Science Education Reform in Confucian Learning Cultures: Policymakers' and Science Teachers' Perspectives on Policy and Practice in Taiwan

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Abstract

This qualitative inquiry seeks to investigate secondary science teachers' and policymakers' perspectives on science education reform in Taiwan. It also unravels the unique challenges involved in implementing constructivist pedagogical approaches in Confucian learning culture. Data from multiple sources including policy documents, curriculum guides, interviews with teachers and policymakers, as well as teachers' reflective journals were obtained to understand various discourses around the reform. Data were analyzed using various analytical tools, such as concept mapping, thematic analysis, and constant comparative method. These analyses revealed diverse perspectives on the complex interactions between Confucian learning traditions and reform-based practices. Notably, teachers' cultural beliefs about teaching conflicted with inquiry-based learning approaches leading to intense internal conflicts, which seemed to have important implications for their professional identity. Various theories of identity construction were employed to understand teachers' struggles and challenges while wrestling with competing cultural and reform-based pedagogical approaches. This work has important implications for current and future education reform initiatives in Taiwan and other Eastern cultures. In particular, this research highlights the importance of considering teachers' cultural values and epistemological beliefs while planning and implementing educational reforms to support teachers in the change process.

Résumé

Cette étude qualitative s'intéresse à la réforme de l'éducation scientifique en Taiwan telle qu'elle est perçue par les enseignants de niveau secondaire et les décideurs. Elle contribue à résoudre les défis qu'apporte l'implantation d'approches pédagogiques constructivistes à l'intérieur d'une culture confucéenne de l'apprentissage. Des données provenant de documents politiques, de guides pédagogiques, d'entrevues avec des enseignants et des décideurs, ainsi que de journaux de bord d'enseignants ont été recueillies afin de comprendre la multiplicité des discours entourant la réforme. Ces données ont été analysées à l'aide de multiples outils, dont la schématisation conceptuelle, l'analyse thématique de contenu, ainsi que la méthode de comparaison constante. Ces analyses ont révélé différentes perspectives quant aux interactions complexes entre les traditions d'apprentissages confucéennes et les pratiques issues de la réforme. Notamment, les croyances des enseignants concernant l'enseignement entrent en conflit avec les approches d'apprentissage basées sur l'investigation. Cela peut mener à des conflits internes majeurs, ayant d'importantes implications pour l'identité professionnelle des enseignants. Diverses théories de la construction identitaire ont servies de cadre afin de comprendre les défis des enseignants devant composer avec des approches pédagogiques conflictuelles. Cette étude a d'importantes implications pour les initiatives de réformes actuelles et futures à Taiwan et dans les autres cultures orientales. Plus particulièrement, cette recherche met en lumière l'importance de soutenir les enseignants lors de la planification et de la mise en œuvre de réformes de l'éducation, en tenant compte de leurs valeurs culturelles et de leurs croyances épistémologiques.

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Chapter 1: Introduction and Overview of the Study

This study seeks to examine the discourses around the new science education policy in a Confucian learning culture. More precisely, it explores Taiwanese science teachers' and policymakers' perspectives on reform in relation to their understanding of Confucianism. In addition, it attempts to illuminate their views concerning the challenges in implementing this reform in Taiwanese schools.

The Taiwanese government has been making earnest efforts to reform the national science education curriculum for elementary and secondary students over the past decade (Ministry of Education, [MOE], Taiwan, 2003, 2004, 2006, 2011, 2012). Importantly, the reform movement in Taiwan has been aligned with the global trends in science education. At the same time, it has been profoundly influenced by the science education discourses in the U.S. (American Association for the Advancement of Science [AAAS], 1989, 1993; DeBoer, 2000; National Research Council, 1996; Yager, 1996). Indeed, educational reform objectives in Taiwan bear a remarkable resemblance to the science teaching standards that were developed by the American Association for the Advancement of Science (AAAS, 1999) and the National Research Council (NRC, 1996) in the U.S.

The Taiwanese reform policy, as outlined in the "White Paper for Science Education," (Ministry of Education, Taiwan, 2004) came into effect in 2004 and is regarded as a turning point in the Taiwanese educational system. According to the *White Paper for Science Education* (Ministry of Education, [MOE], Taiwan, 2004)—the most comprehensive reform policy document available in Taiwan—the goal of science education is to develop critical scientific literacy in students. In particular, the reform

policy highlighted constructivist pedagogical approaches where students are viewed as active participants in their learning (Fosnot, 1996) and teachers are expected to use learner-centered approaches to develop students' knowledge, critical thinking, and problem-solving skills. Compared to traditional classroom environments, teachers in a constructivist classroom act as facilitators during teaching and learning activities (Bransford, 2000; Driver, Asoko, Leach, Scott, & Mortimer, 1994; Fosnot, 1996; Gergen, 1985; Howe & Berv, 1999; Lebow, 1993; Palincsar, 1998). As such, teachers strive to understand their students' needs and provide them with appropriate learning opportunities to promote their engagement and understanding.

The Minister of Education in Taiwan, Dr. Cheng-sheng Tu (2007) emphatically underscored the importance of learner-centered approaches to encourage active participations of students in learning science. As he noted, "The implementation of student-centered pedagogy is the primary goal of science education reform in Taiwan" (p. 12). However, the student-centered approach, which emphasizes students' autonomy, creativity, and critical thinking, challenges the highly regulated traditional education system in Taiwan (Tu, 2007; Zhou & Ching, 2012). Highlighting the reform movement as a significant milestone in education, Tu (2007) argued that Taiwan's citizens asked for this change because they were against the "unreasonable controls and bondages imposed on education by the authoritarian government" (p. 12). As he explained,

> On April 10, 1994, Taiwan's middle-class citizens organized and staged a mass demonstration demanding educational reform. The movement has become a landmark in Taiwan's history. Its main appeal was to demand the removal of all unreasonable controls and bondages imposed on education by the authoritarian

> government and to return to the student-centered educational liberation movement. It demanded a shift of the concepts of "de-centralization" to "individualization." (p. 12)

However, despite these claims by the policy leaders, the science education reform has been strongly contested by various stakeholders within Taiwan. Prior to the publication of the *White Paper for Science Education* (MOE, 2004), a large number of Taiwanese teachers and parents as well as the general public expressed their opposition to the new science standards and curricula, which they thought were largely imported from foreign countries. Furthermore, many teachers and parents felt that the new science learning and teaching approaches were not compatible with certain Confucian values and learning traditions (Zhou & Ching, 2012).

The intense resistance to the reform led the previous Minister of Education, Dr. Yuan-Tseh Lee,[1] to apologize to the Taiwanese people in 2002 for the rapid changes in the science education policy (Zhou & Ching, 2012). However, the Ministry of Education continues to make efforts to implement this policy in Taiwanese educational institutions, despite strong opposition to the reform.

In the following section, I describe the key features of the current science education reform policy in Taiwan.

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[1] The Education Reform Council was formed by Dr. Yuan-Tseh Lee from 1994 to 1996. During Dr. Lee's term as the Minister of Education in Taiwan, the Education Reform Council initiated the reform blueprints and formulated the further reform strategies and implementation from 1999 to 2002 (Zhou & Ching, 2012).

Overview of Science Education Reform in Taiwan

Science is a way of thinking much more than it is a body of knowledge. (Carl Sagan, 1990, p. 263)

Since the beginning of human history, people have accumulated knowledge about the natural world through observation and exploration. In awe and wonder of the universe, the natural process of inquiry has enabled human beings to discover scientific facts and construct logical explanations to make sense of their observations (Sagan, 1999). Science encourages us to ask questions, collect and organize information, test our ideas, and find ways to solve problems. Thus, learning science is essential to know about, think about, and care about the natural and social worlds in which we live. As citizens of the world, humans carry the responsibility to act as stewards of their ecological and social environments. However, despite recent advancements in science and technology, we have not yet succeeded in living in harmony with nature. Indeed, environmental issues such as global climate change, genetically modified foods, and acute resource shortages considerably affect our daily lives. Such global issues have brought science education to the forefront of reform discourses.

Within the past few decades, the international economy has shifted from a traditional industry-based economy to a knowledge-based economy. In response to these economic and social changes, science learning has also shifted to fulfill the needs of a knowledge-based economy. For example, in a traditional industrial economy, individuals would complete their education and often devote themselves to a single lifetime career, such as working as industrial technicians, doctors, schoolteachers, bureaucrats, and so forth. The development of knowledge was relatively slow compared to the rapid growth

in information in the digital age (Zajda, 2003). Furthermore, scientific knowledge has expanded exponentially with the advancement of science and technology, increasing the speed at which scientific facts become updated, irrelevant, or obsolete. According to Gunawardena, Lowe & Anderson (1997), the total amount of knowledge has doubled in a decade, meaning that half of the knowledge today was unknown about ten years ago. In addition, the lifespan of knowledge is diminishing, lasting only a few months, in many fields. Due to these developments in knowledge production, learning has become a lifelong endeavor (Gonzalez, 2004).

Universal science literacy, application of knowledge, and problem-solving skills are essential to the scientific, economic, and social development of a country according to a report produced by the Organization for Economic Co-operation and Development [OECD] (1996), an international organization composed of about 35 countries. These science-learning objectives became the core principles of the national science curriculum in Taiwan. Thus, the current reform in science education is meant to prepare Taiwanese citizens for participation in the global knowledge-based economy (Ministry of Education [MOE], Taiwan, 2003, 2006, 2011, 2012).

Science education now focuses on developing students' inquiry and scientific literacy. The inquiry approach focuses on developing a set of key competencies to foster students' scientific literacy. These competencies include, but are not limited to, critical thinking and problem solving, creativity and innovation, collaboration and leadership, and lifelong learning. Thus, scientific inquiry, and the competencies developed through engaging in science learning, may allow individuals to make informed choices for themselves and their communities. Scientific literacy, on the other hand, reflects a

student's ability to use scientific inquiry to explore the natural world, draw on relevant evidence to identify and understand scientific and social issues, and propose potential solutions to improve our natural and social environments.

The Programme for International Student Assessment (2003) explains scientific literacy as, "The capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to help make decisions about the natural world and the changes made to it through human activity" (p. 21). According to the National Research Council (1996), scientific literacy means the ability to explore, explain, and predict natural phenomena. It not only involves acquiring inquiry skills and scientific knowledge but also reflects the attitudes that a student develops toward science throughout a lifetime.

> Scientific literacy has different degrees and forms; it expands and deepens over a lifetime, not just during the years in school. But the attitudes and values established toward science in the early years will shape a person's development of scientific literacy as an adult. (National Research Council, 1996, p. 22)

Thus, the focus of current science education reform all over the world is to develop meaningful scientific literacy through science education so that all citizens can actively and democratically participate in making decisions and informed choices about our ecological and social spheres (AAAS, 1989, 1993; Blanchard, Southerland & Granger, 2008; DeBoer, 2000; Hagood, 2000; Miller, 1987; Osborne & Dillon, 2008).

Study Objectives

This qualitative inquiry seeks to investigate a number of important questions concerning the reform, as well as its implications for teaching and learning in a culture

where Confucian traditions play a significant role in shaping educational practices. The specific objectives of this study are to:

- Review the goals of science education reform in Taiwan;
- Identify the resources for science teachers' professional development;
- Understand Taiwanese educational policymakers' vision of the science education policy;
- Examine policy leaders' perspectives on Confucian learning traditions and its influence on science education reform;
- Explore secondary science teachers' perspectives on the reform;
- Examine teachers' epistemological beliefs and pedagogical practices in science;
- Understand teachers' professional needs and goals in relation to the reform;
- Investigate the issues and challenges faced by Taiwanese teachers while implementing the reform-based pedagogy.

To achieve these research objectives, data were gathered from different sources, including: (a) science education policy documents produced in Taiwan, (b) interviews with Taiwanese policymakers, (c) interviews with Taiwanese secondary science teachers, and (d) reflective journals written by science teachers. Data from these multiple sources helped in developing a deeper and comprehensive understanding of various issues concerning the reform policy and its implementation in a Confucian learning culture. The study methodology and important findings will be discussed in detail in the following chapters.

Thesis Overview

This thesis consists of seven chapters. In the opening chapter, I have offered an overview of the study, including the research inquiry, its context, and its objectives. Chapter Two provides an overview of the broader philosophical, historical, cultural, political, and educational context in Taiwan to understand the complex discourses around the reform. Chapter Three presents the relevant literature and theoretical frameworks that helped me to conceptualize this study. Chapter Four explains the methodology used to conduct this inquiry. In the same chapter, I also address the issues concerning validity, credibility, and trustworthiness of this study. Chapters Five and Six present an analysis of the salient findings concerning: (a) the evolution of science education policy in Taiwan and the specific goals of the current reform policy; (b) educational policymakers' views about the reform and challenges concerning its acceptance in a Confucian learning culture; (c) science teachers' epistemological beliefs about science teaching and learning and how they shape their professional practice; and (d) the critical obstacles to implementing the reform-based policy in Taiwanese classrooms. Finally, Chapter Seven discusses these findings in light of the relevant interpretive frameworks, researcher's reflexivity, and important study limitations.

Chapter 2: Research Background

In this chapter, I attempt to provide an overview of the geography, history, and culture of Taiwan to illustrate the context in which the contemporary reform is taking shape. Furthermore, I describe the broader features of the educational system in Taiwan. Finally, I present key features of Confucius philosophy that have been instrumental in shaping the cultural and educational values in Taiwanese society.

An Overview of the Historical and Geographical Context in Taiwan

Taiwan, which is also known as the Republic of China, Chinese Taipei, or Formosa, is an island with a total area of 35,980 square kilometers and an approximate population of 23,000,000 people (Executive-Yuan, Taiwan, 2012). The country lies to the east of mainland China, south of Japan, and north of the Philippines (see Figure 1). The official language in Taiwan is Mandarin; English is a compulsory subject in school starting in grade 3.

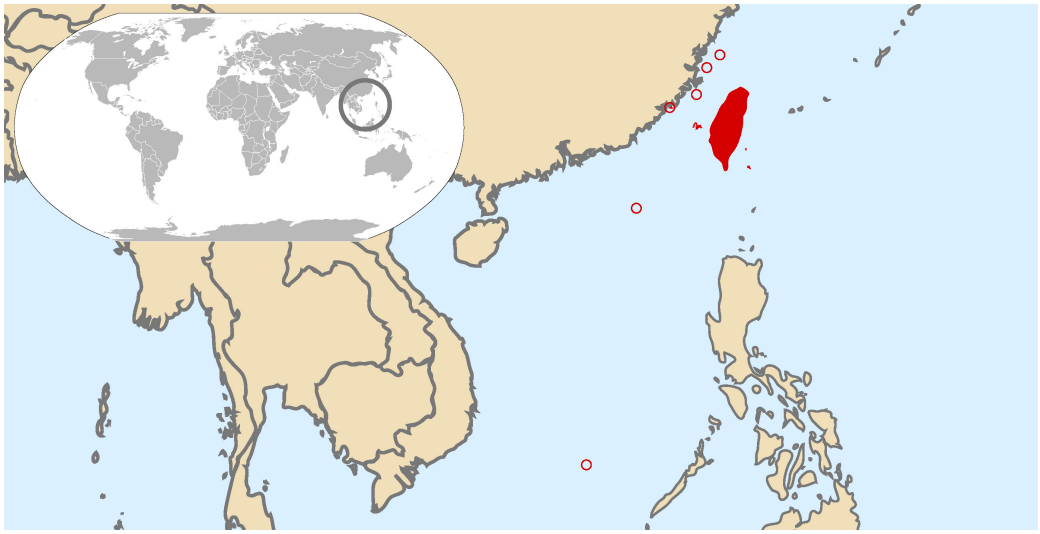

Figure 1: Location of Taiwan (in Red)

Taiwan is shown in red, east of mainland China and north of the Philippines. Adapted from Joshtw, August 10, 2010.

Over the centuries, Taiwan has, at different times, been under the control of China, Portugal, Spain, the Netherlands, and Japan. This makes Taiwanese culture a unique blend of many cultures, though largely dominated by Western culture and Eastern value systems. Today, Taiwan has a democratic and constitutional government despite an ongoing controversy about its historical, economic, and political relationship with China. Citizens of Taiwan are protected by the National Constitution. This Constitution allows the people of Taiwan to protect and conserve their eclectic cultural and religious beliefs.

During the economic boom of the 1970s, Taiwan's rise in the global economy was due to rapid industrialization and advancements in the manufacturing sector. However, since labour costs in Taiwan are higher than those in less-developed economies such as China and Vietnam, Taiwan has been forced away from a traditional manufacturing industry toward a society that requires more innovative economic approaches. Herein lies the significance of science and technology education in the economic and social development of Taiwan.

I turn now to discuss the Taiwanese education system, and then describe the Confucianist learning traditions, which have been instrumental in shaping teachers' ideologies and practices.

History of Education Planning

The development of education planning in Taiwan has always been tied to the country's growing industrial and economic demands. Hay Woo (1991), for example, attributed Taiwan's astonishing economic success before the 1990s to education planning. From the 1970s to the 1990s, secondary science education in Taiwan emphasized vocational training and technological skills. According to Hay Woo, appropriate

educational opportunities and the Chinese work ethic motivate the Taiwanese people to study and work hard. Due to their shared educational and cultural backgrounds, Taiwan, Singapore, South Korea, and Hong Kong became known as the "Four Asian Tigers" and were famous worldwide for their economic success in the 1970s.

In 1996, the National Science Council established an education commission to initiate the first national education reform in Taiwan. The members of the commission consulted experienced science teachers, scholars, and educational leaders while formulating the reform policy goals. The result of these consultations was the *White Paper for Science Education* (2004), which overhauled the country's K-12 science education curriculum. The Minister of Education, Dr. Cheng-sheng Tu (2007), promoted the implementation of student-centered pedagogy as the primary goal of the reform policy. The introduction of student-centered pedagogy has been a milestone in Taiwanese educational reform, as it represents the decline of government control over education (Tu, 2007; Zhou & Ching, 2012).

According to Tu (2007), a student-centered approach carries a historical and political meaning in the educational environment that distinguishes it from imperialist driven education. During the initial stages of the educational reform, Taiwan became a democratic country. Prior to the reform, schools were allowed to use only those teaching materials that were prescribed by the National Institute for Compilation and Translation in Taiwan; moreover, teachers were considered as public servants who had earned high scores on national examinations and were highly respected as role models and experts (Zhou & Ching, 2012). Prior to the educational reform, teachers and students were not allowed to express political opinions or use creative classroom practices (Zhou & Ching,

2012). Taiwanese teachers thus mainly used lecture-based methods for instruction. Student-centered approaches, as a result, contradicted the traditional teacher-centered pedagogy. Instead of using the textbooks developed by the Ministry, teachers now have the autonomy to use creative pedagogies and collaborate with publishers to design new textbooks. However, they continue to rely on the textbooks that they have been using to teach science.

