generation views gender as a legitimate topic while the senior generation views it as an excuse for personal shortcomings. However, this distinction is not meant to create two monolithic sub-categories of women physicists. It is meant to provide a tool for understanding the discrepancy between key participants in the Working Team and to recognize that individual variations do exist, such as Dr. Jing—a junior faculty with the attitude of “no mentioning of gender”—whose experience is depicted in the next chapter. It is also important to note that viewing “gender” as a legitimate topic does not

equate with an acceptance of feminism as a justified cause. It is clear that the key members of the Working Team envisioned a consciousness-raising and network-building group but hoped to avoid any naming of, or connection to, feminism. It seemed to me that they equated feminism with “no men”, and that “no men” meant no resources. Thus while the younger generation had moved from “no gender” to “consciousness-raising,” the Working Team remained deeply sceptical about the term “feminism”.

Relations with “Feminist” Groups

The academic science communities in Taiwan manifested little public interest in identifying themselves as feminists, especially when compared to their peers in the humanities and social sciences. Taking the Feminist Scholars’ Association as an example (founded 1992 with many members transferred from publishing houses), in 2002, there were only three members with a science background among the almost one-hundred members from literature, sociology, law, history, and Education (The majority having completed their PhD degrees in the US). By the time I finished my fieldwork, there were no physicists in this feminist group; perhaps there was one—if I counted as a physicist. However, in the public sphere represented in the media and at various government levels, members (mostly in university faculties) in the Feminist Scholars’ Association were seen as the experts or brain-trust on gender-related issues and policies. In this sense, women scientists were extremely underrepresented in the public domain of issues and policies regarding gender, in Taiwan.

This under-representation perhaps explains why, when the Minister of Education undertook nation-wide curriculum reform in 2001, an elementary science teacher involved in incorporating gender into science had to request help from the Feminist Scholars’

Association through a professor in law. On the other hand, exactly because of this under-representation of women scientists in the feminist communities, these communities reached their limit when providing advice to teachers involved in projects to integrate gender into science. For example, some professors in the association suggested developing gender-specific or girl-friendly programs to attract more girls into science. However, this kind of program proved to be problematic and inefficient—a flaw that the GIST (Girls into Science and Technology) project in the UK had already identified and discussed in the 80s (Kelly, 1985a; Whyte, 1986). This instance indicates that issues of gender and science are under-discussed in the Feminist Scholars' Association, even though its members are influential and well ahead in other gender issues.

Challenges from Men

Their Hurt Feelings

Given the little affinity between women physicists and the feminist movement in Taiwan, the quick formation of the Working Team on women in physics—the first of its kind in science communities in Taiwan—indicates an unusual thrust that accelerated the process. Indeed, rather than a task that originated out of the internal needs of women physicists in Taiwan, the organization of the Working Team is primarily the result of external pressure from the international physics community. It was a mission brought back by two male professors, the president and secretary general, of the Taiwanese Physicists Association, who attended the 1999 annual assembly of the International Association of

Physicists (IAP)⁴. Because of this “foreign lineage” and the international pressure in relation to Taiwan’s special status in international politics, such a group solely for women in physics attained legitimacy almost instantly inside the Taiwanese Physicists Association and among many suspicious male professors in physics departments.

If not for this international pressure, an organization like the WTWIP would have been unimaginable. Such a request, or more precisely, an order, imposed on the Taiwanese Physicists Association from the IAP almost instantly silenced local male professors before they could express any concerns or objections. On the other hand, the key members of the WTWIP knew very well that they benefited from this outside pressure and that they had better tread cautiously and be “understanding” of their male colleagues’ feelings. After all, these male professors still possessed stronger connections, better resources and more power than the women, and for the junior faculty members, these were the same people who would approve or deny their tenure and promotion.

Liao admitted to me that, “It was in the name of international pressure that we formed this team, so that its existence was less threatening and would not hurt the feelings of our male colleagues too much.” (Interview No. 050502) As soon as Liao’s male colleagues—all more senior, since she was the newest—heard about her joining the team, they asked her: “Why did you join the team? Do you feel you are being discriminated against here?” For Liao, this was a tough interrogation because it seemed that she was either accusing her colleagues of unfair treatment or she was wasting her time when she should be worrying about her research productivity. Liao realized that she must respond carefully to

⁴ For detailed descriptions about how this mission was brought back to Taiwan, please see Chapter Four: Research Background, Context and Methods.

these questions, as well as take advantage of this chance to acquire some support and understanding. She described to me how she approached it:

I said, well, yes or no; certainly not here in our department; there are problems out there, like our culture, and those who joined the team simply hope to have a supporting network. Then I asked them: what would they do if their wives were too busy to raise the kids? Do you know what they said? They said they would find other wives! They said maternity was a woman's nature and women are better at raising kids. I had to argue with them that parenting was a learning process for both women and men. (Interview No. 042302 & 050502)

Liao told me that she was furious upon hearing their responses. I think I can understand. It was partly because, at that time, she was fighting very hard with her physicist husband over issues related to equal parenting and equal research. Liao used this conversation as an example to let me know how sensitive it was for her to join the team and how difficult it was for her male colleagues to even notice the cultural problems in their behaviours. Judging from their response, they simply could not link the cultural problems "out there" to their own thoughts and behaviours and could not understand how such a link had an impact on the research productivity of their junior female faculty member.

Problems "Out There"?

Strategically, the problems must be "out there"; otherwise, it was too close and too real to accept. The Working Team needed resources and the members did not want to arouse

any more suspicions or negative feelings. To claim the problem as “out there” would certainly win more support from male colleagues than to associate these colleagues with the problem itself. However, the discourse of “out there” was not initiated by the members of WTWIP but by consensus that emerged from a conversation between nine Department Chairs, including Liao acting as the proxy for her Department Chair. The nine department chairs set up a dinner meeting to discuss some aspects of co-operation. Sitting with the other eight Chairs, all male, Liao certainly wielded the least power amongst them. Liao told me (Interview No. 050502) that at the beginning of the meeting, one Chair (Chair A) recognized her name and immediately asked her:

“Aren’t you in the Working Team for Women in Physics?”

“Uh...I am just an extra; an errand-runner.” Liao answered, trying to soften the atmosphere and conceal the fact that she was an active member. Then Chair B asked:

“Why is there such a Working Team?”