Education Structure

The education structure in Taiwan is similar to the educational systems in Japan, Hong Kong, and Singapore. Administrative resources are divided amongst a central authority, local authorities, and other educational institutions. In Taiwan, the Ministry of Education (MOE) is the main unit of the Central Authority and is legally responsible for supervising schools and all other public, private, special, and supplementary educational institutions. Education bureaus in municipalities and counties are responsible for implementing national education policies in the local context. Local educational authorities are responsible for both public and private educational affairs below the secondary levels (e.g., physical facilities, curricula, student enrollment, teacher qualifications, professional training, and school reorganization).

The National Science Council (NSC) is a specialized science and technology unit run by the Academia Sinica—the highest government academic research institution in Taiwan. Science education policy and reform initiatives in the 1990s were formulated by the NSC, examined by the MOE, and implemented by the local educational authorities. The NSC also promotes the national development of science and technology, supports academic research, and develops science parks. It provides a platform to Taiwanese

universities, industries, and government agencies to meet, collaborate, and create high-technology business.

The education structure in Taiwan supports nine years of compulsory education. The school system is based on a six-three-three model: six years of primary school, three of junior high school, and three years of senior high or vocational school (see Figure 2).

Until 2013, Taiwanese junior high school students (grades 7-9) had to pass a national Basic Competence Test (BCT) in order to attend a senior high school or a senior vocational school. In 2013, the Ministry of Education in Taiwan withdrew the BCT and replaced it with the Comprehensive Assessment Program (CAP). Admission to senior high schools and senior vocational schools is now based on recommendations by county or municipal education bureaus. This act is an important stage in the educational reform movement in Taiwan since it not only empowers the local educational authorities but also introduces an entrance-exam-free and application-based admission to secondary schools (Executive-Yuan, Taiwan, 2012).

Students who expect to enroll in universities or colleges are required to take the national-wide General Scholastic Ability Test (GSAT) or the Department Required Test (DRT). Admission to universities and colleges for senior high school students is based on recommendations by their high schools, school placements, and GSAT results. Those who fail to gain admission to universities or colleges through these methods can take the DRT, and are then assigned to various institutions based on their preferences and performance on the DRT (Executive-Yuan, Taiwan, 2012).

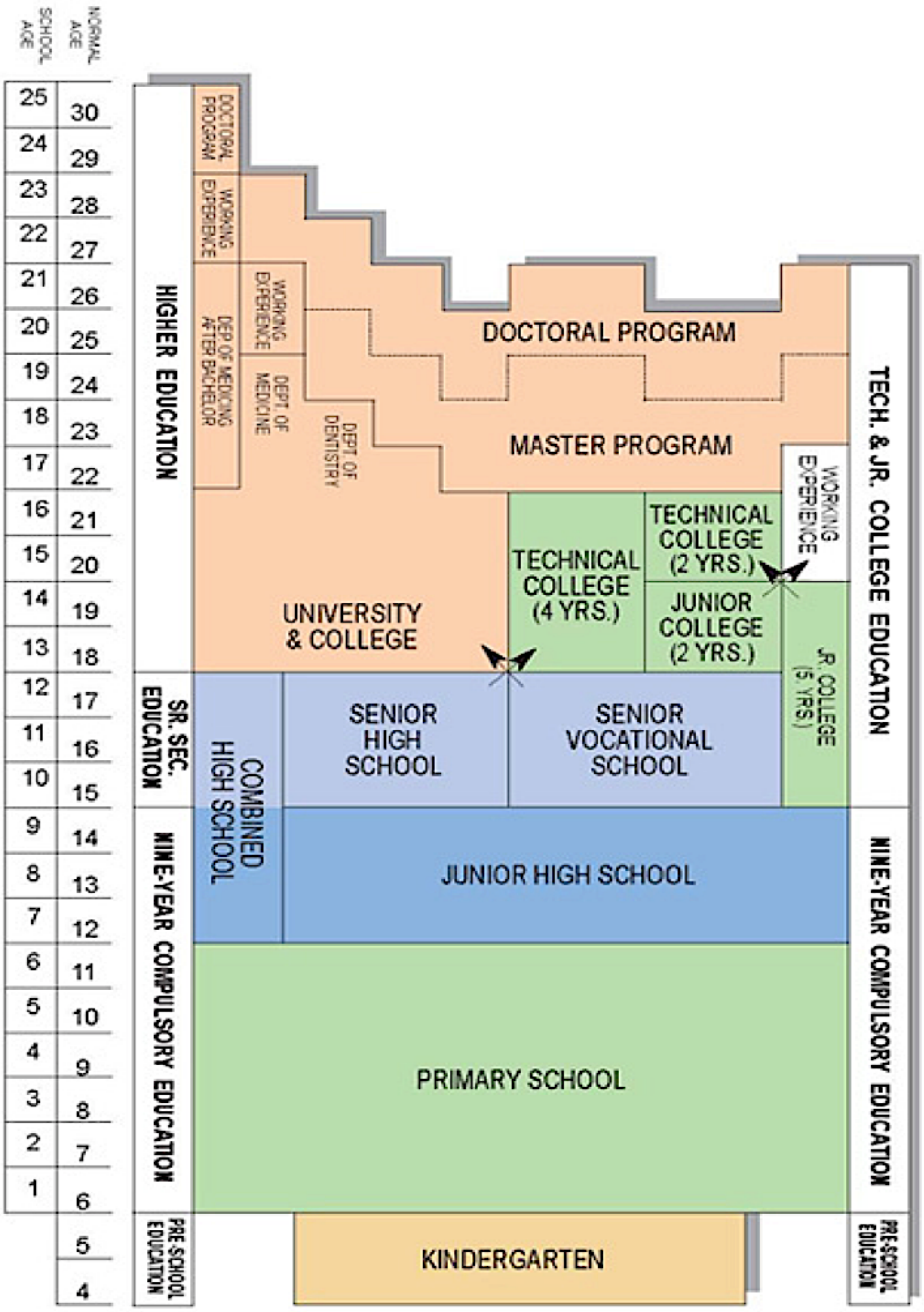

Figure 2: Education System in Taiwan

The education structure in Taiwan supports nine years of compulsory education: six years of primary school, three of junior high school, and three years of senior high or vocational school. Retrieved from

http://www.ey.gov.tw/en/cp.aspx?n=EDF3C4D6FBDCB3F8

The system of National Normal Universities, "Shi-fan Da-xue" (師範大學), offers certification programs for teachers in Taiwan. There are three Normal Universities in the country, one each in the northern, the central, and the southern part of Taiwan. These schools are located in the cities of Taipei, Changhua, and Kaohsiung respectively. The three "Shi-fan Da-xue" have prestigious histories, since they follow the legacy of the teacher training institutions that were established in the Japanese colonial era.[2] The Normal Universities are the primary venues for the professional development of teachers. In particular, they organize ongoing professional development and training for teachers at the secondary or higher levels. Teacher candidates in the Normal Universities are required to specialize in one discipline (science, history, language, social studies, etc.) along with required coursework in education (such as Educational Theory and Educational Strategies) (Executive-Yuan, Taiwan, 2012). Additionally, they are required to take part in a school-based practicum. Since the national goal is to improve citizens' literacy in science and technology, teacher candidates in science and technology are encouraged to major in a teaching subject and in general education (Ministry of Education [MOE], Taiwan, 2006).

After the deregulation of state-controlled education in the 1990s, other teacher training programs were established at universities that did not specialize in professional teacher training. However, these programs prepare only generalist teachers for preschool and primary schools.

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[2] Under Japanese colonization, public universities were established to train Taiwan's doctors, teachers, and lawyers. Because only students who achieve the highest scores on the national exams are admitted to these universities, the legacy of these universities has been preserved to this day. Additionally, the professional occupations have the highest social status in Taiwan.

In order to obtain a full-time and tenured teaching position, teacher candidates must obtain national teacher certification and must attend regional teacher interviews (Executive-Yuan, Taiwan, 2012). Upon passing the national certification examination, a candidate must then look for teaching jobs across Taiwan. There are three rounds in the annual job-search selection process. Prospective teachers are required to demonstrate their teaching, assessment, and classroom management skills as well as content knowledge in their subject area.

Confucian Epistemology

With the introduction of learner-centered approaches that largely developed in Western cultures, it is important to look at how the approaches interact with Confucian learning traditions. Below, I describe the important features of Confucian philosophy and principles of education, as Confucian epistemology has significantly shaped education philosophy and practices in Taiwan (Chan, 1996; Cummings & Altbach, 1997; Gao & Watkins, 2002; Nguyen, Terlouw, & Pilot, 2006; Paine, 1993; Tsui & Wong, 2010; Yao, 2000). This discussion would help in situating and understanding participants' understanding of Confucian learning values in relation to the education reform and teachers' teaching practice in subsequent chapters.

Confucius (551 B.C.E–479 B.C.E.), also known as Kongzi or Kong Fuzi (see Figure 3), is considered the "Great Sage"—the greatest teacher—in Chinese history. At the time of Confucius's birth, the central authority in China was declining, and all dukes and princes under the federal government were trying to recruit philosophers along with military and political consultants to defend their kingdoms. Confucius was one of these philosophers who hoped to devote himself to a political career. His central value, "Ren"

(仁),[3] was grounded in compassion and affection. According to Confucius, to practice "Ren," people should treat others how they wish to be treated. Furthermore, Confucius believed that if everyone practiced "Ren," children would respect elders, siblings, and friends would be kind to each other, citizens would be grateful to their government, and governmental officials would love their citizens. Therefore, a harmonious society and peaceful world could be created based on this value (De, 1960).

Figure 3: Confucius Portrait

Figure 3. Confucius influenced ancient education in Chinese society and continues to influence education to the present day. "Confucius, Gouache on Paper," c. 1770. New York: The Granger Collection.

[3] In order to achieve "Ren" a teacher should teach "Wen" (文)—letters; "Xin" (行)—ethics; "Zhon" (忠)—devotion of soul; and "Xin" (信)—truthfulness (De, 1960).

However, Confucius's ideology of creating harmony in society was not accepted by the dukes and princes during wartime. After failing to achieve a political career, Confucius turned to devote himself to teaching and promoting his central value—"Ren." To accomplish his goal, Confucius encouraged people to learn from the past and study classic literature. He believed that learning helped to cultivate one's virtues, and thus he encouraged all individuals to learn. According to Confucius, to promote harmony, everyone should be devoted to self-cultivation, learning, and practicing "Ren"—compassion and empathy (De, 1960).

Confucius began spreading his ideology to his students, who came from many different regions in China to seek knowledge and to study with him. He accepted students regardless of class, gender, or social status, and thus became the first teacher to make education available to all citizens in ancient China. By the end of his lifetime, his philosophy had become the mainstream value system, and he had gained thousands of apprentices and followers (De, 1960).

After the death of Confucius, the *Analects of Confucius*[4] became the most important text in Chinese education for more than two thousand years. Confucius is therefore recognized as "Wan Shi Shi Biao" (萬世師表), meaning the model teacher of every age. Confucius's legacy survives today, and the publication *Analects of Confucius* is mandated to be taught in secondary and post-secondary schools in Taiwan. In Taiwan, most of the schools display Confucius's statue to inspire teachers and to remind students

[4] The *Analects of Confucius*, also known as "*Lunyu I*" (論語), is the collection of Confucius's sayings and ideas as recorded by his apprentices. It is one the most influential books in Chinese and East Asian history (De, 1960).

to study diligently. Thus, Confucianist epistemology has profoundly influenced teaching practices in Taiwan, as well as mainland China, Hong Kong, Macau, Japan, and Korea.

In the course of this study, all teacher participants mentioned Confucianism when they were invited to discuss their epistemological beliefs about education and learning. Most of the participants referred to two educational philosophies that originate from Confucianism: "You Jiao Wu Lei" and "Yin Cai Shi Jiao."

1. "You (有) Jiao (教) Wu (無) Lei (類)" means that there should be no class distinction with respect to teaching. This means that education should be available to all individuals in the society. As Confucius said, "From the man bringing his bundle of dried flesh for my teaching, I have never refused instruction to anyone" (*Analects of Confucius*, Book I, Chap. VII.).
   Before Confucianism was widely accepted, education was available only to the nobility and the sons of governmental officials. However, Confucius believed that universal education would produce social harmony. The following story from the *Analects of Confucius* explains this point:

   > There was a child that came from Hû-hsiang, where citizens were recognized as uneducated. The child came to see Confucius and hoped to learn from him. Surprising to most of his students, Confucius accepted the child without asking his background and his purpose for learning. To resolve his students' doubts, Confucius said, "I admit people who approach me without committing myself as to what they may do when they have retired." (Book VII: Shu R, Chapter 28)

2. “Yin (因) Cai (材) Shi (施) Jiao (教)” means that teachers should teach in accordance with their students’ abilities. Confucius said that a good teacher should be able to meet the learning needs of his students. Furthermore, Confucius deeply emphasized the importance of knowing students’ individual needs and guiding them in accordance with their interests and strengths. The following story illustrates Confucius’s views on this subject. When one student, Tsze-lu, asked Confucius whether or not he should immediately apply what he had learned, Confucius told Tsze-lu to consult his father and elder brothers first. However, when another student, Zan Yu, asked Confucius the same question, Confucius answered in the affirmative. When he was asked about this, Confucius said,

> Tsze-lu has more than his own share of energy; therefore I kept him back. Zan Yu is retiring and slow; therefore I urged him forward. (*Analects of Confucius*, Book XI: Hsien Tsin, Chapter 21)

In Taiwan, “You Jiao Wu Lei”—education for all children—and “Yin Chai Shi Jiao”—teaching in accordance with students’ abilities—are still valued as key educational principles. In accordance with “You Jiao Wu Lei,” the current education policy mandates 12 years of affordable education to all students. In the *White Paper on Education* (2012), the government reiterates the national commitment to “Yin Cai Shi Jiao”—teaching in response to students’ abilities:

> [T]he implementation of a sound 12-year compulsory education and preschool education is based on the concepts of teaching without prejudice or discrimination. . . . Education in Taiwan should not only focus on teaching in

> line with the student's ability (Yin Chai Shi Jiao) . . . but also cultivating students' virtues and moral education. (MOE, Taiwan, 2012, pp. 6-9)

Chapter Summary

This chapter presented an overview of Taiwanese education system. Moreover, I discussed two key principles of Confucian epistemology: "You Jiao Wu Lei"—education for all children—and "Yin Cai Shi Jiao"—teaching in accordance with students' abilities. These concepts will be elaborated upon in chapter 5, the chapter wherein I look at the ways in which Confucian epistemology shapes teachers' implementation of student-centered learning approaches in Taiwan.

Chapter 3: Conceptual Framework

This chapter reviews various streams of the literature pertinent to this study. More precisely, it focuses on science education reform in relation to teachers' professional identity in the context of Taiwanese education system. In this chapter, I present the literature in three sections, as illustrated in a conceptual map in Figure 4. First, I look at how science education reform might lead to conflicts in teachers' professional practice. Subsequently, I begin with an overview of the literature pertaining to teachers' conflicts that have been identified in education reforms. I then focus on theories of identity development to understand how teachers negotiate their professional identity in the context of education reform.

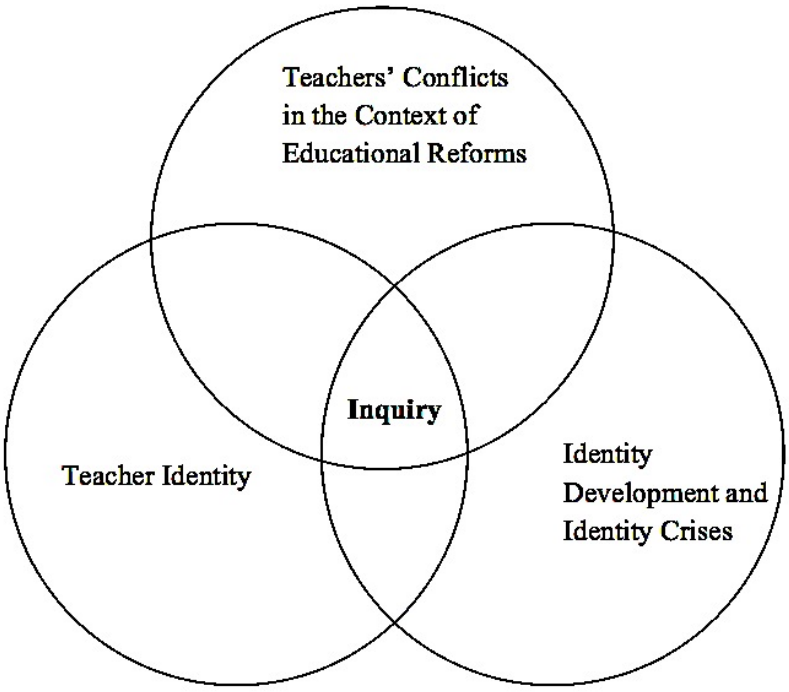

Figure 4: Key Components of the Conceptual Framework

This Venn diagram illustrates the three interrelated concepts that are discussed in this chapter.

Teachers' Conflicts in the Context of Educational Reforms

Teachers are critical stakeholders in education reform and are often perceived as "agents of change" in this process (Day, 2002). As discussed in the research context chapter (Chapter 1), contemporary developments in science education focus on learner-centered approaches to enable students to actively participate in the knowledge construction process to develop essential science literacy skills (e.g., analytical reasoning, critical thinking, conceptual understanding, and problem-solving skills) (DeMarrais, & LeCompte, 1990). These pedagogical changes have also transformed the role of teachers in students' learning process (Mascolo, 2009). In contemporary science classrooms, teachers are expected to act as facilitators or coaches to support their students' learning in learner-centered inquiry tasks. This shift requires teachers to have a deeper understanding of their students' characteristics—interests, attitudes, competencies, and needs—to design supportive learning environments to meet the needs of individual students.

Furthermore, high-quality science instruction depends on teachers' ability to adjust their teaching practice constantly to facilitate students' learning in complex inquiry tasks that are mainly driven by students' interests and questions. Guiding students in these tasks, such as solving problems cooperatively by using evidence-based reasoning, while simultaneously attending to individual needs, can be a very challenging task for teachers. Leading a learner-centered classroom in the contemporary educational system has thus become a more complex and delicate act than in the past. As Bowles (2014) described,

> The nineteenth-century teacher was the boss of the classroom. . . . [Conversely,] the modern teacher is in a more ambiguous position. The very rules and

regulations, which add a patina of social authority to his or her commands, at the same time rigidly circumscribe the teacher's freedom of action. (p. 39)

In view of these developments in the teaching profession, a number of scholars have found that the shifting roles of teachers have led to myriad conflicts and struggles in their teaching practice (Andreas, 2011; Bektas, Ekiz, Tuysuz, Kutucu, Tarkin & Uzuntiryaki-Kondakci, 2013; Fensham, 2009; Fernandez, 2005; Howard, 1999; Kyriacou & Chien, 2004; Lai & Lo, 2007; Osborne & Dillon, 2008; Schleicher & OECD, 2011; Schmidt & Datnow, 2005; She, 2004). Particularly, a number of studies have shown that teachers often experience stress, anxiety, and uncertainty while implementing the reform-based curricula (Dworkin, 1997; Haney, Czerniak, & Lumpe, 1996; Kelchtermans, 2005; Schmidt & Datnow, 2005; Van Veen & Sleegers, 2006; Yerrick, Parke, & Nugent, 1997). For example, Hakanen and colleagues (2006) found that some teachers were concerned about the additional workload that was "imposed" on them, as the new curriculum required them to spend more time in preparing their lessons and learning tasks. Research suggests that increased workload negatively affects teachers' motivation and commitment to reform (Beijaard, Verloop, & Vermunt, 2000; Bianchini & Kelly, 2003; Markic, Valanides, & Eilks, 2006; Munby, Cunningham & Lock, 2000; Silva & Silva, 2011; Yerrick et al., 1997).

Moreover, several studies have indicated that unclear reform policies often lead to confusion and misconceptions about the reform, resulting in a strong resistance on the part of teachers (Haney et al., 1996; Kyriacou & Chien, 2004; Vedder, 1994). For instance, the curriculum in Taiwan has traditionally been controlled by the Ministry of Education. Taiwanese teachers have been used to teaching the textbook content

developed and assigned by the Ministry officials. After the education reform in Taiwan in the 1990s, teachers were given the freedom to select their teaching materials based on the curriculum and instructional goals. However, many Taiwanese teachers reported that a broad curriculum blueprint was not sufficient to help them select appropriate instructional materials. Specifically, in a study that investigated 203 Taiwanese primary school teachers' attitudes toward education reform, Kyriacou and Chien (2004) found that most teachers expressed their disappointment over unclear policy and curriculum goals. Furthermore, over 70% of the teachers reported high levels of stress and anxiety at work. Research suggests that stress often leads to frustration and a lack of trust in the reform (Ingersoll, 2003; McNess, 2004; Rinne, Kivirauma, & Simola, 2002; Valli & Buese, 2007; Welle-Strand & Tjeldvoll, 2002). The culture of distrust, according to Tschannen-Moran and Hoy (2000), generates feelings of uncertainty, anxiety, and insecurity in teachers. As Fullan (2007) explained,

> Teacher stress and alienation are at an all-time high, judging from the increase in work-related illness and from the number of teachers leaving or wanting to leave the profession. The range of educational goals and expectations for schools and the transfer of family and societal problems to the school, coupled with the imposition of multiple, disconnected reform initiatives, present intolerable conditions for sustained educational development and satisfying work experiences. (p. 129)

According to Salzberger-Wittenberg (1983), when a teacher is occupied by personal emotions, such as stress and anxiety, they appear to care less about their students. LeDoux (1998) also argued that negative emotions highly affect teachers'

capacity to think, plan, and retain information. Moreover, several studies have found that these negative emotions could, in fact, provoke self-protection, such that teachers may only focus on what they feel most comfortable with in order to manage stress. In other words, teachers may choose to implement only selective features of the reform in their teaching practice.

Explaining the negative emotions concerning reform initiatives, Collay (2006) asserted that the mainstream reform discourses have not yet considered social and cultural contexts of teaching, including a teacher's race, gender, cultural background, and epistemological beliefs. Many scholars have also identified that policy planning and implementation processes have ignored or devalued teachers' core values and personal beliefs about education, which might lead teachers to feel disconnected from contemporary developments in education policy and practice (Alsup, 2006; Beijaard, Meijer, & Verloop, 2004; Day, 2002; Prosser & Trigwell, 1999; van Driel, Beijaard, & Verloop, 2001). While policy leaders expect teachers to take responsibility and advocate for curriculum and pedagogical changes in order to be more effective in their practice, they first need to understand teachers' multiple perspectives on teaching and learning. As Fullan (2007) elegantly described in the *New Meaning of Educational Change*, "Educational change depends on what teachers think and do—it is as simple and as complex as that" (p. 129).

Scholars argued that supporting teachers in their practice must be the key focus of any reform initiative. In other words, teachers should be provided ongoing professional support to enrich their practice by learning about effective learning approaches and practices. However, they also need to engage in critically reflecting on their teaching

philosophy and practice in relation to the reform objectives (Alsup, 2006; Andreas, 2011; Fullan, 2007; Fullan & Andy, 1992; Zembylas, 2003).

Several scholars have underscored the importance of respecting the teacher "as a person" (Alsup, 2006; Danielewicz, 2001; Fullan, 2007) in any professional development initiative. Furthermore, Alsup (2006) argued that teachers' personal identities should be valued in professional development discourses to support their growth and learning. As such, theories of identity have been used to understand teachers' personal and professional identity development during their teaching and learning experiences. In the following section, I discuss some important identity frameworks to understand the ways in which teachers negotiate their professional identities in the context of educational change.

Identity Theories and Teacher Identity

Teacher identity broadly refers to a teacher's self-concept in relation to his or her professional role. A teacher's identity and professional practice is shaped by a number of internal factors (values, beliefs, emotions) and external circumstances (professional development, teaching conditions, social surroundings). One of the key shifts in professional working conditions that most teachers face in their lifetime is a shift in the curricular focus (Organisation for Economic Co-operation and Development [OECD], 2004; Osborne & Dillon, 2008). Thus, exploring the ways in which curricular changes in educational reforms (re)shape teachers' identity is vitally important to understand how they might respond to those changes.

Scholars in various disciplines have conceptualized identity in diverse ways (Commons & Rodriguez, 1990; Erikson, 1968; Marcia, 1966; Olsen, 2008; Schwartz,

2001; Varghese, Morgan, Johnston, & Johnson, 2005). Given the various perspectives on identity, it is difficult to simply define identity. Although many different conceptions of identity exist, much of the literature in social science shares similar perspectives on what constitutes the formation of identity. While explicating the process of identity formation, Luehmann (2007) concluded that identity has four common characteristics:

- Identity is constituted socially through interactions with others;
- Identity is constantly shaped and reshaped, although changes in one's core identities require intensive efforts and negotiations over a long period of time;
- Identity is complex and "multifarious" as it consists of "a number of interrelated ways one is recognized as a certain kind of person, participating in social communities" (p. 6); and
- Identity is constructed through "interpretations and narrations of experiences" (p. 6)

Other frameworks on identity, for example, Gee's (2000) multidimensional concept of identity, also illuminate the complex processes involved in constructing one's personal, professional, and social identities through various discourses and practices. Particular, Gee (2000, 2013) provided a multifaceted concept of identity to explicate the dynamic effects of social and cultural discourses on identity formation. Gee (2000) argued that identities are shaped by different social discourses, such as institutional rules, shared dialogues within groups, and collective expectations in communities. As such, Gee (2000) proposed four types of identities, Natural Identities, Institutional Identities, Discursive Identities, and Affinity Identities to explicate "what it means to be recognized as a "certain kind of person" (p. 4).

- "Natural Identities" (N-Identities): Nature-identity is a "state" which is developed from the "forces in nature." Gee (2000, 2004, 2013) argued that "we are what we are primarily" because of our "natures" (p. 4). By our natures, Gee meant, the biological traits that an individual inherits from his/her parents (e.g., genes, neurobiological characteristics) and how they are "unfolded" in our "development." Gee said that we have no control over these traits. However, Gee acknowledged that "natural [or biological] identities can only become identities because they are recognized" by other members of the society.
- "Institutional Identities" (I-Identities): Institutional identity is based on one's institutional affiliation and position (e.g., teachers, doctors, engineers, managers, bureaucrats, etc.). More precisely, this identity is constituted in relation to one's roles, rights, and responsibilities in a particular institution and is defined by the institutional authorities. According to Gee (2000), an institution's "laws, rules, traditions, or principles . . . allow the authorities to 'author' an individual's position in that institution."
- "Discursive Identities" (D-Identities): Gee's third perspective on identity is the "discursive perspective." Discursive identity, according to Gee (2000, 2004, 2013), is formulated through social discourses. This type of identity is based on individual traits and accomplishments, such as charisma, academic or linguistic talent, or learning abilities, etc. These personality traits are created through social discourses. From a sociocultural perspective, *discourse* is defined as a collection of historical, political, and societal discussions on certain subjects (Gee, 2000, 2004, 2013). Gee explained that D-Identity is neither natural nor

institutional. Instead, it is based on others' recognition of one's personality traits. Nonetheless, Gee recognized that D-Identities may also be "constructed and "sustained" with the support of "official" institutions" (Gee, 2000, p. 7).

- "Affinity Identities" (A-Identities): Gee described his fourth perspective on identity as the affinity view. Affinity Identities are developed through one's participation in specific shared experiences and social practices in an affinity group. People in an affinity group engage in a shared set of activities, which allows the members to share their experiences with each other (Gee, 2000). In education, affinity groups can be teacher unions, professional learning communities, or online support groups.

Gee's perspectives on various aspects of identity provide a useful lens to examine teachers' institutional, discursive, and affinity identities to understand their professional roles, accomplishments, and participation in their educational communities. The interwoven nature of one's identities (e.g., personal, professional, institutional, and cultural) suggests the importance of looking at the complex ways in which people interact with one another. Thus, many scholars echoed the pressing need to appreciate teachers' personal identities—which comprise their prior beliefs, experiences, personal values, and cultural convictions—in conjunction with their professional identities, to recognize the value systems that teachers bring to their professional roles. Looking at their personal beliefs and cultural values regarding education might help in understanding the ways in which teachers respond to discourses of educational change (Beijaard et al., 2004; Beijaard et al., 2000; Luehmann, 2007; Olsen, 2008; van Driel et al., 2001). In a Confucian learning culture, for example, teachers' responses to educational reform

cannot be understood completely without examining their personal views and cultural traditions of learning. In Confucian education tradition, the primary goal of learning is to achieve the highest moral standard in the society. Therefore, teachers are expected to support not only students' cognitive growth, but also their moral and aesthetic development. In addition, teachers are highly regarded as experts and students are expected to act respectfully in the classroom as they gain knowledge and wisdom from their teachers. These personal and cultural values shape teachers' professional identities in important ways (Beijaard, 1995; Danielewicz, 2001; Holland, 2001; Luehmann, 2007). Thus, understanding the cultural values that teachers bring into the classroom might help in understanding how they negotiate the tensions arising from the discrepancies between their existing practices and reform policies. In the context of social and educational change, teachers may face a range of issues while navigating between different approaches to teaching science (Beijaard et al., 2004; Day, 2002; van Driel et al., 2001). Specifically, when teachers feel uncomfortable with the teaching approaches that are mandated by the policymakers, they may face significant internal dilemmas. Looking at these internal conflicts, Day (2002) noted that the professional identities that teachers have developed in their teacher preparation programs might not have expanded to the level where teachers can support themselves to overcome any value conflicts and emotional struggles in changing educational environments. These struggles might result in teachers' unintentional resistance to the core values of the reform policy (Day, 2002; Day, Kingston, Stobart, & Sammons, 2006; McDougall, 2010; Vanveen, 2005). Subsequently, a number of teacher education programs now tend to recognize teachers' epistemological beliefs, personal values, and cultural experiences in order to foster

meaningful professional growth opportunities for teachers (Alsup, 2006; Beijaard et al., 2004; Danielewicz, 2001; Day, 2002; Day et al., 2006; Fullan & Andy, 1992; Luehmann, 2007; Olsen, 2008).

In the following section, I discuss the concepts of "identity crisis" and "identity transformation" as formulated and explained by Erikson (1968) and Marcia (1966) in order to understand how teachers' identities are constructed and reconstructed in the context of educational change. Importantly, in this research, I am interested in using these lenses to explore the ways in which the reform discourses, that have largely been imported from foreign cultures, might shape Taiwanese teachers' professional identity.

Identity Development and Identity Crisis

The seminal work of Erik Erikson, a prominent psychoanalyst and developmental psychologist in the 1950s, popularized the study of identity. In his book *Identity: Youth and Crisis* (1968), Erikson introduced the concepts of "identity crisis" and "identity confusion" to illustrate a series of internal conflicts that humans experience through various stages of identity development. According to Erikson (1968), "identity crisis" refers to the stage in which individuals are engaged in intense efforts to resolve internal conflicts. For example, during an identity crisis, individuals may reexamine their roles in their profession, culture, or society in order to find a way to be accepted. Moreover, they often ask themselves important questions, such as: "Who am I?"; "How can I fit into the society?"; and "What am I going to do in life?" To address these questions, individuals might begin to search for an understanding of their own roles in their social groups by experimenting with different identities. This process may lead to the stage of "identity confusion," which occurs when individuals try to seek a balance

between their personal identities—"Who am I?"—and social/cultural identities—"Who do I want to be in society?"; "How do I want to be perceived by others?" (Erikson, 1968; Schwartz, 2001).

Some scholars (Badaoui, Lebrun, & Bouchet, 2012; Young, Sproeber, Groschwitz, Preiss & Plener, 2014) illustrated Erikson's point through an example that shows how a series of internal conflicts may lead to "identity crisis" and "identity confusion" in a teenager. A teenage girl may be curious about Gothic subculture and may become a member of the Gothic community, wearing Victorian-style clothing and putting on makeup in order to look like other Goths. She may begin to listen to Gothic music and hang out with friends who are part of the same subculture. Her experiment with Gothic identity may be accepted or rejected by her family, former friends, social surroundings, or mainstream culture. In response to perceptions of her identity by others, she might begin to reflect on and negotiate with multiple self-concepts to resolve her inner conflicts (e.g., "Who am I?"; "What do I want to be?"; "How do I want to be seen by others?"). According to Beauchamp and Thomas (2009), an individual's identity is constantly (re)shaped during this process of self-discovery and experimentation.

Contemporary identity researchers in psychology have also found that identity crisis and identity confusion are not necessarily associated with a certain age, but they accompany life events, such as death, love, loss of job, marriage, or relocation (Eisenberg, Guthrie, Cumberland, Murphy, Shepard, Zhou & Carlo, 2002; Hardy & Kisling, 2006; Kokko, 2006; Schwartz, 2001; Waterman, 1999). This means that identity transformations are, at least in part, inspired by social changes. Further, there are many aspects of social lives (e.g., family, occupations, race, class, and gender) that can initiate

changes in an individual's value system and personal identity. Aside from personal life, identity transformations can also occur in one's professional life. Examples of these transformations include the internal conflicts that a physician might experience while conducting a medical trial on patients, or the professional dilemmas that a lawyer might encounter, such as handling a legal case that he or she finds disagreeable.

This discussion of identity crisis provides a useful lens for looking at internal conflicts that teachers might experience while adjusting their teaching practices in relation to education reform. In Chapter 1, I discussed the key goals of global science education reforms, and argued in the earlier sections of this chapter, that teachers worldwide have faced similar challenges while changing their practices in educational reforms. Drawing on past and current understandings of identity, educators have been interested in exploring teacher identity in relation to these issues (Beauchamp & Thomas, 2009; Beijaard, 1995; Beijaard et al., 2004; Day et al., 2006; Ingersoll, 2003; Luehmann, 2007; Van Veen & Sleegers, 2006; Vanveen, 2005). Herein, I discuss the identity theory formulated by Marcia (1966). This framework illuminates the complex processes involved in identity (re)construction.

James Marcia, one of the most influential clinical and developmental psychologists in the 1960s, defined a crisis to be a sequential process in which individuals reexamine their old values, explore alternative roles, and actively choose new beliefs. This process leads individuals to commit to certain identities or value systems. One of Marcia's (1966) most notable contributions to identity theory is the relationship that he establishes between how an individual may commit to a new value or principle (one that

an individual has adopted), and how that person might integrate it with his/her prior belief systems.

According to Marcia (1966), individuals go through four psychological states in the process of identity development and transformation: "identity diffusion," "foreclosure," "moratorium," and "identity achievement." Furthermore, Marcia (1966, 2002) described a sequential process in which individuals modify their original beliefs, and eventually commit to the decisions they make. Marcia conceptualized these four identity states in relation to changing life circumstances where identity transformations occur based on particular choices or commitments that individuals make in relation to their values, beliefs, goals, and roles. As such, each state is associated with a distinct set of circumstances (Kroger, Martinussen, & Marcia, 2010; Marcia, 1966, 2002; Stephen, Fraser, & Marcia, 1992). Below, I briefly explain how Marcia described these four identity states:

1. "Identity Diffusion": In this state, individuals may become aware of their value systems, but they have not yet made an explicit commitment to a particular identity. In addition, they may or may not have experienced internal conflicts at this stage. For instance, when a person moves to a foreign country, he/she may encounter entirely different local customs, values, and cultural traditions. Although the experience of being different in the new environment may lead to a conscious awareness of his/her previous cultural experience and value systems, but the individual may not explore a range of alternative options.
2. "Foreclosure": This state precedes identity crisis, meaning that an individual has not yet experienced an identity crisis, but they have made a commitment to a

particular identity. Often their identities are based on the beliefs and values expressed by their family and cultural traditions that they tend to conform to and accept without questioning. For instance, at this stage, individuals may not clearly know whether their career goals are their own, or come from their parents/role models. They try to become what their parents/role models want them to be, and feel threatened when faced with a situation in which their prior values are no longer valid.

3. "Moratorium": In this state, an individual is in the midst of an identity crisis while negotiating between competing value systems. Compared to those in other identity states, individuals at the moratorium stage are trying to solve the internal clash in order to choose between beliefs, goals, or roles in order to commit to a coherent value system. However, the individual hasn't been able to resolve the contradictions completely.
4. "Identity Achievement": In this state, an individual has become fully committed to a particular identity after going through an identity crisis. Individuals in this state have sorted through the many possibilities of who they want to be. Coming to this established identity means that an individual has made an explicit commitment to a particular value system, professional role, or life purpose.

Based on Marica's framework, teachers might go through different identity states in the context of educational reform. While having to deal with mandatory pedagogical changes prescribed by the reform policies, some teachers might choose to ignore them altogether if they feel that the changes clash with their existing teaching beliefs and practices. Some teachers might look at their teaching practice in relation to the

reform discourse, but they may not make an effort explore the reform-based practices and thus go on with their existing practices. On the other hand, some teachers might experience a deep internal conflict as their existing epistemological beliefs and teaching practices clash with the reform-based curriculum and pedagogy. Therefore, they struggle with the dilemmas posed by the two competing educational approaches. In this situation, some teachers might make an active effort to resolve the contradictions between their existing and reform-based approaches and eventually make a new commitment to the new pedagogical approach.

Hence, changing one's core identity, which is firmly entrenched in one's beliefs and value systems, is neither instantaneous nor easy (Gee, 2000; Giddens, 1991; Goodnough, 2011; Olsen, 2008; Reicher, 2004). Therefore, expecting teachers to instantly change their epistemological beliefs, values, and teaching habits in accordance with new educational approaches is not realistic. Teachers who are in the moratorium identity state would need sufficient professional support and continuous professional development opportunities to help them resolve their internal pedagogical conflicts (Marica, 1966). As such, several researchers have suggested that teachers' professional development in the context of reform should take into account teachers' identity development and internal conflicts. This framework would help in supporting teachers in changing their practice, as they experience fundamental transformation in their teaching philosophies, personal values, and professional goals (Alsup, 2006; Beauchamp & Thomas, 2009; Beijaard et al., 2000; Conley, Pintrich, Vekiri, & Harrison, 2004; Danielewicz, 2001; Flores & Day, 2006; Volkmann & Anderson, 1998).