Liao started to explain and gave examples. She mentioned that in mathematics and other natural sciences at least 30% of the students were women, but in physics, as far as she knew, women made up less than 15%.

“Oh, that depends on the subject. Women are not suitable for some subjects” Chair C from a university in the south said. Liao told me that she was not happy to hear that, but since it was quite predictable, she actually had been expecting to hear that line coming out from somewhere. She remained silent and observed more.

“But hey, many girls are doing well as undergraduates. I remember, when I was an undergraduate, my female classmates were pretty good.” Chair D replied, in a slight objection to Chair C. Liao promptly caught this opportunity and slid into one line:

“...but most of them disappeared in the graduate schools.”

At this point, according to Liao's description to me, most Chairs started to show some facial expressions of understanding. Then Chair D continued:

“Why did they not continue to graduate schools? I don't understand.” Liao did not directly answer his question, but approached it from another angle:

“Were you ever discouraged [by someone] throughout your study?” All Chairs looked around, and Chair D said:

“No. Were you?” He looked at Liao, but Liao kept silence.

“Oh, now I understand. Men are not discouraged, but women are not encouraged to study physics.” Chair D said. At this time, Chair E jumped in to make a concluding comment:

“I think you should educate those people out there, not us.”

What Chair E referred to, in Liao's description, was that it was the culture *out there*, not in the department, which was discouraging women from pursuing higher degrees in physics. It is through this event that Liao learned about the difficulty of promoting the WTWIP's cause among male professors, especially those in power. To be fair, there were male professors who were supportive of the cause. Dr. Shan and Dr. Koh were two male professors who supported establishment of the Team, and who have continued to support it. However, they were still the only two when I wrapped up my fieldwork. Male professors like these two were just so rare that they stood out in the physics community in Taiwan. Chair A in the 9-Chairs meeting jokingly said: “In my department, there are already three women faculty members.” He counted Shan and Koh in addition to Dr. Jing, the only female professor in his department.

Problems “in” the Department

Is it true that there were only problems *out there*? In the first few WTWIP meetings, there had to have been some sharing of unpleasant experiences, not out there, but inside the physics departments. Otherwise, the tough and proud Dr. Wu would not have been offended in those meetings by what she considered to be “moaning.” After I joined the WTWIP, the purpose of the meetings was mainly to prepare for the international conference and the local symposium. I did not have the opportunity to hear about other’s problems with my own ears. However, in the second preparatory meeting for the local symposium, Liao did mention the astonishing experience of her friend, who was also an assistant professor in another university.

In that meeting, the members were discussing how to put a proposal to their universities concerning an extension of the tenure clock for young female professors, because their own biological clock, marking the prime years for child bearing and the tenure clock, during which time academic papers are published, basically tick simultaneously. This idea of extending the tenure clock was brought to the meeting by members who had attended the international conference. Liao did not go to the conference and was impressed by this idea, but she said she was not optimistic about its success in Taiwan. Liao then gave the example of another new assistant professor. When this new junior faculty member was taking part in her job interview, the committee members asked her, “In the future, when you are pregnant or have kids, would you let the department take the load for you?” (Interview No. 041502) Liao described this question as one of the “harsh questions” young female faculty members might encounter. Using this example, Liao tried to express her concern that

if male colleagues could not, or did not bother to, understand the extra work load of motherhood that the culture and the society still exclusively bestowed upon their female colleagues, how would they support an idea to prolong the tenure clock for female faculty members because of their child-rearing responsibilities?

As for Liao herself, I was curious about the story she shared in the early WTWIP meeting where Dr. Wu was also present—the story that irritated Dr. Wu so much that she took it as the symbol of her objection to the WTWIP. Later in a conversation with Liao, I heard what happened at her first class of the first-year undergraduate “Physics Experiment,” when I was also present elsewhere in the same classroom:

Remember I was in the same group with the other two guys, Chung and Yong?

Strangely, at that time the atmosphere was as if we girls better have some guys in the same group to take care of us. As soon as we formed the groups, do you know what Yong said to me? He said: ‘You know you just took away the future career of some guy? Because of your talent, you took this position and some guy was excluded from admission. But after you finish your degree, you will most likely become a housewife and waste your education in physics; and that guy has to raise his family!’ I was shocked. I was shocked to hear what I heard.

To my understanding, Liao has no brother and is the youngest of three daughters in her family. In her upbringing, she says she never experienced differential treatment or gender based expectations from her parents. Perhaps the words of our classmate Young was the first blatant sexism she had ever encountered. Such blatant sexism outraged her and

registered in her mind so deeply that she used it as an example to show the signs of gender inequity in both the class and in the physics department. Later in our undergraduate days, Liao had a continual discourse about women's equal rights as human beings. When the WTWIP was just recruiting, she was the first, and remained the only, junior faculty member active in the group. Liao's commitment to fighting gender inequity in physics and in society was very convincing to me. For her, as she told me, what matters most are the opportunities for women to *freely* choose their careers and not to be addressed as "special cases" or be explicitly or implicitly discouraged if they choose physics. Unfortunately, the senior and often tough professors, such as Dr. Wu took the sharing of such examples to be a discourse in "moaning." This generation gap on the legitimacy of gender issues has denied the first women's group in physics a more cohesive and united organizational standing.

Field of Negotiability

As illustrated above, the organization of a women's group in physics in Taiwan has been and is still being challenged by various parties. Issues of seniority and the pressure for academic achievement are major concerns that cause tension between senior and junior faculty participants in the group. Junior members have joined the group to seek support in dealing with situations in their own departments but have encountered a similar hierarchical power structure in the group. Outside of the group, the precedent set by the tough women physicists of the older generation diminishes the legitimacy of such a group and masks some important issues for women physicists of the younger generation. A discourse of "Chinese" culture was used to justify the position of the older generation and exacerbates the

generational discrepancies. The minimal interaction between this women's group in physics and other groups that call themselves "feminist" provides a very limited exchange, in theory and in practice, to make a strong case about the gender issues in physics. Such shortcomings leave participants of the WTWIP with few resources to cope with the prevalence of blatant sexism in their own departments. However, there was and still is a golden opportunity for the development of the group. The international discourse of organizing "women in physics" provides an almost indisputable legitimacy to fight off the suspicions and suppression from those senior professors in power, some female but mostly male.