Chapter Summary

In this chapter, I provided an overview of various theories of identity construction and their implications for teacher development. I presented an overview of the literature on teachers' conflicts resulting from education reforms and the ways in which they shape their professional identities. Further, the identity crisis framework has provided a tool to look at how science teachers might embrace, adapt to, or resist the science education reform. The literature on identity serves as a pivotal framework for this study, since it allows me to systematically examine the ways in which teachers' social, cultural, and educational contexts may influence their professional practice as well as their response to the reform discourses.

Chapter 4. Methods

In this chapter, I begin with an overview of my methodological approach, followed by the specific research questions that I addressed in this inquiry. I then provide a detailed description of each component of the research design, including the research setting, participant characteristics (teachers and policymakers), and data collection instruments. Next, I explain the strategies that I used for data analysis. Finally, I address issues of validity, reliability, and trustworthiness, as well as my reflexive understanding of my positionality as a researcher in this study.

The objective of this study is to explore how the current science education reform in Taiwan is perceived by policymakers and secondary science teachers, as well as how the reform is being implemented in local schools. In addition, various obstacles to the reform initiative are critically examined from teachers' and policymakers' perspectives.

Methodological Approach

In order to gain an in-depth understanding of policymakers' and teachers' perspectives, I chose to use the qualitative research approach to conduct this study (Creswell, 2007; Creswell & Miller, 2000; Crotty, 1998; Denzin & Lincoln, 2000; Holliday, 2002; Maxwell, 1996). The following questions guided this inquiry:

1. Science education policy:
    (a) What are the goals of science education reform in Taiwan?
    (b) What kinds of resources does this policy suggest to support teachers professionally in implementing the reform-based curriculum?
2. Secondary science teachers:

(a) What epistemological beliefs shape secondary science teachers' teaching and learning practices in science?

(b) How do teachers learn about the science education policy in Taiwan? Further, how do they prepare themselves professionally to achieve the reform-based curriculum objectives?

(c) What aspects of the science education policy do teachers feel are relevant to their science teaching practices?

(d) What epistemological beliefs inform teachers' approaches to teaching and learning science? Moreover, what pedagogical approaches are they using in their practice?

3. Policymakers:

(a) What is Taiwanese policymakers' vision of the science education policy? What particular goals did they consider while formulating these policies?

(b) What are policymakers' views about supporting secondary science teachers to implement the science education policy goals?

Research Design

Data Sources. I chose to draw on qualitative approaches to conduct this inquiry, as I hoped to gain a critical and deeper understanding of Taiwanese policymakers' and teachers' beliefs and perspectives on the current science education reform. In addition, I attempted to explore their critical views about the challenges concerning this reform. Furthermore, my hope was that a qualitative inquiry would enable me to deeply explore Taiwanese science teachers' epistemological perspectives on the teaching and learning culture in Taiwanese schools. In order to collect these types of data, it was essential that I

build trusting relationships with participants during the data collection process (Kirby, 2006). I did this through face-to-face interviews, which can help in building respectful and trusting relationships with participants (Creswell, 2007). However, because I was interested in participants' perspectives on the reform policy, I also collected a series of science reform documents and reports produced by the Ministry of Education and the National Science Council in Taiwan to gain a deeper understanding of this reform. Finally, I invited teachers to write reflective journals in which they could elaborate on the themes that we discussed in the interviews. More specific descriptions of these data sources are discussed below.

Government reports. The most comprehensive reform policy document, the *White Paper for Science Education* (2004), provided me with a comprehensive understanding of the national education vision and policy goals. I also reviewed three government reports that are related to secondary science education in Taiwan, including the (a) *White Paper on Creative Education* (2003); (b) *White Paper on International Education for Primary and Secondary Schools* (2011); and (c) *Important Teacher Cultivation Policy* (2006). I analyzed these government documents in order to deepen my understanding of the national science education policy in Taiwan.

Individual interviews. Initially, I conducted semi-structured interviews with three policymakers and ten in-service secondary science teachers. The conversations with policymakers lasted between 60 and 90 minutes each and the interviews with teachers lasted between 40 and 60 minutes. After these interviews, I invited the teachers to continue our interview conversations. Nine of the ten teachers agreed to participate in the second round of interviews. These interviews lasted between 60 and 90 minutes. The

main goal of these individual conversations was to examine participants' understandings and perspectives on the reform policy. Furthermore, I focused on exploring teachers' epistemological beliefs, views about Confucian learning traditions, and the challenges that they have been confronting while implementing the new teaching approaches. All the interviews were audio recorded and transcribed.

Teachers' reflective journal writings. The nine teachers who had participated in two rounds of extended conversations were also requested to write reflective journals, before the second interview, in which they shared their views on Confucianism and reflected on their science teaching practices. They responded to four open-ended questions, which were designed to elicit their values and beliefs around science education. The four questions are:

1. What does science learning mean to you?
2. What does your classroom teaching look like?
3. What are your views about Confucianism?
4. What does Confucian teaching and learning culture mean to you?

Data Collection Process. Following the approval of my study from the Research Ethics Board (REB) at McGill University in April 2013 (see Appendix A), I collected data in Taiwan from May 2013 to September 2013. I did the first round of interviews with policymakers and teachers from May to June 2013. I then invited all teacher participants to participate in the second round of interviews. Those who agreed (nine teachers) were also asked to write their reflective journals in July 2013. Afterwards, I conducted the second round of interviews with the nine teachers from August to September 2013 (see Figure 5).

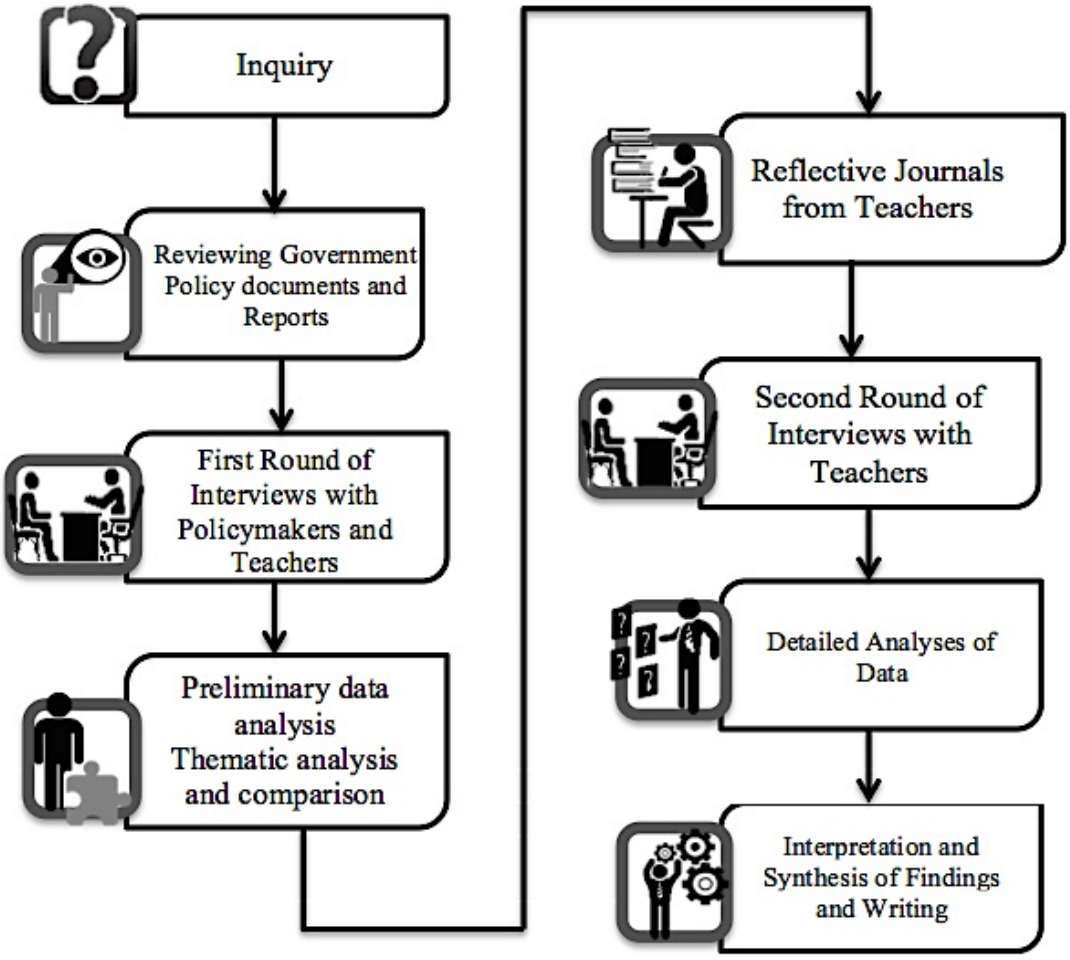

Figure 5: Data Collection Process

Recruitment of participants. I used purposive sampling methods (Maxwell, 2012) to select participants who could provide useful information and perspectives to help me answer my research questions. Through this sampling process, I made contact with two groups of participants: policymakers, the architects of the reform document, the *White Paper for Science Education* (2004), and in-service secondary science teachers in Taiwan who are currently teaching science and technology subjects, including physics, chemistry, biology, and earth sciences.

Policymakers. Because I was interested in understanding the context of science education reform and its implications for teacher development in Taiwan, I selected the policy leaders who were involved in formulating the science education policy and designing teacher education programs. Subsequently, I invited five policymakers to participate in this study (see Appendix B and Appendix C for study invitation letter). Eventually, three policymakers, Huai-guo, Yang-ming, and Qian-hua[5] agreed to share their perspectives on the reform vision and implementation process with me.

Participant characteristics. Huai-guo was one of the editorial committee members who formulated the *White Paper for Science Education* (2004) in Taiwan. He was also one of the review committee members who had developed the curriculum goals for K-12 science education. Since 2000, he has been involved in in-service teacher education and has been actively promoting the curricular changes through his professional development activities. Further, Huai-guo has been the Director of the Office of Teacher Education and Careers Service at one of the teacher education universities in Taiwan since 2011.

Yang-ming, another policy leader who participated in this study, was actively involved in initiating the Taiwanese science education reform in the late 1990s. Notably, Yang-ming was one of the core editorial team members who organized nationwide consultation meetings with science teachers, reviewed the relevant literature and reform policies from other countries, and carried out the implementation of the reform as outlined in the *White Paper for Science Education* in 2004. In addition, he was a member

[5] All participants' names are pseudonyms.

of the K-12 science curriculum review committee, as well as the Director of the Science Education Center that developed the science education curriculum in Taiwan.

The third policymaker, Qian-hua, was the Deputy Minister of Education. In this role, he had actively promoted the science education reform in Taiwan. Like Yang-ming, he was also one of the core members who initiated the Taiwanese educational reform in the late 1990s. He was also a core member of the committee that formulated the *White Paper for Science Education* in 2004. Additionally, Qian-hua focuses on how teachers can support and nurture students' interest and talent in science.

Teachers. To recruit teachers, I drew on my personal and professional networks in Taiwan. Notably, I invited only those teachers who are certified to teach as secondary science teachers in the local public school systems. I sent out 25 invitation letters (see Appendix B) to secondary science and technology teachers—12 male and 13 female teachers—working in various public schools in Taiwan. Ten teachers—eight males and two females—voluntarily agreed to participate in the individual interviews. Nine of them—one female and eight male teachers—agreed to participate in reflective journal writing and the second round of individual interviews. Although I had hoped to explore the perspectives of female and male teachers in this study, most of the teachers who had agreed to take part in this research were males. I tried to contact more female teachers through the listserves in various teacher associations and professional communities, but did not get any response from them. I also tried to reach out to some female science teachers through my local friends, but they declined the request due to various reasons, such as lack of time due to their personal professional commitments. In Table 1, I present an overview of the participants' characteristics.

Table 1. *Participants' Profiles*

Policymakers

No.	Pseudonym	Gender	Role in the Reform Committee
1	Huai-guo	M	Editorial Board
2	Yang-ming	M	Core Editor
3	Qian-hua	M	Core Editor

In-service Science Teachers

No.	Pseudonym	Gender	Grade(s)	Teaching Subject(s)	Teaching Experience (in years)	Professional Training
1	Zhong	M	8, 9	Physics/ Chemistry	7	National Normal University
2	Xiao	M	7	Biology	17	National Normal University
3	Ren	M	8, 9	Physics/ Chemistry/ Earth Science	24	National Normal University
4	Bao	M	8, 9	Physics/ Chemistry	2	National Normal University
5	Jing	F	7	Biology	4	National Normal University
6	Yi	M	8, 9	Physics/ Chemistry	12	National Normal University
7	Hei	M	8, 9	Physics/ Chemistry	27	National Normal University
8	Wei	F	8, 9	Physics/ Chemistry	3	Center for Teacher Education
9	Ting	M	7, 8, 9	Physics/ Chemistry/ Biology	8	Center for Teacher Education
10	Chang	M	7	Biology	9	National Normal University

Methods of Data Analysis

In this research, I see myself as a constructivist inquirer; that is, someone who is interested in exploring the complexity of participants' historical, social, and cultural experiences (Creswell, 2007; Crotty, 1998; Denzin & Lincoln, 1998, 2000; Holliday, 2002; Maxwell, 1996). Thus, the collection and analyses of data are grounded in the

historical and social context of science education reform in Taiwan. I conducted this exploratory investigation to discover policymakers' views on the reform and science teachers' cultural and epistemological beliefs in relation to their science teaching practices.

This inquiry drew on data from three main sources: policy documents, interviews, and teachers' reflective journals. In addition, I kept a research journal to keep track of my emerging understandings of the data. I analyzed the data from these sources using various qualitative analysis tools and techniques. Specifically, I used thematic analysis at every stage of my data analysis. Thematic analysis involves categorizing themes and clustering phenomena that are associated with research questions. According to Creswell (2007), thematic analysis allows researchers to identify common patterns among different types of data.

Furthermore, salient concepts were identified by carefully reading the policy documents, interview transcripts, and reflective journals. This process allowed me to identify important concepts related to my research questions. Additionally, I paid attention to participants' ideas and meanings that seemed important to them even if they were not directly related to my research questions because it was very important to understand participants' meaning-making of the reform. Then, I categorized the data into broader categories by grouping related concepts (Creswell, 2007; Denzin & Lincoln, 2000).

This process helped me to generate themes across participants' interview transcripts and written documents, as well as my own reflective notes. Central themes that emerged from this analysis include: Confucian moral values; respecting for

authority; professional support for teachers; professional learning communities; internal sources of conflicts; commitments to traditional practices, teachers' negotiation strategies, and so forth.

Another analytical tool that I used to for analysis was concept mapping, which together with other visual displays (i.e., thematic matrices) helped me visualize the relationships among various categories and themes. Concept mapping is useful for visualizing relationships among different concepts that arise from the data (Butler-Kisber, 2010; Creswell, 2007; Maxwell, 1996; Thody, 2006). Below, I present a concept map (Figure 6) to illustrate the relationships that I saw among different thematic units of data.

I also used the constant comparative method to further identify and untangle the complex relationships among various themes ((Butler-Kisber, 2010; Creswell, 2007; Denzin & Lincoln, 2000; Holliday, 2002; Maxwell, 1996). Constant comparative analysis is a process in which several sets of data are compared to draw out patterns of similarities and differences (Butler-Kisber, 2010; Creswell, 2007; Holliday, 2002; Maxwell, 1996, 2012). In this study, the constant comparative analysis method was used to compare policymakers' and science teachers' perspectives on science education reform vision, specific curriculum goals, and professional support systems for teachers. Also, this analytical approach helped me answer my research questions about teachers' epistemological conviction, cultural values, pedagogical approaches, understanding of Confucianism in relation to their teaching, and their views on challenges to the implementation of reform. Furthermore, throughout the analysis, I critically compared the various factors that posed significant challenges to their beliefs and practices. Further, I

focused on comparing the ways in which teachers have been negotiating their professional roles and identities in the context of educational change.

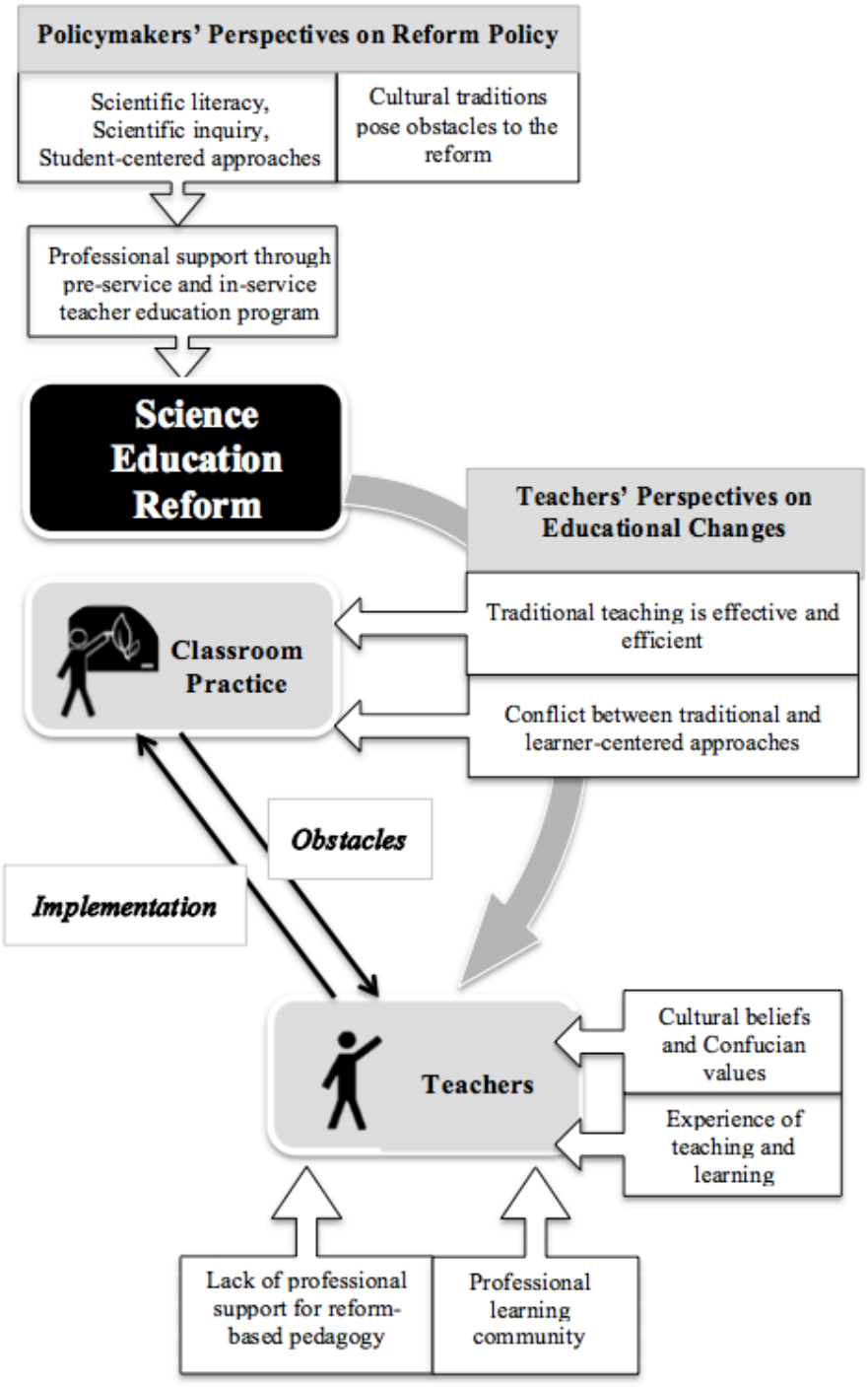

Figure 6: A Concept Map: Illustrating Salient Themes

Credibility and Trustworthiness

During data collection and analysis, I made conscious efforts to be aware of the to the validity and credibility issues and attempted to address them in a number of ways as detailed in this section. The interviews with teachers and policy leaders were mainly conducted in Mandarin. To address descriptive validity issues, I transcribed and translated all the interviews and reflective journals from Mandarin Chinese into English. Approximately 60% of the translated, and de-identified, interview transcripts were also reviewed by two of my colleagues—whose mother tongue is Mandarin and who are also fluent in English—to check the accuracy of the translated materials. Moreover, follow-up discussions including member checks with participants helped to discuss my interpretations of the data with them. In addition, about 30% of the translated data excerpts on Confucianism and Confucian learning culture were reviewed by a colleague who is an expert in East Asian studies at McGill University. Furthermore, all the translated data were edited by two professional translators who are certified as Mandarin and English translators in Canada.

In addition, I shared my interpretations with my supervisor and colleagues in the Faculty of Education at McGill University. These conversations helped me examine my biases and assumptions that are grounded in my cultural values (Creswell, 2007; Denzin & Lincoln, 1998; Ely, 1991; Maxwell, 1996). My peers also helped me detect the themes that I overemphasized or underemphasized across the data. According to Creswell (2007), real life is composed of multiple perspectives, and researchers have the responsibility to share perspectives that run counter to researchers' assumptions. Thus, in the following chapters, I present and discuss different perspectives on my data in order to

increase the credibility of this study (Creswell & Miller, 2000; Holliday, 2002; Maxwell, 1996; Thody, 2006). In addition to discerning the prevalent trends in the data, I also looked for negative cases or contradictory instances to develop a comprehensive understanding of the complex issues discussed by the participants.

A key aspect of qualitative research is researchers' reflective and reflexive understandings of the data (Ely, 1991). Therefore, ongoing reflections on my interpretations helped me to look at my research findings and conclusions critically (Creswell & Miller, 2000; Maxwell, 1996). Further, to identify and acknowledge the limitations of my research, I maintained a regular reflective diary to critically look at my biases, motivations, and assumptive interpretations of participants' meaning-making (Creswell & Miller, 2000; Denzin & Lincoln, 1998; Holliday, 2002; Maxwell, 1996; Thody, 2006).

Chapter Summary

In this chapter, I began by presenting my overarching research questions; I then provided a description of my research setting, participant characteristics, and data collection instruments. I used constant comparative and thematic analysis approaches to analyze the data from various sources. I also developed concept maps and thematic matrices to demonstrate the salient themes and connections among them. Additionally, I discussed the issues of validity and trustworthiness of this study. In the next chapter, I present the policy analysis, as well as policymakers' and teachers' perspectives on the implementation of science education reform in Taiwan.

Chapter 5. Findings I

In this chapter I address my research questions regarding the science education policies in Taiwan and how they are understood by the policy leaders and science teachers. This chapter is organized in two main sections. In the first section, I present a critical review of the policy documents on science education reform. In the second section, I discuss the salient themes that emerged from the interviews with policymakers and secondary science teachers. Specifically, I illustrate policymakers' and teachers' understandings of the reform policy, their perspectives on professional support and development, and the myriad challenges they have faced during the implementation of the reform. Finally, I conduct a comparative examination of teachers' and policymakers' notions of the above themes to highlight important similarities and discrepancies in their perspectives on educational change in Taiwanese culture.

Science Policy Documents: A Critical Review

In this section, I examine the *White Paper for Science Education* (2004)—the most comprehensive reform policy document produced by the Ministry of Education and other government reports related to secondary science education in Taiwan. In this analysis, I particularly focus on the reform vision and curriculum goals, as well as mechanisms for teacher support and professional development that are described in the policy documents. As noted earlier in Chapter 1, the science education reform policies in the U.S. and Taiwan share a common vision (American Association for the Advancement of Science [AAAS], 1993, 1999; Ministry of Education [MOE], Taiwan, 2004). Specifically, the primary goal of contemporary science education in both countries is to enhance their citizens' scientific literacy. To achieve this vision, the reform initiatives

have focused on promoting a shift in K-12 classroom practices towards student-centered and inquiry-based learning approaches (AAAS, 1993, 1999; Ministry of Education [MOE], Taiwan, 2004). The national policies on science education have been through important shifts over the past four decades in Taiwan. Table 2 presents the historical landmarks in science education reform in Taiwan from 1970 until now (National Science Council, Taiwan, 2006).

Table 2. *Evolution of the Secondary Science Education Curriculum in Taiwan*

	Before 1970	**1970–1990**	**1990–2000**	**After 2000**
Policy Vision	Master scientific knowledge			
		Learn application of science		
		Learn science process skills		
			Develop cognition and science concepts	
			Learn about science-technology-based society and integrated science	
				Learn scientific inquiry
Curriculum Goals	Cultivate citizens' health			
	Prepare students for exams			
	Career training			
	Develop technology talent			
			Cultivate citizens' science literacy	
Teaching Activities and Strategies	Lecture-based teaching			
	Lab experiments			
			Application of science to practice	
				School-based curriculum
				Teacher and school autonomy
				Student-centered pedagogy
Evaluation and Assessment	Emphasis on final evaluation			
			Emphasis on formative assessment	
				Emphasis on evaluation of basic skills (reading, writing, numeracy skills, ability to apply scientific knowledge in everyday life)

The above table demonstrates that before the reform, the science curriculum primarily emphasized that students should develop scientific knowledge and facts. In addition, the assessment approach was mainly examination-oriented to evaluate students' factual knowledge. Policymakers at that time believed that developing scientific knowledge in citizens was necessary for the nation to advance its military and technology goals. Before the reform, content-based science curricula largely focused on memorization and regurgitation of scientific knowledge. Science labs mainly focused on following specific instructions to conduct science experiments without developing an understanding of the context and application of scientific models. In addition, teachers were required to teach the content prescribed by the Ministry of Education (MOE) in Taiwan.

With the introduction of competency-based curricula in the 1990s, the Ministry of Education (MOE) shifted its role from controlling content-based curricula to providing teachers with competency-based guidelines. This shift also affected teachers' role in their classroom practice. In the most recent Taiwanese *Grade 1-9 Curriculum Guidelines* (MOE, 2011), secondary science teachers are expected to improve students' scientific literacy to enable the students to contribute to global economic growth and sustainable development. To achieve this objective, teachers should mainly focus on helping students to understand and apply scientific knowledge to solve authentic problems.

In addition, teachers are required to develop students' scientific inquiry skills, such as critical thinking and evidence-based decision making skills. This is emphasized in the curriculum guidelines for grades 1-9 (MOE, 2011): "At the end of K-12 science, all students should be equipped with certain scientific skills, such as inquiry (e.g., observing,

inferring, categorizing, and comparing) . . . critical thinking and problem solving skills to design scientific experiments" (p. 3). These teaching guidelines expect science teachers to develop students' inquiry skills, creativity, critical thinking, and positive attitudes toward science (*White Paper for Science Education*, 2004, p. 9). To this end, the *White Paper for Science Education* suggests that the MOE and the National Science Council in Taiwan should emphasize "student-centered pedagogy in teaching and evaluation practices" (p. 12). In particular, the concept of "group teaching" (分流教學) was suggested in curriculum guidelines as one of the strategies to foster student-centered pedagogy in K-12 science classes. It encourages teachers to place students into various groups or configurations according to their abilities.

Teachers are now expected to use teaching approaches and evaluation methods that will allow them to identify students' individual needs so that teachers can support students in accordance with their specific needs. The focus of teacher education has turned to improving teachers' pedagogical skills to implement the reform-based curriculum. As a result, both the MOE and the National Science Council in Taiwan have highlighted the importance of teacher autonomy in creating curriculum materials. For example, developing teachers' creativity in designing teaching/learning materials has become a key goal of pre-service teacher preparation programs. Therefore, to expand and improve pre-service teachers' teaching skills, the MOE has provided funding to Taiwanese universities to offer various courses that enhance their teaching skills, such as "Field Teaching Credit Classes," "Second Specialty Credit Classes," and "Specialty Augmentation Credit Classes." Universities are also funded by the MOE to offer scholarships to encourage pre-service teachers to enroll in masters programs.

In addition, the MOE has set up mentorship programs to provide personal and professional support to in-service teachers. According to the *White Paper for Science Education* (MOE, 2004), teacher mentorship programs have been developed to promote partnerships among teachers, provide teachers with opportunities to observe teaching in other classrooms, and support them in implementing non-traditional teaching methods in their classrooms. In addition, the MOE has established regional in-service education centers. According to the policy documents, the *White Paper for Science Education* (Ministry of Education [MOE]-Taiwan, 2004) and *Important Teacher Cultivation Policy* (MOE, 2006), the regional education centers serve to establish professional communities for teachers and provide them with relevant resources for implementing student-centered and inquiry-based approaches in local schools.

Moreover, the MOE and the National Science Council in Taiwan have organized annual "Technology Innovation Contests" and "Science Education Activities" for students. Science teachers can encourage their students to participate in these activities. The Taiwanese National Science Council regularly holds technology competitions for innovative science and technology projects developed by scientists and students and posts the results on its website. Furthermore, Academia Sinica in Taiwan—the highest government academic research institution in Taiwan—regularly organizes public lectures to help teachers and parents learn about the current developments in science and technology. As the *White Paper for Science Education* (MOE, 2004) states, "Science activities should become a part of citizens' cultural events" (p. 29).

With the focuses on improving citizens' scientific literacy and increasing students' interest in science, the MOE has also funded museums, such as the National

Museum of Natural Science and the National Science and Technology Museum, to organize various events and activities (e.g., the Exhibition for Creative Science Experiments and the Competition for Solar Powered Vehicle) to foster students' engagement in science as well as provide teachers with more professional support. As the *White Paper for Science Education* (MOE, 2004) indicated, mainstream, institutional, and social media should promote popular science.

In this section, I presented an overview of the policies related to science education reform in Taiwan. My analysis reveals that the overarching aim of K-12 science education is to cultivate students' scientific literacy. Teachers are expected to develop learning materials and pedagogical approaches in line with this goal. In addition, the policy documents outline the professional resources that should be provided to teachers to facilitate the implementation of this policy. I now turn to the second major section of this chapter, which focuses on policymakers' and teachers' perspectives on science education reform in Taiwan.

Policymakers' and Teachers' Perspectives on Science Education Reform in Taiwan

In this section I attempt to address my research questions regarding policymakers' and teachers' perspectives on the current developments in science education. More precisely, I attempt to address the following research questions: (a) How do secondary science teachers perceive and understand the science education policy and its specific curriculum goals in Taiwan?; (b) What is Taiwanese policymakers' vision of the science education policy?; and (c) What particular goals did they consider while formulating these policies?. I begin by discussing my interview conversations with the policymakers who initiated the science education reform and formulated the *White Paper*

for Science Education (2004). I then present the main themes that emerged from my conversations with secondary science teachers. Further, I investigate how these teachers learned about the policy and curriculum goals as well as where and how they received any professional support to implement the reform. Finally, I provide a comparative analysis of the policymakers' and teachers' views on the reform and the challenges concerning its implementation in Taiwanese public schools. The discussion of teachers' views of the reform policy lays the groundwork for the discussion in Chapter 6 on the relationship between teachers' cultural beliefs and their teaching practices.

In my interviews with the three policymakers, I focused on how they initiated and formulated the reform documents, as well as their visions and goals for science education in Taiwan. Some policymakers clearly explained that developing scientific literacy of Taiwanese students has been the primary purpose of science education reform in Taiwan. Specifically, Qian-hua,[6] who was a member of the core editorial team for the *White Paper for Science Education* (2004), commented that "[earlier] we used to only emphasize textbook knowledge . . . but the vision of reform is to develop citizens' literacy in science." Likewise, Yang-ming, another member of the core editorial team, echoed Qian-hua that "increasing everyone's science literacy . . . has become the goal of science curricula at all levels of education."

For Qian-hua and Yang-ming, scientific literacy means knowledge and understanding of scientific concepts and process skills for participation in civic affairs. For Qian-hua, "science literacy no longer just concerns the scientists. All citizens would have to learn science." Similarly, Yang-ming explained his understanding of scientific

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[6] All participants' names are pseudonyms.

literacy as, "students taking interest in science and understanding how to use the scientific concepts" for civic engagement rather than "just memorizing a bunch of information."

In addition, Huai-guo, who coformulated the reform policy on teacher preparation, noted that promoting diverse interests and talents among students is also the primary reason for the reform. Huai-guo noted that the policy goal was to provide teachers with more autonomy in their practice, so that "students' diverse interests, capacities, and skills can be developed." Huai-guo further explained that the reform promoted an "interdisciplinary science curriculum." For example, the secondary biology content has been integrated with other disciplines, such as farming, food sciences, medicine, and environmental sciences. As Huai-guo said:

> I hope our education system can embrace diversity. . . . We can support different perspectives. . . . The system won't just produce two kinds of students: those who get into Medicine and those who failed their exams."

Contrastingly, nine of the ten in-service teachers I interviewed were not aware of any policy science education reform and half of them had never heard of the concept of scientific literacy. Some teachers knew about scientific literacy as a policy goal, but lacked a clear understanding of what it meant for their professional practice. Only one secondary science teacher, Chang, who is also an instructor in a professional development program for teachers, explained scientific literacy as developing "students' problem-solving skills." As Chang noted, "students should be able to look at things with a scientific eye and use scientific methods to solve problems to further their knowledge in this field."

In the *White Paper for Science Education* (2004), student-centered and inquiry-based teaching approaches are highlighted as key strategies for improving students' scientific literacy. In my interviews with science teachers, I found that about half of the participants thought that the current science curriculum promotes student-centered teaching approaches to improve students' hands-on skills, critical thinking, and problem-solving competencies. The rest of the teachers thought that the policy emphasizes a rigorous preparation of Taiwanese students for international science assessments. For instance, a number of teachers (6/10) talked about preparing secondary students (i.e., grade 9 students) for the Programme for International Student Assessment (PISA). When teachers were invited to talk about their understanding of the PISA test, Zhong, who has been teaching secondary physical science courses for several years, mentioned that this test requires teachers to provide their students with problem-solving opportunities to develop their analytical thinking. Similarly, Ren, who has been teaching physical and earth science for twenty-four years, saw PISA as an exam that aims to evaluate secondary students' comprehension of basic science concepts and analytical skills. Zhong, Ren, and Yi, all physics and chemistry teachers, explained:

> The only policy I know is the PISA test. . . . It asks teachers to provide different solutions instead of giving them the right answer directly. It also requires students to think of where the solutions come from. (Zhong, physical science teacher)
>
> The PISA test only tests their basic skills . . . they are simpler than what they are tested on in traditional [national] exams. (Ren, physical and earth science teacher)

> The PISA test focuses on basic life skills that students need to tackle practical day-to-day problems. (Yi, physical science teacher).

On the other hand, some teachers said that they had only heard of the PISA examination during their in-service education programs, but they did not know any details about this international assessment program. Ting, a high school physics and chemistry teacher, remained silent when he was asked to explain his understanding of the PISA test during the interview. Furthermore, Xiao, who teaches secondary biology, didn't seem to have a clear idea about it, as he thought that PISA meant "science literacy." However, he also did not answer my question about how to develop scientific literacy in students. Similarly, Jing, who is a biology teacher, noted that she had not heard about the science education policy. She was only aware of the PISA exam in mathematics for grade 9 students.

The discussion in this section addressed the research questions regarding policymakers' and teachers' understandings of the reform vision and goals. Interestingly, the policymakers and teachers expressed very different understandings of the reform goals. While the policymakers articulated developing students' scientific literacy and nurturing their diverse talents and inquiry skills as the main goals of the reform, most of the teachers perceived that the aim of the reform policy was to prepare grade 9 students for the secondary science PISA exam.

Also notable is that although a number of teachers were familiar with the science education policy and relevant government documents, they were not aware of the details of the science education policy. Further, several teachers shared that they mainly learned about the current educational developments and trends from other sources (e.g.,

newspapers, magazines, and online resources for teachers). I will present these findings in more detail in Chapter 6 where I elaborate on how teachers' epistemological beliefs are related to their instructional goals and practices.

Policymakers' and Teachers' Perspectives on Professional Development and Support

In this section, I discuss teachers' views about existing professional supports in relation to the reform-based practices. Most teachers thought that the existing in-service teacher education programs organized by the Ministry of Education were generally irrelevant to their needs, as they did not help them in learning practical skills to improve their teaching. Additionally, several teachers pointed out that preparing students for the PISA test appears to be the main purpose of professional training sessions for in-service teachers. The findings suggest that science teachers mostly valued the professional support from their colleagues, school-based teacher communities, and online professional networks. Interestingly, none of these teachers mentioned learning anything related to the reform policy in their teacher preparation programs. In my interviews with teachers, only some of them (4/10) highlighted the useful skills that they had learned during their pre-service preparation, such as computer skills, hands-on science activities, and information technology. Other teachers (5/10) believed that professional learning communities could provide them with adequate support through workshops on new teaching methods, global trends in science education, and other relevant information about teaching and learning resources. They seemed to believe that the professional development activities organized by the learning communities were exclusively initiated by the teachers.

A number of teachers also mentioned that the Internet is their main source of information about the new trends in science education. For instance, Wei, a beginning physics teacher, shared that teachers' online group discussions have been helpful in developing new materials and skills. Specifically, Wei has been designing teaching materials and sharing them with her friends and colleagues through online forums. Wei said that receiving feedback from other teachers on her ideas was more helpful than the information that she had received in the in-service workshops.

Furthermore, I noticed striking differences between teachers' and policymakers' perspectives on professional support for teachers. The policy documents indicate that pre-service and in-service teacher programs are meant to prepare teachers for implementing the reform-based pedagogy; moreover, allocating professional resources and supports for teachers to local teaching communities is an important strategy for promoting the reform-based pedagogy. All the policymakers also pointed out the importance of designing ongoing professional development programs to scaffold teachers in shifting their practice. They strongly believed in reforming the teacher development programs in line with the science education reform. Indeed, in their leadership roles in the teacher education system, they have been trying to introduce significant systematic changes to enhance the quality of teacher education programs. However, they felt that teachers are not benefitting from ongoing in-service programs, even though the government has allocated tremendous amount of financial resources to establish these programs. They were concerned that teachers are generally not interested in participating in regular in-service training to improve their teaching. In contrast, I found that most of the teachers did not find these programs useful because they felt that the in-service programs organized by the Ministry

were mostly irrelevant to their classroom practice. Instead, they preferred to participate in their local professional communities to exchange new ideas and teaching experiences with other teachers.