The opportunities and challenges the WTWIP faced have formed what Etienne Wenger (1998) calls "the field of negotiability." The field of negotiability is a locale where participants in organizations manoeuvre strategies and tactics and calculate their gains and losses. Those who join an organization carry their hopes corresponding to stated organizational goals. Negotiability is one of the determining factors of their participation because "once something has become negotiable, it expands our identities because it enters the realm of what we can do something about" (p. 248). The membership of the organization becomes one of individual identities, I stress, *subject to change*. Individuals maintain their membership and retain that identity as long as they can perceive the scope of their influence and the purview of their contribution. This field of negotiability will affect the types of problems the members try to address, the available resources they are able to mobilize, the risks they should avoid and how they direct their inventiveness. It is with and through these practices that personal hopes are disappointed or fulfilled, corresponding identities relinquished or fortified.

In the next chapter, I will focus on how identity reconstruction can take place in the experience of the WTWIP, as a field of negotiability. Through the organization of a women's group in physics, I investigate how they position their identity as women in physics, in relation to their identity as women and as physicists. I also look at their career decisions to remain in the identity of "women in physics" and what kind of "women in physics," is negotiated and contested through their participation in the WTWIP. I then draw the lessons that can be learned from their decisions and ponder the implications for a gender-informed physics curriculum.

CHAPTER 8

IDENTITY RECONSTRUCTION WITHIN DISCOURSES

In Chapter 7, I argued that negotiability is an important factor in decisions regarding participation and identity. Once people sense that they can do something for a particular cause, in a group or in an organization, they are more likely to take part and their membership and participation in the group become one of their identities. Responding to the “interpellation” of “women in physics” from the international community, the organization of a women’s group in physics gave rise to opportunities for women in physics to address issues that mattered to them. With various priorities and concerns, however, its members perceived different scopes of influence and different purviews of contributions; they consequently formed different senses of belonging. The Working Team for Women in Physics (WTWIP) thus provided women physicists in Taiwan with a contentious site for identity reaffirmation and reconstruction. Their personal identities as women in physics interacted with the organizational identity of “women in physics,” leading to new career visions and decisions regarding physics.

In this chapter, I illustrate the outcomes of organizing a women’s group such as this, in physics in Taiwan. I describe the identity change of women physicists through their various types of participation and their corresponding career decisions.

Identity Reconstruction of Women in Physics

As explicated in Chapter 7, the opportunities and challenges facing the WTWIP formed a field of negotiability and, within this field, its members formed different senses of belonging. These various formations, though, did not happen automatically or independently, but took place when individuals negotiated between the multiple subject positions provided by available and competing discourses. As I discussed in Chapter 3, discourse is not merely words written or spoken, but something people *do*—some actions through which people actively work out their subject positions and their roles in the process of negotiating discursive constraints. In this sense, theories of discourse have a connecting point to theories of practice within which the concept of the field of negotiability is based. Various senses of belonging and negotiability are the outcome of negotiations between various subject positions.

In the following sections, I use the theory of discourse to illustrate the identity reconstruction of women in physics. First I describe the four competing discourses available to women physicists in Taiwan. Second, I use the experiences of three women physicists—Jing, Hong, and Kim—to demonstrate how they reconstructed their identities in relation to these four discourses. I then draw conclusions for this chapter.

Three Women Physicists and Four Competing Discourses

Jing, Hong and Kim are women physicists working in three different institutions. Jing works at the prestigious National Wannice University as an associate professor, having been hired in 1995. As mentioned in Chapter 6, although Jing was among the younger

generation of women physicists, she was not enthusiastic about the topic of gender in physics. Hong, also described in previous chapters, was a fairly new full professor in a national university in the south, which, in her opinion, is less prestigious and has less impressive resources than universities in the north. Unlike Jing or Kim, Hong obtained her PhD degree from the National Taiwan University—a “home” degree perceived to be less competitive than foreign ones in the academic culture of Taiwan. Kim served as a full research fellow, equivalent to a full professor, in a separate research unit from Jing’s department but in the same university. Before returning to Taiwan, Kim worked for famous US companies such as GE, GM, and IBM. The Taiwanese government recruited her for her rich experience in a leading field of physics which recently had garnered much interest and into which, had been poured vast resources. More relevant details regarding their backgrounds will be included in subsequent sub-sections.

I chose the experiences of these three women physicists because they represent a range of identity reconstruction through the reconfiguration of available competing discourses. The discussion of identity reconstruction will focus on two identities: woman and/or physicist. Being the only female faculty member in her department, Jing strongly resisted being identified as a “woman in physics”. With exposure to limited competing discourses, several of her decisions showed the existence of conflict between her identity as a woman and her identity as a physicist. Hong also spent many years as the only female faculty member in her department. Her identity as a woman and her identity as a physicist were first confluent, but later conflicted when other competing discourses appeared. Confluence between these two identities emerged again after she participated in the organization of the working team. Kim was another key member of the group and was

exposed to discourses regarding gender and feminism. She showed coherence between her identity as a woman and her identity as a physicist in her active role in the working team.

Four discourses were involved in the identity reconstruction processes of the three women physicists. My aim is to show that, through the reconfiguration of such discourses, Jing, Hong and Kim demonstrated different levels of identity conflict, confluence and reconstruction. These discourses are “the physics discourse,” “the woman discourse,” “the international discourse of women in physics,” and “the local feminist discourse.” By the physics discourse, as described in Chapter 5, I mean the discursive practices that delimit the definition, value and meaning of working in the field of doing physics and of being a physicist that occur in physics communities and departments in Taiwan. By the woman discourse, I mean the discursive structures of physics departments and the cognitive status of physics that trigger the dual o/Othering process for women in physics, as described in Chapter 6. By the international discourse of women in physics, as was partly described in Chapters 4 and 7, I refer to the mandate set by the International Association of Physicists (IAP) to organize a women’s group in physics in every member country. It became a task that most male physicists in Taiwan did not dispute and had to accept. By the local feminist discourse, also partly described in Chapter 7, I mean the feminist development in Taiwan and its current influence in the political arena and the academia of social sciences and humanities, especially after 1994. All of these are valid discourses because they generate statements, ideas, and practices that call individuals into the subject positions of physicists, of women, of women in physics and of feminists in Taiwan.

From a feminist poststructuralist point of view, these four discourses form the “discursive field” where the interaction and competition of these four discourses take place.