Obstacles to Science Education Reform

During my interviews with policy leaders, our conversations also focused on their views on the barriers to education reform. The three policymakers felt that it has been very challenging to implement the education policy that is described in the *White Paper for Science Education* (2004). They described the *White Paper* as an "ideal proposal" for certain educational settings, which may not be suitable for Taiwanese schools. Although the current amendments to the *White Paper* placed more emphasis on teacher preparation and revising the assessment systems, the policymakers felt that the reform policy is not yet widely understood and accepted by teachers, parents, and students. One of the policymakers, Yang-ming, noted that it is difficult to implement the policy because "teachers cannot persuade the parents to change their cultural values [regarding education]." While explaining his views on these challenges, he said:

> Teachers cannot persuade parents to change the values of society . . . teachers are afraid of changing teaching methods. . . . I don't know what we could do to help teachers. Teachers choose teaching methods that are acceptable within the society. (Yang-ming, interview, June 5, 2013)

When invited to elaborate on their experiences of implementing the policy, all policymakers shared similar challenges, which include the national examination system and cultural education traditions. In particular, all of them pointed out parents' expectations in regard to their children's academic achievement in national examinations,

which force the teachers to place more emphasis on preparing students for the standardized exams. Consequently, parents' expectations pose a massive challenge to competency-based curricula that promote active engagement and critical thinking on the part of students.

Huai-guo explained that parents' expectations are deeply entrenched in the prevailing societal notions of success, therefore, he thought that "parents will never comprehend [the reform] because they basically want their children to perform well on the exams." However, in Huai-guo's opinion, success in national and international assessments doesn't mean that the education system in Taiwan is really successful. In his words:

> It doesn't mean that our education is successful even though our students perform well on international competitions like PISA and TIMSS. It is because we memorize for exams. However, parents will never be able to comprehend [open-ended inquiries] because we have always thought that knowledge should be memorized. (Huai-guo interview, May 17, 2013)

Like Huai-guo, Yang-ming also believed that since teachers and parents highly value the teaching and medical professions, parents expect their children to study hard so that they can achieve higher grades on exams that are required for entry into these professions. This worldview affects the implementation of reform-based pedagogy in science classrooms. Similarly, Qian-hua pointed to the huge gap in policy and practice that results from the value that is placed on achieving high scores in exams. Specifically, Qian-hua thought that parents reacted negatively to the learner-centered approach

because they believe that lecture-based instruction would be the best method to prepare their children for the national exams.

> Parents' pressure is easy to explain. Whenever you change something new, they [parents] panic. Parents are so used to sending their children to cram schools [to prepare for exams]. But now, even cram schools do not know how to teach [using inquiry]. Of course, parents panicked, so they rejected this policy. (Qian-hua, interview, June 5, 2013)

Further, all policymakers asserted that contemporary developments in education cannot be sustained without a fundamental transformation in the traditional learning culture. In this connection, they highlighted the profound ways in which Confucian learning principles have historically shaped educational traditions in Chinese culture.

According to Huai-guo, "Confucianism emphasized collectivism, harmony in family and community, which conflict with the notion of individualism in Western cultures." He further added: "Collective thinking about establishing a balanced social order has led the society to prioritize discipline and rules without considering the long-term effects of these values." He continued,

> Widespread acceptance of Confucianism restricts the space for developing new ideas or values in the society. The dominance of these values affects science classroom practice, since teachers mainly ask their students to behave in a disciplined manner and conduct structured science experiments by following the directions given in the textbooks. Teachers do not encourage innovative thinking and other scientific skills, [such as] critical thinking and problem-solving skills . . .

> which affects the development of scientific knowledge in the society. (Huai-guo, interview, May 17, 2013)

Thus, Huai-guo stressed that, in order to reform the educational practice, "students have to change the concept that teachers and textbooks are always right; teachers have to accept that students can challenge the knowledge and authority of teachers." Echoing Huai-guo, Yang-ming noted, "The emphasis is on conformity and respect for tradition has prevented the implementation of nontraditional teaching methods in the formal education system. . . . It's difficult for the society to accept the inquiry method as it [disrupts] discipline."

Qian-hua also shared the same perspective on Confucian traditions vis-à-vis the reform. Particularly, Qian-hua noted that Confucian values "have limited the progress of science in this country." Since respecting elders and following traditional norms are considered as important values that individuals should develop, innovation and exploring different ways of thinking might be viewed as a sign of disrespect, in Qian-hua's view. Qian-hua felt that Confucian learning culture has been overly emphasized in Taiwanese society. Qian-hua further explained:

> In Confucian cultures, functionalism, collective thinking, acting according to tradition . . . are important characteristics . . . knowledge, professional education and credentials are valued more than technical, hands-on skills. These are obstacles to scientific advancement . . . and the reason why science in Asia cannot advance. (Qian-hua, interview, June 5, 2013)

In contrast, the issues that were highlighted by the science teachers were very different from the policymakers' views on the implementation challenges. In my

conversations with teachers, most of the teachers (7/10) noted that policymakers did not really understand the real obstacles that teachers have to face in their actual teaching environments. Chang, who is a mentor in the in-service teacher community, felt that policy planning and implementation measures do not speak to the issues that exist in actual classrooms. As an instructor in professional development programs, Chang follows the developments in educational policy and planning closely. From his perspective, "policymakers see what they want to see and take it as a sign of change, whereas teachers don't feel anything different." As Chang explained, "The higher authorities have their policies . . . [but] the local people have their countermeasures . . . the implementation is not successful because there is still a huge gap [between policy] and the reality in schools."

Echoing Chang's views, Bao, who is a beginning physics and science teacher, noted that improving students' hand-on skills is not applicable at the school where he is teaching because of limited funding and resources. As Bao explained, "I think improving students' hands-on skills is too idealistic. The funding and resources are not enough for this kind of science teaching."

Hei, who has been a physics and science teacher for 27 years, also believed that policymakers did not fully understand teachers' actual needs. In his opinion the education system should "group students into different levels based on their abilities," because in his view, it would "help teachers and parents to use specific supports to facilitate students' learning more appropriately." However, in Hei's words,

> Policymakers have to know how parents think. Parents only care about exam scores. No matter how much effort a teacher puts in, parents will blame the

> teacher for not helping students improve their exam scores. However, I think the policies and experts in the field of education don't really know our actual teaching practices. (Hei, interview, May 31, 2013)

Some teachers specifically pointed out that policy leaders did not help parents understand the policy changes before they expected the science teachers to alter their teaching practices. All the teachers felt that policy leaders need to increase parents' and teachers' understanding of the new educational policies. Xiao, who teaches biology in a secondary school, shared his struggles in explaining the reform goals to his students' parents. Xiao said that he tried to incorporate some new approaches in his teaching practice, such as using open-ended questions and encouraging students to think and develop creative solutions to scientific problems, but he felt that both parents and students could not understand why there were no standard "right" answers to these problems. Consequently, Xiao felt that he "wasted a lot of time and energy" explaining his teaching goals to the parents. In the end, he gave up on these practices and chose to satisfy parents' and students' expectations by returning to his traditional methods.

Additionally, some teachers felt that adequate professional development opportunities were not provided to support the teachers who used the inquiry and competency-based approaches in their classrooms. Talking about these challenges, Xiao commented:

> It is very challenging . . . if we want to improve students' thinking, teachers need to have more time to train students to learn how important it is to think in science . . . need more time to check their answers to open ended questions. I

wanted to try, but in the end, I was trained to provide standardized answers. (Xiao, interview, May 20, 2013)

Other teachers shared that their main concern about these new teaching methods was that they did not having enough time to facilitate class discussions. For example, Zhong, who has been teaching physics for seven years, shared that he tried to encourage his students to engage in class discussions. However, he felt that students' answers to his open-ended problems were not relevant. In order to catch up with the term schedule and lesson plans, he said that he had to regulate students' discussions by giving them the right answers directly. As a result, Zhong felt that student-centered pedagogy was not practical because teachers mostly ended up directing and dominating class activities. As Zhong stated,

> Student-centered [approach] was a mess and I had a hard time monitoring students' learning progress. . . . After my experience of trying group learning methods, I [now stick to the traditional teaching methods]. (Zhong, interview, May 21, 2013)

Similarly, Jing, who was aware of focus on promoting student-centered learning in the new science policy, said that she tried to use active learning methods in her teaching. However, because of the time constraints, she couldn't follow the reform-based approaches, as she lacked professional skills and experience in these methods and also had to cover the curriculum content in a short amount of time before the exams. As Jing said, "I think I don't have enough training and time to try different teaching methods . . . even now with just lectures, I feel like I already need to rush through things" (Jing interview, May 31, 2013).

Chapter Summary

My analysis of teachers' and policymakers' perspectives on science education reform revealed a number of complex issues concerning their understanding of the reform. Teachers encountered a myriad of issues including unclear policy goals, a lack of comprehensive understanding of the reform policies, and limited professional support related to the new science curriculum. Most of the teachers did not feel that the policy changes were relevant to the current educational environment in Taiwan. Teachers also reported difficulties while trying to use nontraditional teaching approaches (i.e., inquiry and problem-based activities), particularly in the context of high-stakes testing in Taiwan.

The national examination system was highlighted as the main challenge to the reform by both policymakers and teachers. The policymakers also seemed to have a fairly clear position with regard to the challenges posed by the Confucian traditions to science education reform. Notably, all policymakers and teachers shared similar concerns about the ways in which the heavily examination-oriented education system negatively affected the implementation of the reform policy. However, teachers thought that irrelevant policy planning, insufficient instructional time, and inadequate professional development were the main barriers to the reform. In Table 3, I have summarized the views of policymakers and teachers on these issues. Thus, I decided to investigate teachers' views on Confucianism in the second round of conversations with them. Those findings will be discussed in the next chapter. Specifically, I will illustrate the relationship between teachers' Confucian epistemologies and teaching approaches.

Table 3. *A Comparative Examination of Policymakers' and Teachers' Perspectives on Science Education Reform Policies and Challenges*

Policymakers	Science Teachers
Policymakers' and teachers' understanding of the reform policy	
• Comprehensive understanding of the reform; co-authored the reform policy document—the *White Paper for Science Education (2004)*	• Not aware of any reform policy documents or reform goals • Lack of clarity regarding science literacy
• The reform goal is to improve all students' scientific literacy; nurture their inquiry skills and diverse talents	• The reform means preparing students for the PISA test; improve students' critical thinking skills and problem-solving competencies
Policymakers' and teachers' perspectives on professional development and support	
• Pre-service teacher preparation programs provide professional supports for reform-based pedagogy	• Pre-service teacher education mainly provides information technology and computer skills and hands-on science activities
• Ongoing in-service professional training is offered at local educational centers to support teachers to implement the reform	• In-service professional development mainly helps in preparing students for the PISA test
• Professional resources and support are provided for teachers to create school-based teaching communities	• Colleagues, school-based teacher communities and online group discussions are the main sources of information about new trends in science education
Policymakers' and teachers' perspectives on obstacles to the reform	
• Examination system	• Irrelevant policy planning
• Parents' pressure to prepare for exams	• Insufficient instructional time
• Cultural education philosophy and learning traditions	• National examination system
	• Cultural education philosophy and learning traditions

Chapter 6: Findings II

In Chapter 5, I reviewed the education reform policy and analyzed policymakers' and teachers' interpretations of the policy and various challenges regarding its implementation. As noted earlier, the policy leaders in this study shared a common concern that Confucian educational philosophy has deeply influenced teachers' practice, and in their view, some Confucian learning traditions have posed significant obstacles to the reform. However, the science teachers didn't talk about Confucianism in relation to their pedagogical approaches in the first round of interviews. As I was very interested in exploring teachers' epistemological beliefs about Confucianism, I invited the participants to write about these issues in their reflective journals. After reading their journals, I interviewed each teacher again; and this time our conversations centered upon their professional practice in relation to their understanding of Confucianism.

This chapter is divided into three sections. I begin by exploring Taiwanese science teachers' perceptions of Taiwan's Confucian learning culture and the ways in which their understanding of Confucian philosophy of learning inspires their teaching practices. This analysis helps to answer my research question about Taiwanese science teachers' pedagogical commitments.

Taiwanese Science Teachers' Perceptions of Confucian Learning Culture

When invited to share their perspectives on Confucianism, all teachers emphasized the profound role of Confucian philosophy and values in shaping human relationships in Chinese society. They specifically talked about the fundamental virtues, that is, discipline, benevolence, righteousness, character, integrity, humanity, and wisdom, upheld by Confucian philosophy in connection with education. Importantly, all

teachers believed that the purpose of learning is to cultivate these virtues within human beings.

Hei, the most experienced teacher in this study with 27 years of teaching experience, believed that "Confucian values helped to create stable families and communities in Chinese society." In Hei's view, "Confucianism emphasizes the development of one's personal character to develop harmonious relationships in the society." Hei continued, "Confucianism encourages civility, respect for elders, loyalty to friends, family members, and superiors, and acting responsibly while performing one's duties." Hei further wrote in his journal, "If these social relationships and Confucian traditions are established, peace would prevail in the world." Similarly, Zhong, who has been teaching secondary physics and chemistry for seven years, underscored the Confucian virtues that education should promote to further the development of the individual and the society. In particular, Zhong believed that the role of a teacher is to develop Confucian moral virtues, work ethic, and discipline in students.

> Everyone in the society should learn and live by the moral values of Confucianism, especially behaving in a disciplined manner and studying hard. This way, one could achieve their life goals . . . happiness in their family . . . harmony in our society, and peace in the world. (Zhong's journal entry, August 24, 2013)

In the same vein, Ting, who has been teaching physics for nine years, believed that the traditional values that Confucianism helps to build harmonious relationships between teachers and students "still exists in the current educational environment."

I also invited the teachers to share their perspectives on Confucian learning culture in relationship to their teaching practices. In this connection, a number of teachers talked about how Confucian learning values influence their relationship with students. Three participants—Zhong, Jing, and Ting—shared that, "respect is at the heart of" their relationship with their students. Notably, respect for teachers is a very important virtue for them that should be cultivated in students through education. In the context of their classrooms, they expect their students to respectfully follow the rules because this experience would enable them to develop self-discipline, which they believed would also contribute to the larger vision of "maintaining a balanced social order" in the society. Further, building other Confucius virtues, such as personal character, perseverance, and humanity, emerged as an important goal of their teaching philosophy. Ting also talked about the importance of building a collegial relationship with students to support their character development. Significantly, Ting thought that teachers should act as "moral models" for their students. In fact, a number of other teachers also shared the same view about their students' personal and moral development. As Ting explained,

> Learning is a heritage. We pass on not only knowledge, but also personal character. Therefore, teacher-student friendship is extremely important. . . .In order to best teach personal character, it is not enough to explain in words, teachers should be moral models for students. (Ting, journal writing, August 7, 2013)

Other teachers—Xiao, Ren, Bao, Yi, Hei, and Chang—discussed important Confucian principles that continue to inspire instructional practices in Taiwanese schools. More specifically, they highlighted "*You Jiao Wu Lei*—there should be no class

distinction with respect to teaching" and "*Yin Cai Shi Jiao*—teachers should teach in accordance with the students' abilities." These Confucian principles are discussed in the background and context chapter (Chapter 2).

Specifically, Hei explained that "You Jiao Wu Lei" has led the Taiwanese government to provide equal educational opportunities for all students. He further added that this principle has helped in creating a learning culture "where our students do not feel isolated, particularly those with disabilities and also those who are from lower income families." Similarly, while explaining "You Jiao Wu Lei," Ren, who has been teaching science for 24 years, noted that "every student has the same right to education, so teachers should not treat their students differently based on their socio-economic status and performance."

Yi and Xiao also agreed that Confucianism has mostly positively influenced the learning culture in Taiwanese society. Elaborating on the second Confucian principle, "Ying Cai Shi Jiao," Yi, who teaches physics and chemistry, noted that "teachers should care about and focus on the specific needs of all students." Xiao, a biology teacher, also shared that "teachers should not judge their students and they should make persistent efforts to nurture their unique talents." Bao, a physics teacher, shared similar views:

> Confucianism emphasizes developing students' character . . . helping students to become self-motivated . . . giving students systematic guidance to meet their [specific] leaning needs. (Bao, reflective journal, August 23, 2013)

Notably, these teachers also noted that that these elements of Confucianism are compatible with the reform-based pedagogy. This particular interpretation of Confucian teaching approach has inspired these teachers to appreciate their students' ideas and they

try to engage them in discussions and active learning experiences. I will elaborate on their teaching practices in the next section.

Interestingly, although all the teachers recognized the positive influence of Confucianism in Chinese society, some teachers—Zhong, Bao, Hei, Zhong, and Chang—also commented that certain Confucian values, particularly social discipline, conformity, and respect for societal rules, have obstructed creative thinking and scientific advancement in Taiwan. Critically reflecting on these issues, Zhong explained,

> Ethical teaching in Confucianism has constrained your thinking and prevented you from thinking outside of the box. A teacher would have to constantly consider whether others would criticize your action or teaching. (Zhong, second interview, August, 21, 2013)

Importantly, some of them also noted that certain elements of Confucian learning culture, such as self-discipline and respect for authority, conflict with student-centered and discovery-oriented learning approaches. The emphasis on conformity in Confucianism limits students' creativity and participation in classroom discussions. Since the inquiry approach in science is based on critical and creative thinking on the part of students, asking critical questions might be seen as challenging the teacher's authority. As Yi argued, "In Confucian learning cultures, few students dare to challenge their teachers or raise questions in class." Since the practice of science requires free enquiry, Yi thought that "there would be no scientific advancement or economic improvement" without creative thinking. Echoing Yi's views, Bao, a beginning science teacher, reflected that Confucian philosophy "heavily emphasizes conformity and teachers' authority," which may prevent students from "expressing their own ideas and creativity." Similarly, Hei

pointed out that overemphasis on conformity and harmony in the society has inhibited Chinese students' critical thinking and ability to challenge traditional norms and ways of thinking. In Hei's words, "The result is that modern science and objective knowledge cannot be developed within the Chinese culture." Similarly, Chang pointed out that "moral ethics, social discipline, and conformity have been overemphasized" by the government and in the Taiwanese education system. Chang further explained, "[The culture of conformity] has not only inhibited students' free thinking, but also led teachers to be less willing to embrace innovative ways of teaching."

Across the interview conversations and journal entries, I present a concept map to highlight the main themes that emerges from this analysis (Figure 7). In particular, I found that all teachers and policymakers talked about cultivating Confucian values in students, such as "courtesy, benevolence, respect, discipline, humility, and a strong work ethic." According to their understanding of Confucianism, these values would help in developing a balanced and "harmonious society." It is important to note that all participants seemed to share a common understanding of Confucian moral values and ethics and their implications for the society at large. They also underscored the importance of teachers' social duty to cultivate these moral virtues in their students. However, I noticed divergent views regarding the ways in which certain Confucian traditions tend to constrain creativity, critical thinking, innovation, and scientific development. These learning traditions, in turn, have important implications for the implementation of the reform-based pedagogy.

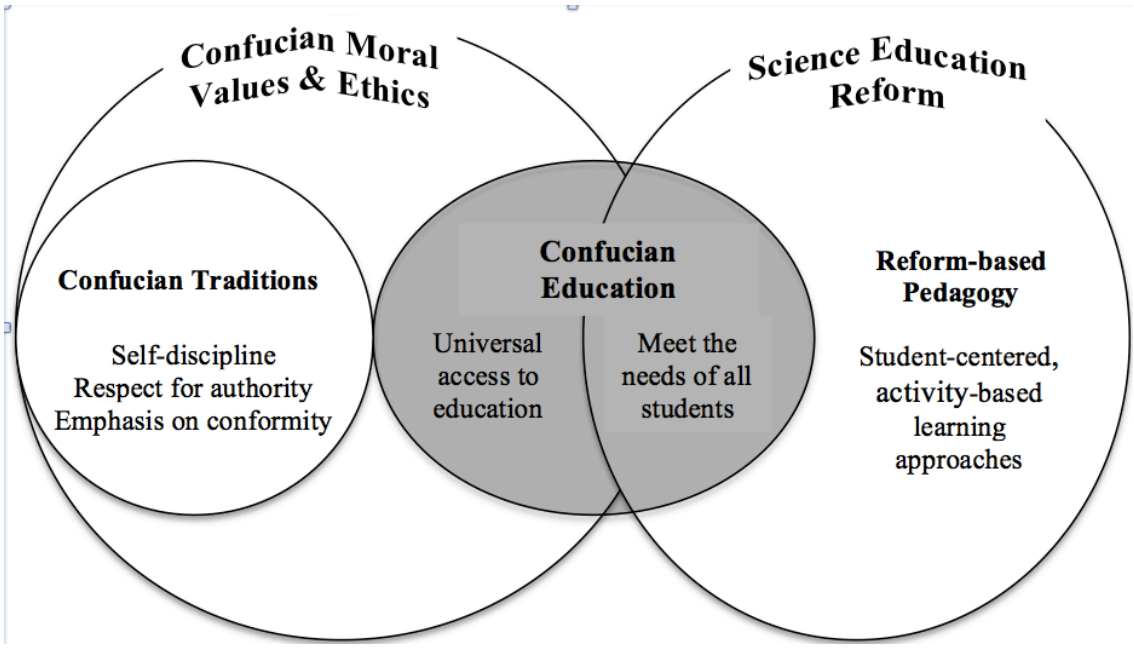

Figure 7: A Concept Map: Teacher Participants' Perspectives on the Relationship between Confucianism and Science Education in Taiwan

In the following section, I discuss Taiwanese science teachers' pedagogical approaches and actual classroom practices in order to illustrate how Confucian epistemology has shaped their science teaching.

Taiwanese Science Teachers' Teaching Philosophy and Pedagogical Approach

My conversations with science teachers during the second-round interviews also centered on their philosophy of teaching as well as their actual pedagogical practice. Below, I discuss their epistemological commitments and how they have shaped their instructional practices. In addition, I also examine the dilemmas that they have been facing vis-à-vis the science education reform policy.

Commitment to traditional practice. The finding suggested that some teachers were deeply committed to traditional science teaching approaches. For example, Zhong, Jing, and Ting believed that traditional methods are effective in teaching science. Further,

they thought that interactive approaches (e.g., discussions) were not helpful to students, as students tend to get distracted in discussions and cannot concentrate on science content. These teachers believed that a teacher should "enforce discipline in the classroom." Although they were not aware of the goals of the reform policy, they seemed to have learned about active learning approaches from their pre-service courses, in-service professional development programs, and online sources.

These teachers mainly tend to rely on traditional teaching methods, as they believe that teachers should help students memorize scientific knowledge and concepts. Importantly, they indicated that they had found traditional methods to be useful in their own learning experiences. For example, Zhong, who has been teaching at a secondary school for seven years, reflected on how his own learning experiences with lecture-based instruction had helped him succeed academically. He insisted that "lecturing is the most effective and efficient way of [teaching and] learning." While acknowledging that students "may not be actively using their thinking skills in a lecture setting," Zhong believed that direct teaching is "still the most effective method for students to achieve academic success." Though he learned about the cooperative learning method during his pre-service preparation, he was not comfortable losing control over his students' learning. Zhong emphasized that a teacher's role is to help students earn high scores in exams so that they could pursue successful careers in their lives." Zhong noted that "students at the secondary level have not yet acquired the science knowledge to support their independent thinking process." Therefore, he believed that "innovative thinking may lead to overthinking the science content."

Similarly, Jing, who has been teaching at a secondary school for four years, also noted that she was more comfortable with traditional teaching approaches. She grew up in a traditional learning environment and felt that she learned science well through traditional methods. In addition, Jing believed that her role as a teacher is to guide her students in their learning. As she stated:

> I interact with my students in the way I feel comfortable. . . . I teach my students by using the way I like. I don't give my students autonomy in the class. My role as a teacher is to lead their learning process. . . . Although I may seem to be transmitting knowledge to them through lectures, I don't see anything wrong with this method. (Jing, first interview, May 31, 2014)

Moreover, Jing said that she prefers to guide her students in the lab. Students should review the lab manual before the lab and then follow the stepwise instructions in the manual. Jing also believed that the purpose of "doing science experiments is to help students memorize"; and that, students at the secondary level "are only capable of following instructions, and they cannot design their own scientific experiments."

Like Zhong and Jing, Ting, who has been teaching at a secondary school for 12 years, shared that guiding students' learning and maintaining discipline in the classroom are important features of his teaching practice. He believed that the teacher-student relationship should be based on respect. He further added that as a public schoolteacher, he sees his role in building his "students' character and respect between individuals." Ting believed that developing positive personality traits and seeing successful scientists as role models can help students improve themselves and achieve academic success. While describing his teaching approach he said, "I teach by writing on the blackboard

while students quietly sit in the classroom and listen to the lecture." In his reflective journal, Ting noted, "As a teacher, I have to instruct students to do science experiments while maintaining classroom discipline." Ting thought that lab work can distract students, therefore, while teaching his lab, he said that he guides his students to carefully follow the instructions for experiments. Further, he firmly believed that the role of the teacher is to lead his student to "achieve their learning goals."

Interestingly, in my conversations with Zhong and Ting, I noticed that, in some ways, they did seem open to interactive teaching approaches, but at the same time, they were not convinced about the effectiveness of these approaches. In particular, while expressing their appreciation for class discussions, they also insisted that direct instruction methods were useful in keeping students attentive and maintaining discipline in the classroom. They also shared that their experience of incorporating discussions in their classroom were not very successful. For example, Zhong shared that he tried to engage students in group work and in-class discussions, however, he recalled that "it was a mess" because he "had a hard time controlling students in discussions." He also felt that "most of the discussions in class were not relevant to the science concepts." Likewise, Ting commented that most of the classroom discussions "ended up being irrelevant to science lessons." Further, both Zhong and Ting perceived their own role as "ethical and professional role models" as teachers. They also viewed learning as a cultural heritage and wanted to see Confucian traditions passed on to the next generations for the sake of maintaining social harmony. They thus appeared less open to teaching methods that were different from those of their own teachers and cultural traditions. In sum, their commitments to traditional practices were based on their beliefs in the effectiveness of

traditional approaches in terms of students' success in exams. Additionally, they felt more comfortable in leading students' leaning and maintaining classroom discipline while using traditional methods.

Straddling between traditional and learner-centered approaches. A number of teachers shared the dilemmas that they have been experiencing vis-à-vis their epistemological beliefs and actual classroom practice. More specifically, they highlighted the conflicts while making comprises in their teaching practice in the face of external pressures imposed on them by the heavily examination-oriented education system. The following analysis illustrates these tensions in their beliefs and practice.

Some teachers—Yi, Hei, and Bao—were aware of and, in some ways, influenced by the discourses concerning student-centered teaching approaches. They learned about the new instructional strategies from other teachers and different media sources (education newsletter and magazines, television programs, social media sites and online teaching resources). These discourses have led them to reflect critically on their prior beliefs about teaching and learning. Some of them also reflected on the changes in their pedagogical beliefs in their reflective diaries. Looking back on their own learning experiences, they felt that the ways in which they had been taught might not be the best way to teach their own students. Therefore, they seemed more receptive to learning about and experimenting with other teaching approaches. Some of them admitted that they had considered alternative ways of teaching science, such as using hands-on activities and project-based learning methods. For example, Yi and Hei, who have been teaching for 12 and 27 years respectively, expressed their willingness to adopt inquiry-based teaching strategies.

As discussed in the preceding findings chapter, Yi was not aware of the goals of the formal reform policy. Since then he had learned about the Programme for International Student Assessment (PISA) in some of his in-service workshops. He assumed that the main purpose of science teaching was to train his students for the PISA test. However, Yi tended to agree with the pedagogical approaches promoted by the PISA test (PISA items assess students' science competencies including their problem-solving ability). Although Yi did seem to think that science learning should focus on application of science concepts to solve problems, at the same time, he was cognizant of the issues concerning the constraints imposed by the standardized exams. He explained that problem-solving approaches would not help his students to achieve high scores on these exams. As a novice teacher, Yi had tried to use hands-on approaches to engage his students in learning science; however, he felt that his students did not do well on exams. Concerned about his students' future careers and their parents' dissatisfaction with the exam results, Yi was asked by the parents to stop using activities in his class. Thus, Yi had to resort to traditional approaches. Nevertheless, Yi still believed that "students do not engage in thinking and deep learning while listening to lectures."

Similarly, another physics teacher, Hei, believed that there is an overemphasis on exams in the education system, which has led teachers to instill knowledge in students to perform well in exams. When invited to share his pedagogical practice, Hei described his struggles more explicitly. According to Hei, "The problem is that in this overly exam-orientated system, students cannot develop critical thinking and creativity." Although Hei said that he hopes to encourage students to think and be creative, Hei said that he doesn't have sufficient time to "cover the textbook content." Moreover, Hei felt that "the

majority of students are more interested in their exams." Consequently, Hei said that he mainly uses traditional lectures in his class. Hei continued,

> All the science teachers in Taiwan face the same obstacle, which is lack of time and the pressure of exams. . . . Instead of teaching them how to think, I can only follow the textbook content. I hate to be in this way, but I can't change the reality. . . . [Problem-solving] also doesn't help the students to think and have different perspectives because it is useless to help [them in] exams. (Hei, first interview, August 19, 2013)

Similarly, Bao—a biology teacher—also shared his views on activity-based teaching strategies. He thought that hands-on approaches were more useful in terms of promoting students' science understanding as he believed that active learning and reflection can help in a better understanding and retention of knowledge. Nonetheless, Bao said that "he has not been able to do lab work in his class" as he has to cover a vast amount of content in a short period of time before the exams. He felt that teaching through lectures was an efficient, but not an effective, way to teach the curriculum content. While talking about the reform initiative, Bao said that although "most of the educational reform policies were developed with good intentions, the education leaders were not able to solve the actual problems in local schools." He further added that teachers are not supported adequately to deal with these challenges. Moreover, he felt that "Taiwanese parents are not concerned with issues as they only care about the exams." Consequently, Bao admitted that most of the time, he felt "frustrated and helpless" while trying his best to "provide his students with opportunities to conduct science experiments themselves."

Based on these discussions, I noticed a conflict in Hei's, Yi's, and Bao's epistemological beliefs about learner-centered teaching approaches and their actual teaching practices. Particularly, while they seemed to believe that inquiry-based strategies would be useful in developing their students' critical thinking and problem-solving skills, they had to decide in favour of traditional methods to focus on preparing their students for the standardized exams.

Other teachers—Xiao and Ren—demonstrated a greater commitment to learner-centered pedagogy. Xiao and Ren, who have been teaching for 17 years and 24 years, respectively, believed that inquiry-based approaches are essential to develop students' understanding of science. They explained that they have been trying to integrate inquiry-based strategies into their teaching practice. However, since they also have to deal with the pressures of an examination-driven learning culture, they cannot fully implement active learning approaches in their practice. Xiao shared that as a student and beginning teacher, he "used to believe that memorizing could lead to greater academic success." However, influenced by the new trends in science learning that he learned from his professional colleagues and the media, he realized that his only memories of learning were of studying and taking exams. Looking back at his own learning experiences, he said, "We spent all our weekends studying at school. However, when I look back, I feel that it was not worth it. My youth is gone." He further added, "Testing how much information students can memorize doesn't really lead to greater success." Realizing that studying for exams could be boring, Xiao decided to explore different ways of encouraging his students to discover their own interests in science. However, despite this transformation in his beliefs, Xiao said that he has to comply with parents' requests to use

traditional methods for teaching science. He reflected, "I tried . . . [but] because the current education system in Taiwan still focuses on teaching to the test, I had to provide standardized answers to problems to prepare students for their exams." Nonetheless, Xiao hasn't given up completely in the face of these systemic, cultural, and social pressures. He said that he tries to practice inquiry-based teaching while addressing his students' and parents' needs concerning the exams. Thus, drawing on the Confucian principle, *Ying Cai Shi Jiao*—"teach in accordance with the student's ability"—Xiao said he requires his students to practice the exam questions at home, while he monitors each student's progress by using online tools. At the same time, Xiao designed an online test to provide his students with further training and practice for the national standardized exams. However, at the same time, he also uses group activities and science experiments in his classroom. Using a combination of traditional and activity-based approaches helps him to address parents' concerns while using inquiry-based methods. Xiao noted that although he still focuses on preparing students for exam, he has "transformed [his] teaching from an exam-oriented approach to one that increases students' interest in learning."

Ren, who has been teaching physics, chemistry, and earth science for 24 years, was also dissatisfied with his own learning experiences, and hoped to provide his students with a different learning environment. He said that he was "frustrated with this learning environment, as students' ideas were suppressed and they were not allowed to ask questions while learning." Ren recalled, "When I was a student, I had thousands of questions popping out while reading an article," but in class, he was "expected to sit quietly and listen to teachers' lectures," and he "did not get answers to his questions."

Like Xiao, Ren believed that "teachers should not suppress students' curiosity by asking them to behave and sit quietly in class." In his own practice, he attempts to create a learning environment where students could engage in group activities and design their own learning tasks. Although Xiao and Ren seemed committed to the inquiry approach, Ren's pedagogical commitment appeared to be more aligned with student-centered approaches. Ren shared that he did not see teachers as the only "knowledge holders" because "students can learn better in groups" by sharing their knowledge with each other. Specifically, in this digital age where information is easily accessible to students on the internet, "it is not necessary for students to acquire all the knowledge from teachers," he explained. Talking about his pedagogical practice, Ren further added, "Through group discussions and collaborative learning, students are allowed to set up their own learning goals and achieve those goals by working with their peers." Ren continued, "Teaching and learning approaches now are different from the earlier [traditional] methods . . . teachers should become learning partners rather than knowledge providers" in the teaching and learning process. However, because of students' expectations to excel in national exams, Ren shared that he also has to use traditional lectures in his class. Ren is trying to use a combination of traditional and inquiry-based strategies to address his students' and parents' demands. Given these external pressures, Xiao and Ren seem to be straddling between the two pedagogical paradigms due to the conflicts between their teaching beliefs and the demands placed on them because of the traditional examination system. Hence, they have attempted to create a middle ground to pursue their pedagogical goals while finding ways to address the issues concerning the assessment system.

Commitment to reform-based practice. While the majority of teachers in this study talked about various obstacles to active learning approaches, Chang, a biology teacher and a mentor in the in-service professional development program, appeared to be deeply committed to inquiry-based learning. Chang had a clear understanding of the reform policy goals and explained that his teaching objectives focus on increasing students' interest in science, improving students' scientific literacy, and developing students' inquiry skills to enable them to design scientific investigations. In order to achieve these curricular and instructional objectives, Chang said that he has created a problem-solving based classroom, where his students can acquire scientific knowledge through experiential learning as they engage in conducting science experiments. He designs cooperative group activities as well as engages his students in solving problems using the scientific method. Chang further noted that he acts as a facilitator in the classroom. As he explained, "Students work in groups and solve problems, conduct experiments, and offer scientific explanations." In order to encourage his students to pursue their own learning goals in class, Chang assesses his students' engagement and participation in group activities also. Assessments interwoven with classroom activities also enable Chang to provide students with opportunities to demonstrate their diverse talents and creative ideas in his class. According to Chang, "When students are given the chances to perform differently, they display more passion for science learning." In this way, he is able to understand his students' diverse needs and teaches them in accordance with those needs. Unlike other teachers, Chang didn't share any discrepancies between his epistemology and actual teaching practice. He believed in learner-centered

approaches, student autonomy, and inquiry-based learning and he said that he implements these strategies in his classroom to improve his students' scientific literacy.

In this section, I illuminated Taiwanese science teachers' teaching philosophies and pedagogical practices in their actual teaching contexts. Some teachers emphasized cultural values alongside teaching science and shared their passion for passing on their cultural traditions to students. They also felt responsible for their students' academic success in life and stressed the importance of preparing them well to excel in national and international examinations. Most of the teachers said that they use direct teaching approaches in their practice. On the other hand, some teachers also tend to encourage their students to think critically and participate in class discussions. However, these discussions mostly focus on giving standard answers to the students to help them practice for their exams. A few teachers also said that they have been trying to engage students in experiments and problem-based activities, but they have limited time for discussions and inquiry tasks as they have to cover a vast amount of curriculum content through lectures to prepare their students for standardized assessments. I have illustrated teachers' commitments, confusions, and challenges in the following table (Table 4).

Table 4. *Teacher's Understanding of Reform Policy and Their Pedagogical Commitment*

	Teacher	Understanding of Science Education Policy	Teaching Philosophy and Pedagogical Practice	Stance on traditional and inquiry-based approaches
Committed to Traditional Practice	**Jing**	Science education policy promotes student-centered teaching	- Traditional lecture-based methods, memorization - Focus on preparing for exams - Ensure classroom discipline - Respect for teachers as experts and role models	Traditional teaching is efficient and effective
	Ting	Science education policy means preparing students for the PISA exam	- Traditional lecture-based methods, memorization - Focus on preparing for exams - Ensure classroom discipline - Respect for teachers as experts and role models	Traditional teaching is efficient and effective
	Yi	Science education policy means preparing students for the PISA exam	- Traditional lecture-based methods - Focus on preparing for exams - Teachers provide knowledge, students have to think and apply that knowledge	Traditional teaching is efficient, but may not be effective in meaningful learning
Straddling between Traditional and Student-centered Teaching Approaches	**Hei***		- Traditional lecture-based methods - Focus on preparing for exam - Teachers provide knowledge, students have to think and apply that knowledge - Class discussions; students answer teachers' questions	Traditional teaching is efficient, but may not be effective in meaningful learning
	Bao	Science education policy focuses on improving students' hands-on skills	- Traditional lecture-based methods - Teachers provide knowledge, students have to think and apply that knowledge - Focus on improving students' hands-on skills - Teachers demonstrate experiments and provide opportunities for students to do experiments on their own	Traditional teaching is efficient, but may not be effective in meaningful learning
	Xiao	Science education policy promotes inquiry-based teaching	- Traditional lecture-based methods - Focus on preparing for exam - Teachers provide knowledge, students have to think and apply that knowledge - Group work and team activities - Meeting students' learning needs	Use traditional methods, but willing to try inquiry-based pedagogy with parents' support
	Ren	Science education policy promotes students-centered teaching and inquiry-based learning	- Traditional lecture-based methods - Focus on preparing for exam - Group work and team activities - Meeting students' learning needs - Students lead their own learning, teachers facilitate	Use traditional methods, but willing to try inquiry-based pedagogy with parents' support
Committed to Reform-based Practice	**Chang**	Science education policy aims to develop students' scientific literacy	- Group work and team activities - Meeting students' learning needs - Students lead their own learning, teachers facilitate - Constructivist approaches	Implement inquiry-based and student-centered pedagogy

*Hei did not share his understanding of the science education policy.