Chris Weedon (1987) defines “discursive fields” as:

...consist of competing ways of giving meaning to the world and of organizing social institutions and processes. They offer the individual a range of modes of subjectivity. Within a discursive field, not all discourses will carry equal weight or power. Some will account for and justify the appropriateness of the status quo (p. 35).

In the following sub-sections, as I describe the individual cases of the three women physicists, I show how their identities as women and as physicists conflict or coincide with each other through the reconfiguration of the above discourses. While the physics discourse, the women discourse and the local feminist discourse were available locally, the international discourse of women in physics was brought into being and functioned to anchor and sew the three other discourses together. It had a crucial impact on making the identity reconstruction process possible and functioned as what I would call an “interventionist discourse.”

Jing: Don't Single Me Out as a “Woman in Physics”

Jing was recruited as the only female faculty member of her department at the prestigious Wannice University in 1995. Wannice University was established after World War II, when the KMT government began its close ties with the US and established the first physics department in Taiwan. With this particular historical heritage, the university is

viewed as the Harvard equivalent for Taiwan; it also holds an international reputation.

Before Jing was hired, there had been another female faculty member, also the only one, in the department for twenty-five years. When it came time for this senior female member to retire, she insisted that her position be filled by another female in order to keep the tradition and maintain their department as a model physics department in Taiwan, wherein every physics department should have at least one female faculty member. When Jing applied for the position, she was also the only female candidate among others. In one of the selection committee meetings, this senior female professor told other committee members that she would reconsider retiring if the department failed to recruit an excellent female candidate.

The selection committee decided to hire Jing. In fact, many senior committee members knew her well because she had completed both her Bachelor's and Master's degree in this very same department. In both degree programs, as the senior retiring female professor remembered, Jing received the first place award every year. With such extraordinary distinction and strong reference letters, Jing was admitted to a famous, prestigious US Ivy League university to continue her PhD program in physics. When she applied for her current position, she presented an outstanding academic record, excellent publications and cutting-edge research proposals with her newly earned PhD degree. The selection committee's internal reason for hiring Jing remains unknown, but later she learned that there was a "hire a woman" conversation during the competition process. She was very upset by this.

After Jing joined the department, the retired female professor approached her and asked her to take special care of the few female students in the department because they would see Jing as their role model, a position the senior professor had held before her

retirement. Jing rejected her suggestion and told her that she did not see any reason to separate female students from male students, nor did she think female students needed special care. In the first few years of her employment, Jing was asked several times to sit on various departmental committees because she was the only female faculty member. She was expected to speak for female students and for herself, in ways her male colleagues were not expected to. She rejected these invitations and told them that she refused to sit on any committee as simply a woman representative. When her male colleagues presented to her the mission to form a working team on women in physics, she rejected it again and stressed that she had no interest in participating in such a group if it was merely focusing on women. Her colleagues were surprised by her rejection and later learned not to mention the word “woman” if they wanted to include her in any collaboration. When I was wrapping up my fieldwork in the summer of 2002, I learned that she was looking for a position in another institution.

Jing’s repeated rejections of the label “woman in physics” and her refusal to act as a woman representative clearly show her discomfort with the fact that she was both a woman and a physicist. However, her reaction is quite common among many women physicists and is a stance many minority members often take when pressed to represent their minority group in their institutions or in other public spheres. As I discussed in the “Identity Politics” section in Chapter 6, minority members resent being addressed by the aspect that makes them different from the majority of members. Some of them follow the expectations and rules of the institutions even more strictly than the majority members because they want to show that they are qualified members of the community. In order to justify their existence, many choose to silence their differences or may offer hostile responses towards any

conversation about these differences because, to them, difference can mean some intrinsic inferiority that they have tried hard to dispel so that they can be just like one of the majority. A process such as this is how a community or an institution, acting as a discursive structure, functions to regulate the perceptions and behaviours of individuals and perpetuates the existing power structure. In such instances, a role model for minorities runs the risk of becoming an excellent substitute member of the majority; that is, a black role model becomes a substitute White or a female role model becomes a substitute male.

Jing was troubled by the conflict between the woman discourse and the physics discourse. These two discourses function to produce the common stereotype that ordinary women cannot do physics, or that ordinary women do not have an adequate ability to do physics. Within such discourses, the idea of woman is associated with inferiority. As an exceptional woman who can do physics, Jing tried hard to prove that "some" women, such as herself, could be "as good as men" in physics and that she was a qualified member on the superior side. However, when it came to the moment of recruitment as recognition for her accomplishments, it struck her that the woman in her was brought out by others and was, she suspected, attached to the fact that she was given the recognition. The deemed inferiority came back to haunt her. Jing was overtaken by the physics discourse against women. She failed to acknowledge that her own academic excellence could be fully and legitimately consistent with her sex and gender. The incompatibility between the woman discourse and the physics discourse continued to bother her to such an extent that she did not feel comfortable being addressed as a woman in physics or to join any kind of group associated with such an idea. Her identity as a woman and her identity as a physicist continued in conflict with each other. It prevented her from being exposed to or accepting other

discourses related to women, such as the local feminist discourse and the international discourse of women in physics.

Hong: Maybe I'll stay for the Future of Women in Physics

Hong had been the only female faculty member in her department for 10 years and there had been no other woman hired before her. She used to brag that she was the only female physicist between the north and south quarter-ends of Taiwan for a decade (Field Note No. 052502), until two other female physicists were recently recruited into other universities in the same region. It seems to me that she was proud to be a “woman”—an extremely exceptional and certainly not an ordinary one. She kept long, black hair and sometimes wore skirts to state her femininity in the department. Besides her use of such a coded femininity, she stressed that she could be very tough and rigorous with her male students, though sometimes easier on her female students. She said, “They [the female students] tended to have more emotional troubles” and “If they have emotional breakdowns, the whole lab can be affected.” (Interview No. 041402). In the 10 years, Hong had once encountered sexual harassment by a male faculty member from another department but had no one in her department or in her network to talk to. She felt quite isolated and helpless in this sense. She also complained about feeling isolated because her male colleagues usually formed groups for activities in which she could not join. She considered these activities unsuitable for women.

Hong joined her department in 1993, and after five years, was promoted to full professorship in 1998. She had a reputation among other female physicists of being a “hard working” type—a single woman focusing on nothing other than work. In 2000, she married

another physicist who worked in the US and began trying to have children. She had difficulty getting pregnant partly because she was in her early forties and partly because she was maintaining a long-distance marriage. Because her husband worked overseas, Hong complained that it was difficult to arrange to spend time with her husband. Hong was considering quitting her job, if necessary, to be a full time mother-to-be because she was feeling tired of, and unsatisfied with, her work. She questioned whether choosing a demanding and hard-working career in physics was a good decision for women who also wanted a family life.

When Hong first received the invitation to form a working group for women in physics, she was not particularly interested until another invitation arrived. Her closest female friend in the same university, who called herself a feminist sociologist, invited her to speak to some female students in a prestigious high school to encourage their interest in science and technology. This second invitation inspired her interest in forming a working group to support and mentor the future women in physics. Drawing from her experience, she thought that it was important to talk with girls about whether they were suitable for physics and the possible challenges that lay ahead.

She then actively responded to the first invitation and took the initiative to form the working group. She organized several meetings and recruited several other women physicists to join her. However, in as many instances as possible, she wanted to make sure that some male colleagues were also included in this working group. She was afraid that excluding males also meant excluding resources. Hong believed that forming a women-only group, or a considered-to-be feminist group, inside the physics community, would not gain support but instead, offend male colleagues who usually have more resources and were

members of a more powerful network. She took a very careful, almost anti-feminist, stance in organizing this group. In a ten-page report to the Taiwanese Physicists Association, she mentioned five times that this working group should not be mistaken for any kind of “feminist” group. In a preparatory meeting in which some male colleagues and students were present, she urged them to take it easy on the establishment of this group and not to think of it as a “feminist” attempt.

I asked Hong how she felt and what she thought about feminism. She told me about her feminist sociologist friend. This friend “revealed” to her some of the fierce conflicts inside the feminist scholars’ association. Sometimes good friends became enemies. Feminism, to her, was not working well even within its own feminist community. Therefore, Hong did not believe that it would be a good strategy for this working group to adopt any feminist stance. Hong’s sociologist friend also brought up some negative feelings when this friend tried to “sell” feminism to Hong. The friend, who was interested in women in science, kept telling Hong that because she was a minority in physics, she must have been oppressed or discriminated against. She wanted Hong to identify how her male colleagues oppressed her and how Hong should fight for her equal rights. Hong did not feel that her situation was so and was not in the position to receive this kind of advice. For Hong, this friend’s feminism was not emancipating, but rather coercive.

After two years of service, Hong stepped down from the chair position of the WTWIP but remained involved in group activities. She worked with other women physicists in the team to maintain a support network among women like herself and to help female graduate and undergraduate students to survive in physics. This task became the most meaningful to her and she decided to remain in her physics professorship to carry out this

task. During my research period, she once specifically mentioned to other members of the working team that conflicts between the professional demands of physics and the biological constraints of women physicists' were neglected issues in the discipline of physics (Field Note No. 030902). She urged other members of the team to work to make these issues visible and not to dismiss them as personal problems. The working team certainly gave her a sense of community in which her ideas of collective action against a structural problem were inspired and fostered.

Unlike Jing, Hong's understanding of her recruitment to the department was not involved with issues of "hiring a woman". Her bragging about "both quarter ends of Taiwan" and her feminine appearance showed that she was quite happy to be seen as an exceptional case among ordinary women. In this sense, her identity as a woman and her identity as a physicist were confluent with each other. In her marriage, she started to draw on other aspects of the women discourse and felt the pressure to give birth. Her repeated failure drew her to question the physics discourse she had formerly embraced. At this period in her life, her identity as a woman began to conflict with her identity as a physicist. She questioned whether physics was a good choice for women and she was considering quitting her job even though she had achieved a full professorship. This situation changed when the international discourse of women in physics intervened. The international discourse of women in physics provided her with an internationally legitimate ground to call herself a "woman in physics" and gave her a new and meaningful understanding of her position. It encouraged her to remain in the position of a woman in physics. This international discourse, however, has not changed her negative opinions about feminism. She interpreted the kind of local feminist discourse she was exposed to as rather imposing and dogmatic. It would be

interesting to see how her identity as a woman in physics may change or transform in the future if she becomes exposed to more diverse kinds of feminist discourse.

Kim: We Are Responsible For the Word “Feminism”

In contrast to Hong, as the successor chair of the working group, Kim was keen on addressing gender issues and was friendlier to the idea of “feminism”. She responded enthusiastically to my request for an interview about women in physics and immediately told me that improving the situation of women in physics was always an important issue for her. Her different attitude towards feminism was shown in a preparatory meeting for the local symposium when she had a dispute with Hong. During the meeting, as usual, Hong was stressing the importance of including men in the working team. Therefore, she argued, they must include several important men from the physics society in this symposium, even though the symposium was designated for women only. From Kim’s viewpoint, however, the purpose of organizing such a symposium was to provide a safe, private, space for women physicists to gather and meet each other, which would be different from other kinds of public conferences or symposia. After several exchanges among meeting participants, when Hong’s opinion was about to be approved since it was a habit she had established, Kim anxiously interrupted with “Why do we always have to hold on to men’s legs?” (Field Note No. 0330)

In my observation, Kim’s belief in a “women’s safe space” was a product of her participation in an awakening group for women. Troubled by family problems, Kim was introduced to this women-only workshop whose main goal was to reflect upon the stereotypes concerning women and women’s body concepts. Through the course of her

participation, Kim said that she experienced tremendous personal growth and re-identified herself as a strong woman growing out of a previously vulnerable, insecure and self-doubting one. She believed that women's growth and strength could be evoked in a women-only space and she was ready to share this positive experience with other members in the working group. The kind of support she received made her strong, capable, and ready to continue her career in physics. It empowered her to encourage other women to stay in physics.

Eight years ago, before returning to Taiwan, she served as a senior research fellow in the Research and Development sector of a famous US company for energy and technology applications. In that company, some family-friendly facilities were provided and policies were implemented to assure equal opportunity for the participation of women and minorities. Although Kim was not particularly active in pursuing women's equal rights at that time, she was certainly exposed to that kind of feminist discourse available in the US. Therefore when the call for organizing a women's group in physics arrived at her office, she was no stranger to such discourse and promised to participate as an active member. For her, the fairly smooth connection between local and international feminist discourse enabled her to view the organization of the team from a feminist perspective. One day she shared with me a conversation she had with Hong about their different attitudes towards women's equal rights and feminism. In the conversation, when Hong tried to suggest to her a necessary distance from the idea and label of feminism, she told Hong:

I don't see the point of distancing ourselves from feminism. To say that we are not doing something for women's rights is to undermine women's rights. What we are

doing is pursuing the equal opportunities and equal rights that men already have.

What we want is a win-win result. There is nothing wrong with talking about women's rights. Maybe we are socially responsible for the word 'feminism' too.

(Interview No. 051502)

For Kim, her identity as a woman was once at stake because of family issues, but soon after her participation in the awakening group, her identity as a woman became settled. She did not question the value of being a woman in physics but celebrated it. In this sense, her identity as both a woman and a physicist appeared to be confluent and coherent. Her exposure to the local feminist discourse prepared her for a personal and powerful commitment to a feminist endeavour. The international discourse of women in physics provided her with an opportunity to carry out such a commitment. It is reasonable to expect that her identity as a "woman in physics" will be sustained and will enable her to change her surrounding environment.

The Availability of Various Discourses including an Interventionist Discourse

The stories of Jing, Hong and Kim present a range of identity reconstruction via the reconfiguration of four identifiable competing discourses. My descriptions have focused on the dynamics between their identities as women and their identities as physicists. Jing did not have exposure to either local feminist discourse or the international discourse of women in physics. The conflict between the woman discourse and the physics discourse troubled her identity so much that she strongly dis-identified herself as a "woman in physics". Hong's identity as a woman was at first comfortable but came into conflict when the competition

between the “women discourse” and the “physics discourse” appeared. Her exposure to the local feminist discourse was not positive and caused a barrier that prevented her from gaining any benefit from such discourse. The international discourse of women in physics functioned as an interventionist discourse for Hong and persuaded her to stay in her position. Kim was exposed to all four discourses and was able to reconfigure them to support her identity and her ideas about what the working team should stand for. Kim was also capable of dealing with the intrinsic conflict between the woman discourse and the physics discourse and was able to transform the conflict into an emancipating task by utilizing the other two discourses. She expressed compatibility between her identity as a woman and her identity as a physicist.

The experiences of these women show that the availability of various discourses is important to the identity reconstruction process. When the number of discourses is limited, the subject positions, which provide sensible and meaningful identities, are also limited. Individuals can contest the durability of their identities among these subject positions. Such contesting can be a process of internal contradiction, especially when the available discourses are competing against each other, as in the case of the woman discourse and the physics discourse. The availability of various discourses is crucial for identity durability, reconstruction and potential transformation.

Also evident from the experiences of these three women physicists is that the existence of an interventionist discourse is necessary for an individual's identity reconstruction. The international discourse of women in physics functioned as a discourse which intervened in the existing discursive field made up of the women discourse, the physics discourse and the local feminist discourse. It was able to carry special force and

make a big impact because of the particular international status of Taiwan. Physicists in Taiwan, regardless of whether they were male or female, regardless of whether they agreed or disagreed with its mandates, could not simply ignore or dismiss this international discourse of women in physics because it was a token of admission for Taiwan's participation in the international community of physicists. This "interventionist discourse" changed the existing discursive field and brought in alternative but related subject positions so that individuals could reconfigure their positions in that field.

Identities are the matching of individuals onto meaningful subject positions they find within available discourses. If current discourses do not provide meaningful positions for the identities of individuals, the availability of other discourses becomes critical. When alternative discourses intervene, they offer individuals more possibilities for reconstruction and transformation. Subject positions produce meanings for people to see who they are and what they can do. Identity reconstructions affect individuals' choices regarding whether they stay in their own positions, in their own departments, or do progressive work based on their positions. The cases of Jing, Hong, and Kim elaborate the importance of the availability of various discourses, including interventionist discourses, in the identity constructions and career decisions of women in physics in Taiwan.

Negotiability and Empowerment

Riding the high tide pushed by the international discourse of women in physics, the working team of women in physics in Taiwan organized a local symposium for women physicists and chemists. Its goal, as finally settled by the team members, was to provide a

women-only space for women scientists to meet and to get to know each other. During the symposium, several women physicists explicitly showed their sense of negotiability and empowerment after participation in this symposium.

For example, Dr. Fang, who was the vice president of student affairs in her university, stated that physics was the easiest thing in her life. Compared to other personal anguish she had long suffered, including living with a life expectation of only a few years because of a chronic disease that was still bothering her, physics was the easiest thing to negotiate and something that granted her a strong sense of accomplishment. Another symposium participant, who was a PhD student in a local university as well as a full time physics lecturer in another institution, commented that education was her only opportunity to escape from her extremely patriarchal-sexist parents and their conservative village. Physics was a gift to her because it allowed such an opportunity. She was always close to 100% in any physics examination but was forced to give up program admission to an Ivy League university in the US because her parents were opposed to a daughter's education. She was constantly fighting her way out by way of physics. For her, physics was something she could use to negotiate strict conditions and constraints in her life. Even Dr. Hong mentioned that physics offered her tools to deal with the hardships and challenges in other aspects of her life. She gave the example of dealing with her demanding and sometimes difficult in-laws. In her opinion, constantly investing emotions into relationship management was not wise because people could end up giving too much of themselves and still not solve the problem. She thanked physics for teaching her how to stay detached and objective from situations and how to negotiate in her best interests. She also suggested using research skills to solve interpersonal problems.

These exchanges show how collective actions could be imagined through the organization of a local symposium under the mandate of the international discourse of women in physics. Although these women had known that other women worked in other physics departments, they found that meeting so many of them in person, and in one place, was eye-opening and empowering. In such a setting, their positive view of physics was evoked and highlighted. Their acknowledgement of the use of detachment and objectivity furthermore carries theoretical potential to talk back to feminists' heavy criticisms of the problems of positivist sciences and their negative impact on women, as described in Chapter 2. In these exchanges, their *feelings for physics* were transformed from those of individual struggle to those of collective endeavour. Physics had become a field wherein they could negotiate their sense of belonging and a tool to negotiate other parts of their lives outside of physics. In this sense, the international discourse of women in physics enabled a sense of negotiability in the discipline of physics and confirmed their identities as women in physics.

The identities of individuals are constantly under reconstruction through the reconfiguration of available subject positions provided by on-going discourse. If current identities are under challenge or contest, a process of identity transformation or confirmation can take place. New discourses intervening with direct relationships to existing discourses are crucial in this process of transformation or confirmation. The moment of feeling a sense of negotiability—feeling that there is something they can *do*—defines a temporary settlement for this identity reconstruction: fitting in a new identity with which they can negotiate, or staying with an old identity within which a new sense of negotiability becomes possible. To be a woman in physics or not, becomes a consequence of the availability of

both accessible and interventionist discourses, and the sense of negotiability in a given time and place.

CHAPTER 9

CONCLUSION

This dissertation has attempted to first track, then further explore, a shift in focus from equity to identity in gender and science education studies. This shift can be understood in two ways. First, the identity focus investigates some questions that the equity focus left unasked. One such question is why providing equal access does not necessarily increase the participation of under-represented groups. In response to this question, the identity focus suggests that decisions regarding participation should also be understood as a matter of identity. Second, the identity focus can be seen as an attempt to bring more research attention to the question of individuals' agency in making decisions, while the equity focus can be seen as an attempt to put greater emphasis on the structural constraints on these decisions. However, because notions of agency can never be defined without understanding societal constraints, the identity focus cannot produce a comprehensive picture without drawing upon and connecting itself to the equity focus project.

In this dissertation, I have found that discourse theories have been especially useful in making this connection between an equity focus and an identity focus in gender and science education studies. Discourse is where social structures are realized; it also provides the materials that individuals pick up to author themselves. The configuration of a discursive field reveals the structural power behind it—the power that determines what discourse is available, what is absent, which is more important and which is less pertinent. By investigating individuals' identity formation and transformation, we see discourses, discursive fields, and the structural power behind them. An identity focus requires us to trace

a trajectory beginning at the level of the individual and landing at the level of structure. In this way, a shift to identity promises to talk back to equity focus projects.

A discursive field is where identity evolves and a site where naming happens. All naming—to name oneself or to be named as someone—involves interests and leaves traces of the execution of power. Whether a physics teacher counts as a physicist depends on the context and the purpose of naming. A physics teacher may be addressed “you are the physicist here” when people are looking for someone with a science background, either to ask questions or to attribute responsibility; they may also be seen as second-tier students—as opposed to “the real type”—in the training of physics; and they are certainly not seen as physicists when surrounded by their colleagues who are conducting research while they are “just” teaching. Women in a physics department are usually said to be “no different from” or “as good as” their male counterparts, but they can be identified as “the woman” amongst physicists as soon as the women discourse suits the interests of the physics discourse. Examples here include assigning tedious work to female students because women “are” more careful than men or treating female colleagues as sexual objects. On the other hand, these “exceptional” females may use the physics discourse to distinguish themselves from the “ordinary” ones who did not “take the hard route”. They see themselves as “the physicists” amongst women. In this sense, granting—or not granting—the label of “physicist” involves re-circulating the image and status of physics as the hardest science, male normalcy in physics, the cognitive superiority of physics and the values and norms in the reproduction of physicists.

Power issues in naming become visible when we ask whether, and when, one would identify oneself as a “woman in physics.” In most cases, efforts to make gender visible in

physics are readily seen as violating the belief of gender neutrality in science. Women physicists who talk about gender bear the potential stigma that either they are finding excuses for limited research productivity or they are discounting women's abilities in physics. However, once the label of "women in physics" carries international legitimacy, and once this label can be used as a token to justify the membership of other physicists' in an international organization, this identity of "women in physics" becomes instantly desirable and highly supported. When the international discourse of "women in physics" translated to a local call for a working team for women, different women physicists' various responses to this call revealed a generation gap concerning different women's relations to the development of the local feminist movement. Based on my interviews, I found that the younger generation may have smoother identification with the subject position of "women in physics" and feel more comfortable in making gender visible in their discipline, while the elder generation may feel that the discourse of "women in physics" could lead to a discounting of the value of their accomplishments and their previous hard work in the discipline of physics.

Such tension between the subject position of physicists and the subject position of women echoes the long-standing and well-known tension between women scientists and feminist science studies. Superficially, feminist critiques of science seem to devalue the achievements of women scientists—those who have made it into the enclaves of the "hard" sciences. Many women scientists take the discourse of the gender neutrality of science as the ground on which to prove that women "can also do" science. For them, feminist critiques of science reinforce traditional stereotypes—both of women and of science—and is hurting rather than advancing their cause (Longino & Hammonds, 1990). This situation partly

explains why feminism, several decades after it has influenced and significantly redirected many other disciplines, has made only a limited impact in science and still bears a deeply stigmatized image among women physicists. The problem is, as Longino and Hammonds (1990) has pointed out, that many women scientists recognize the difficulties women encounter but nevertheless ignore the problems in the structure of scientific knowledge and science education. They persist in arguing against the perception that women can't do science but have not questioned the source of such a perception. In my view, that is to say that they approve of the "woman question in science," but disapprove of the "science question in feminism."

In Chapter Five, I have argued that the source of such a perception resides in the basis of scientific knowledge—reductionism. While the physics discourse is constructed around reductionism, the women discourse is shaped in antagonist relation to it. If the conflict between the subject position of physicists and the subject position of women is not eased, there cannot be a smooth and durable identification with the identity of "women physicists"; if the conflict between the physics discourse and the women discourse is not solved, the dream of stating that "there need be no conflict between being fully-fledged scientists and being fully female—we get to be both"¹ cannot come true.

The findings of my dissertation research suggest that whether to identify—or not identify—oneself as a "woman in physics" is a political move that requires careful calculations and that has real-life consequences. Women physicists need to consider what these labels do to their image in their departments, how their colleagues respond to these images and what these images do to their chances for career mobility. On one hand, the

¹ Quoted in Longino and Hammonds (1990), original source from Sheila Widnall, "We're Ok: International Sexism: Issues for Women Scientists," AWIS Newsletter, 18, 3 (May/June, 1989).

women physicists I interviewed have to take care of their male colleagues' hurt feelings and assure them that their actions are not accusations of any unequal treatment or complaints about working in a disadvantaged environment; on the other hand, they have to accumulate support from these male colleagues who have better power connections and access to better resources. It is a situation of simultaneously being critical of and passively accepting their working environment. While the senior women professors may strategically include male participants in the "women in physics" group to ensure that resources are available, the junior faculty members have to, in front of their male colleagues, downplay their connections to the "women in physics" label in order to promote the cause of "women in physics."

The situation of the junior faculty member in my study is even more challenging when one considers that review of her promotion has to receive her powerful colleagues' approval. Her current passion, time and effort spent on the cause of "women in physics" may be used as "evidence" to disadvantage her future promotion under the rationale that, since she was into "women's work," she must not have been able to spend adequate time in her professional career. However, this junior faculty member's evolving connection to another organization—the WTWIP—can provide future support and resources to cope with pressure from her department. Her membership in another physics-related community indicates her lessened dependence on—and the diminished control of—the original community.

My dissertation has found that identifying oneself as a "woman in physics" is a two-fold identity politics. It is an identity politics internal to how women physicists perceive themselves when they deal with the conflict between the woman discourse and the physics

discourse. It is also an identity politics on the external, practical ground concerning the interests and benefits of being a woman and/or being a physicist. Taking on a particular identity is thus “both cognitive and social,” borrowing Brickhouse’s and Lottero-Perdue’s (2003) words. It is a result of how individuals perceive themselves and how others respond to these claims. Through my analysis, I have argued that identity involves the purposes, the interests and the contexts of particular naming processes. Power leaves traces in each step and is in the consideration of each move. Nevertheless, identity construction can be used as a means to accumulate resources. Therefore, identity is not only a result of power execution; it is itself a tool *of* power and *for* power.

Identity reconstruction takes place in discursive fields and various discourses are necessary conditions for identity reconstruction. Identity can never be fixed but is always under challenge. Identity stability and durability reside in the critical balance of currently available and sometimes conflicting discourses. A change in a discourse leads to a change in the discursive field. This change enables individuals to reconsider who they are and what they may potentially do. Sometimes individuals begin to imagine alternative careers because of this change. On the other hand, if there are other related discourses intervening in the dynamics of the existing discursive field, such interventions provide individuals with additional elements to reconfigure a new balance of all the discourses “in their hands” and to reconsider their decisions and their careers accordingly.

My study of the identity reconstruction of women in physics in Taiwan shows that both the availability of diverse discourses and the existence of interventionist discourses are crucial to the identity reconstructions and career decisions of the women physicists who participated in this research. For some of the women I interviewed, exposure to the local

feminist discourse helped to soothe the tension between their identities as women and their identities as physicists. Exposure to this discourse also helped junior women physicists to foster more positive attitudes toward the topic of “gender” and allowed them to develop more flexible images of women physicists. The international discourse of women in physics provided some in-doubt women physicists with new elements to re-imagine their contributions to physics in new dimensions. These examples address, again, the importance of the availability of diverse discourses, including the interventionist discourse, in a discursive field. My study therefore demonstrates that investigations of identity reconstruction are important ways to understand gendered decisions under structural inequities. I argue that structural inequities are manifested in the lack of diverse and interventionist discourses and are in turn maintained by such lack. I suggest that examining current discursive structures and introducing interventionist discourses help generate social transformation and help make possible a more equitable future.

The lessons I have drawn in this dissertation from the experiences of women physicists in Taiwan have important and varied implications for our understanding of education. Curriculum ought to be thought as a discursive field where various discourses are present and competing with each other. Curriculum is also a path on which learners live through a period of their lives and contest or reconstruct identities that will have long-term effects on their future decisions. Curriculum discourses provide potential subject positions and produce potential meanings through teaching and learning. Critical reflections on current curriculum structures should include space to inquire about what subject positions are available in current curriculum structures, what meanings are produced through these curriculum discourses and what identities are called upon and produced through teaching

and learning. Investigations of the current, usually mainstream, curriculum discourses should expose what norms are maintained, what beliefs are perpetuated, what values are reproduced and what is marginalized or excluded. Social inequity ought to be understood as an outcome of the lack of variety of discourses in current curricular structures. Hope for social transformation can be situated in the interventionary power of new discourses and the subsequent reconfiguration of existing curricular discursive fields.

For science education, viewing curricular change from the perspective of discourse resonates with the goals of gender-inclusive science education. In gender-inclusive science, active inclusion aims to engage students of various backgrounds and to develop corresponding teaching strategies for teacher education. It also aims to expose the scientific orthodoxies, the masculinist values and the controversial character of science so these problematic features can be challenged and hopefully changed. As the Women in Science Education (WISE) group has advocated, science education ought to be an education not only *in* science but also *about* science. However, these goals can be easily trivialized as “adding flavors” to the dominant science curriculum and be simply transformed into one or two marginalized “lesson units.” The perspective of discourse on curricular change, on the other hand, stresses that the existing curricular structure is an outcome of power politics about norms, beliefs, values and identities, and that curricular change requires a systematic reconfiguration of the discursive field of curriculum rather than simply adding items within the existing power structure.

For teacher education, viewing curriculum from the perspective of discourse enables us to imagine a teacher education to prepare future science teachers to be “double agents.” First, curricula for science education should equip student teachers with perspectives of

discourse to identify for themselves the previous dominant curricular discourses that had prepared them. Student teachers need to be able to identify the norms, beliefs and values in their previous science education and to develop skills to locate biases and narrowness in order to contrast the mainstream from the marginalized. Student teachers, then, need to be equipped with the ability to increase the variety of curricular discourses and to recognize and introduce interventions into the existing curricular discursive field. This means that, on the one hand, student teachers need to be able to recognize that they were prepared as agents of the dominant curricular discourse; and, on the other hand, they need to transform themselves to become agents to question and potentially disrupt such dominant curricular discourse. With these critical skills, teachers can facilitate students' various identity formations and transformations.

For gender issues in science education, the deeply held hope for gender equity in science can no longer be naively translated to projects to increase women's participation in science. We instead need to question: why include more women in science? Is science good or is science problematic? After the feminist critique of science has proved that the science is problematic, especially for women and for minorities, how do we approach the issues of gender equity in science? While waiting for a feminist version of alternative science to develop before recruiting more women is too utopian, assuming that a critical mass would necessarily lead to change may also be too optimistic. How role models for minorities can remain active and critical and not become substitute members of the dominant group is an urgent matter of identity management involving competing discourses about minorities and about the dominant. The possibility of alternative science relies on how these role models understand critiques of science and how they envision their contributions based on viable

and durable identities as alternative scientists. The participation question of women in science and the science question in feminism can be integrated in this way through the future investigation of identities and discourses.

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