Chapter Summary

In this chapter, I presented the findings related to Taiwanese science teachers' understanding of Confucian epistemology, beliefs about teaching, and actual practice. I found that most of the teachers believed in the importance of Confucian virtues and moral education in creating a harmonious society in Taiwan. Moreover, some teachers thought that Confucian educational principles, that is, equality of educational opportunity and meeting the learning needs of all students, are an important cultural legacy that should be preserved in Taiwan's education system.

After my first round of interviews, I found that all the policymakers viewed Confucianism as a cultural obstacle to the reform, whereas the teachers did not mention Confucianism as a barrier. Moreover, as indicated in the previous chapters, I was also interested in exploring teachers' beliefs about teaching and learning science, and how their epistemological commitments shape their science teaching practices. I thus decided to focus on Confucian epistemology in my second round of interviews with science teachers. Additionally, I also asked them to reflect on Confucianism and its role in education in their reflective journals.

Some teachers viewed Confucianism as a valuable cultural asset that should be passed on through formal and informal education. These teachers believed that Confucian learning values must be cultivated in students. Respect for teachers' experience, expertise, and knowledge emerged as a very important Confucian learning tradition in their interview conversations and reflective journals. They also appeared to be firmly committed to traditional teaching approaches, as they believed that the role of the teacher

is to enforce discipline in the classroom. However, some teachers thought that these social traditions have not allowed Taiwanese children to express their creativity.

Therefore, these traditions were seen by some as impediments to scientific advancement and progress in the society. This perspective is, in fact, consistent with policymakers' observations about Confucianism in relation to education and scientific development. In the second section of this chapter, I presented the findings regarding teachers' teaching philosophies and their pedagogical practices. As noted in the previous findings chapter (Chapter 5), teachers have mainly learned about new teaching strategies from their colleagues, professional communities, and online forums. Even though most of them thought that traditional ways of teaching were more effective in preparing students for exams, some teachers have been trying to integrate nontraditional teaching approaches in their classroom practice as well. For example, some teachers noted that they have tried to engage students in discussions and help students to learn about the application of scientific concepts. In the same section, I also drew attention to the discrepancies between teachers' teaching goals and their actual practices. Although most of the teachers believed that direct teaching could help prepare students to succeed in Taiwan's exam-driven learning culture, a few participants were open to new teaching approaches. However, they have not yet been able to fully implement the learner-centered approaches in their teaching. Only one teacher, who is a science teacher leader as well, said that he uses inquiry-based strategies regularly in his classroom.

External factors, such as the traditional examination system and parents' expectations to focus mainly on test preparation in school science, have negatively

affected the implementation of inquiry-based approaches. In addition, inadequate professional support has led to a number of dilemmas and challenges for teachers.

In the following chapter I will discuss these findings in order to understand the identity conflicts that the study participants have been experiencing while wrestling with different approaches to teaching and learning science.

Chapter 7. Discussion and Implications

This inquiry examined the ways in which the science education reform has been unfolding in a Confucian heritage culture. Before embarking on this research, I searched the relevant literature to understand the discourses around contemporary developments in science education in East Asian cultures. Since I was also interested in looking at how these discourses intersect with Confucian learning values, I specifically looked for studies on the role of Confucianism in the context of science education. However, I found that the number of studies investigating the interactions between science education reform and Confucian heritage values are sparse to nonexistent. Only a handful of studies focused on Confucian values in relation to education more broadly (Biggs, 1998; Chan, 1996; Cummings & Altbach, 1997; Kim, 2003; Li, 2012; Paine, 1993; Tsui & Wong, 2010; Tao, Oliver, & Venville, 2013; Tweed & Lehman, 2002). These studies suggested that teaching in East Asian cultures primarily focuses on direct instruction or transmission of knowledge from teachers to students. Some scholars argued that this approach is based on Confucius's way of teaching. In Confucian tradition, knowledge is gained through persistent efforts, perseverance, and passion (Chan, 1996; Clayton, 1998; Li, 2012; Li & Wegerif, 2014; Simon, 2011; Yao, 2000). However, Tweed (2003) argued that "Confucian learning involves passivity" (p. 148). This view of Confucian learning has led to a debate in the literature. Some researchers contended that Confucius valued deep thinking, introspection, and contemplation. Kim (2003) asserted that whereas Western scholars may assume that silence means passive acquisition of knowledge, "many East Asians believe that silence is beneficial to high levels of thinking" (p. 85). Further, some scholars maintained that Confucian emphasis of "teaching thinking" is a

notable feature of the "Confucian heritage" (Jin & Cortazzi, 2006; Li & Wegerif, 2014; Simon, 2011; Tweed & Lehman, 2002).

This work attempts to understand how Confucian learning traditions may influence contemporary teaching practices in an East Asian cultures. Studies on teaching approaches in various cultures have highlighted significant differences in teaching practices between East Asian (i.e., Singapore, China, Hong Kong, Taiwan, South Korea, and Japan) and Western countries (Mullis, 2008; Mullis, Martin, Gonzalez, & Chrostowski, 2004; OECD, 2007, 2012). For instance, East Asian teachers tend to be more comfortable with traditional teaching approaches (Paine, 1993; Rao, 2002; Tao, Oliver, & Venville, 2013). These differences could considerably impact the implementation of constructivist reform initiatives in East Asian countries, where teachers' cultural beliefs and teaching philosophies may not be congruent with learner-centered approaches (Nguyen et al., 2006). However, these studies do not explain how Eastern cultural values could lead to differences in interpretations of constructivist approaches. Thus, this inquiry investigates how East Asian teachers' cultural values may shape their response to educational change based on constructivism. In addition, it seeks to highlight the policymakers' visions and the policy discourses around the constructivist initiatives.

My analysis suggests that policymakers and secondary science teachers in Taiwan have different understandings of the science education policy. Specifically, the reform documents and policy leaders in Taiwan highlighted the vision of this reform as developing students' scientific literacy. However, the Taiwanese science and technology teachers in this study were not aware of the policy developments regarding science

education. Surprisingly, a number of them believed that the educational change was meant to prepare students for the international PISA tests as detailed in Chapter 5.

Even though most teacher participants stated that they were not aware of the reform initiatives pertaining to science education in Taiwan, they have, in fact, been surrounded by the discourses on interactive and learned-centered approaches in their professional communities. Most teachers shared that they have heard or learned about the concept of improving students' scientific inquiry skills (e.g., creative and critical thinking skills, problem-solving competencies) by engaging in conversations with their colleagues and friends, or by participating in local teaching communities. According to Gee (2000, 2013), teachers are surrounded by collective social expectations and dialogues in their communities. These discourses might imperceptibly influence a teacher's beliefs about teaching and learning, which may gradually transform his/her professional practice. As such, regardless of teachers' understanding of the reform policy, their professional practice has been shaped by the ongoing discourses on science teaching and learning. Indeed, this study illuminates the various ways in which science teachers in Taiwan are navigating through the traditional and contemporary discursive practices in science education.

Furthermore, different understandings of the curriculum goals have led the policymakers and teachers to perceive different challenges concerning the implementation of reform in Taiwanese schools. As the findings revealed in Chapter 5, policymakers asserted that the impact of Confucianism on education ought to be weakened because they believed that certain Confucian traditions constitute significant obstacles to innovation and scientific advancement in the society. Moreover, the

emphasis on maintaining a harmonious social order in Confucianism has led to excessive social conformity. In this context, the reform in science education carries an important mission to bring about a fundamental shift in the society to promote individual initiative, innovative ideas, and freedom of expressions in the classroom. The policy leaders hoped that introducing learner-centered and inquiry-based approaches in Taiwanese classrooms would encourage student autonomy, critical thinking, and creativity.

However, these transformations are not easy in a learning culture where respect for tradition is highly valued. In particular, they require significant shifts in teachers' cultural and professional beliefs, values, and commitments. For instance, in a Confucian cultural context, it might involve challenging teachers' beliefs about their role and relationships with students. In a study with East Asian teachers, Lai and Lo (2007) examined teachers' attitudes toward education reform in Hong Kong and Shanghai. The study suggested that leaner-centered approaches affected teacher-student relationships in these traditional learning cultures. Most of the teachers reported that the feeling of losing control of their students led to feelings of frustration and anxiety. Other studies also suggested that feelings of incompetence and frustration might lead to a strong resistance to educational reform. Specifically, when teachers are expected to adopt new practices during a reform, they might struggle with their own memories and experiences of learning, or lack the skills to teach in new ways, especially if they have been teaching in traditional settings (Alsup, 2006; Bradley & Lang, 1994; Day et al., 2006; Erikson, 1968; Howard, 1999; Marcia, 2002; Smagorinsky, Cook, Moore, Jackson, & Fry, 2004). In this work, Taiwanese teachers shared similar concerns regarding the challenges involved in using learner-centered approaches in their teaching. Importantly, lack of professional

support in addressing the challenges, arising from a heavily examination-oriented education and social expectations in terms of students' academic achievement in these exams, has led to significant dilemmas concerning teachers' practice.

While the policy leaders promoted active and inquiry-based science teaching, the majority of teachers shared their struggles with the contradictions between traditional and constructivist approaches to learning, which may further lead to conflicts in teachers' cultural and professional identities. While Gee's (2000, 2004, 2013) identity framework—as detailed in the Conceptual Framework Chapter—helps in situating these teachers' identity challenges within their institutional roles, professional discourses, and learning communities, Marcia's theory (2002) on identity crisis provides a useful tool to interpret how these teachers have been negotiating their professional identities while dealing with these struggles. In this study, I see identity construction as a dynamic process involving an ongoing negotiation between individuals and their broader sociocultural surroundings. As such, an individual may display different personal and professional identities in the context of educational change. Based on this analysis, I argue that the science education reform in Taiwan has led a number of teachers to experience a certain level of identity crisis while wrestling with competing cultural and reform-based approaches to teaching.

Some teachers in this study seemed to have firmly entrenched beliefs about the effectiveness of traditional approaches in terms of student learning and academic success in exams. These convictions are grounded in their own traditional learning experiences, which seemed effective to them. They believed that it is their professional responsibility to pass on important cultural and moral values to their students, such as diligence,

humility, discipline, and respect for teachers' knowledge. Thus, respect for traditional values lies at the core of their professional identity. Learner-centered approaches, which essentially encourage student autonomy and independent thinking, are seen as a challenge to these cultural learning traditions (Magolda, 2004). According to Marcia's (2002) identity construction framework, this commitment to traditional teaching approaches is based on the beliefs that they gained from their cultural value systems.

On the other hand, several teachers demonstrated complex perspectives regarding the traditional and constructivist approaches. In looking at their teaching philosophy, I did not notice any clear commitment to a particular approach. In fact, they seemed to be struggling with competing values underpinning the traditional and inquiry-centered approaches. In addition, they were trying to cope with external pressures imposed by the traditional assessment system. I argue that these internal conflicts have led to a crisis in these teachers' professional identity. For instance, they were grappling with difficult questions, such as, *Do I teach according to parents' expectations?* or *Should I use the inquiry approach, which I am not familiar with?* These dilemmas have led them to either resort to traditional lectures or find a middle ground by combining traditional and inquiry-centered strategies. Several studies indicated that teachers need constant professional support during educational change to effectively deal with these struggles and issues (Day, 2002; Day et al., 2006; Gee, 2000; van Driel et al., 2001). Interestingly, one of the teachers seemed to have resolved his conflicts by making a strong commitment to reform-based approaches because he strongly believed in the reform vision to support his students' thinking and achievement.

An important finding that emerged from this analysis was that teachers interpreted Confucianism in divergent ways to resist or embrace the new teaching and learning approaches. While some teachers thought that Confucian traditions inhibited independent thinking and creativity in teachers and students, others felt that Confucian principles of equality and equity in education were compatible with contemporary educational approaches.

Reflexivity

Herein, I attempt to critically look how my reflexive understandings evolved as I was engaged in this inquiry. I hope that this helps my readers to understand my learning journey in this process. Specifically, I criticize my assumptions and biases that I brought to this study, the conceptual lenses through which I have been examining the data, as well as my engagement in this knowledge construction process with the participants. According to Creswell (2007), a researcher's background and experiences are assets in qualitative research. The researchers and participants collaboratively contribute to the meaning-making process (Crotty, 1998; Denzin & Lincoln, 2000; Holstein, Gubrium, Seal, Gobo, Gubruim & Silverman, 2004; Kirby, 2006). As such, it is important for me to critically examine my role in this study and what I gained from this process.

I am a Taiwanese woman who grew up and lived in Taipei until 2011. The year I was born, 1988, Taiwan finally became a democratic country after being controlled by the totalitarian Kuomintang—the Chinese Nationalist Party—regime for 60 years. Against the backdrop of these significant political and social changes, herein, I introduce two personal memories that illuminate the social and educational changes that were occurring in Taiwan at that time; these experiences have profoundly shaped my identity

as a researcher. In the first story, a "stack of handouts" symbolizes my primary memory of my school life. For me, it represents the burden on teachers to maintain the traditional education system.

A Stack of Handouts

When I was in high school, teachers kept a stack of handouts from several traditional, ministry-approved textbooks. Even though educational reforms were beginning to be implemented, we, the students, were still being bombarded with handouts and exam practice handbooks. Although the new curriculum emphasized active learning and application knowledge, the national exam still focused on evaluating our factual knowledge. Being trapped between the changing education policies and the reality of the actual classroom, my classmates and I felt like guinea pigs undergoing experimentation in the name of education reform. Because we were uncertain about our education, most of us went to "cram schools" every night until 10:00 p.m. We actually ended up trusting cram school teachers more because they gave us "sure-fire ways" to achieve high exam scores. Finally, I decided to put more effort into studying my handouts from cram school. I began to question the purpose of public schools and wondered why schoolteachers did not teach like the cram school instructors. Teachers in cram schools would give us standard answers to exam questions and help us in organizing the most relevant information to memorize it quickly. They also gave us all the exam questions from previous years and taught us tricks to quickly answer the questions. While the teachers in my school spent most of their time on science demonstrations and reading from the textbook, I felt like I was wasting my time in school, and, like many of my classmates, I wanted to skip classes to spend more time at the cram school to learn about the tools and tricks that would help me do well on the national exam.

The second story is from my years at McGill. It is a memory of suitcases that symbolizes my learning experience in Canada, where the classroom environment is more interactive and student-centered. Coming from a very different learning culture, I did not see myself actively participating in class discussion at the beginning of my studies at McGill. This is when I came to realize that it is not easy to transform into an "active learner" in class.

A Suitcase of Teaching Materials

In 2013, I visited the secondary school that I had attended in Taiwan. When I was there, the school board was hiring new teachers, so there were many novice teachers lining up for the opportunity to demonstrate their teaching ability. Something that stood out to me in that moment was that most of the novice teachers were carrying large suitcases. The suitcase mystery was solved when a teacher opened her suitcase prior to her teaching demonstration. I was amazed to see all kinds of materials for classroom activities, but no handouts. Instead of getting handouts, students did hands-on activities and engaged in discussions in a candidate's demo lessons. The novice teacher was moving about the classroom being a facilitator rather than standing in front of the class as a lecturer. Not that long ago, I was taught not to speak in class, but now, I saw this novice teacher encouraging students to interact with each other. I asked an interviewer, an administrator in the same school, if teachers really use this approach in their regular classroom practices. The examiner answered, "Not really. This is not teaching; novice teachers always try to be creative in the beginning."

These two personal experiences offer glimpses into the social and educational situation in Taiwan; beginning teachers may demonstrate active and learner-centered ways of teaching, but they do not really teach using these approaches in their actual teaching. In fact, it was my conversation with the school administrator after the teaching demonstration that motivated me to investigate the current science teaching practices in Taiwan. Although I have witnessed the differences before and after the education reform, I still feel that certain societal values remain firmly entrenched and continue to constrain the possibilities for change in Taiwanese classrooms.

To investigate the various reform discourses in this inquiry, I tried to engage in critical conversations with Taiwanese educational leaders and science teachers. According to Denzin and Lincoln (2000), an interview is not simply a tool to collect information, but it should be seen as a process in which both researchers and participants come to learn about themselves and the society they live in. Thus, I strove to build my

research relationships based on trust and respect to create a context for engaging in candid conversations with the study participants. During this process, I kept a reflective diary to critically reflect on the ways in which my predictions and biases were influencing this inquiry as well as how this engagement was changing my understandings and assumptions as a researcher.

As someone who was born and raised in a Confucian learning culture, I am consciously aware of the fact that my interpretations of the data would be shaped by my beliefs about the traditional cultural values and their complex interactions with modern (Western) discourses on educational change. According to Ely (1991), a key aspect of qualitative research is to encompass researchers' reflective and recursive processes, in which researchers are allowed to sculpt the research findings and conclusions (Maxwell, 1996). I went into this research thinking that certain cultural norms and traditions act as a roadblock to educational reform. In fact, during my interview conversations, I found that the policy leaders and some teachers had similar perspectives on this issue. At the time, my interpretations of the interview data were influenced by my agreement with this perspective on Confucian traditions. I began to investigate the ways in which Confucian values have posed challenges to the implementation of the science education reform in Taiwan. However, as I began looking critically at the various trends emerging from the data, I noticed that a number of teachers whose teaching practices fell into traditional and contemporary approaches didn't seem to view Confucianism as an obstacle to inquiry-centered learning approaches. I began to wonder whether Confucian values might also positively influence teachers' engagement with constructivist pedagogies. Indeed, I found that some teachers viewed the Confucian learning principles as compatible with the

contemporary teaching approaches that focus on providing meaningful education to all children, meeting individual needs of the students and nurturing their unique talents. As I revisited the data and my interpretations repeatedly, I began to notice the shifts in my own thinking about Confucianism. This is elucidated in a reflective memo that I wrote about the policymakers' perspectives on Confucian learning heritage:

> I used to have the same perspective as these policy leaders; particularly, I thought that the traditional learning culture and Confucian traditions were the primary obstacles to scientific advancement. However, I somehow disagree with this view now because I feel that the policymakers used Western standards of teaching and learning to assess Taiwanese teachers' and students' cultural learning behavior . . . am I doing the same? (Ying Syuan, memo, September 18, 2013)

This reflexive engagement with the data and my evolving understanding of participant' meaning-making expanded and enriched my own standpoint as a person and as a researcher.

Limitations

It is important to acknowledge some study limitations. Although I had intended to explore the perspectives of both female and male teachers, unfortunately only two females volunteered to participate in this study. I recognize that this study mainly presents the perspectives of male science teachers. Future studies need to examine female teachers' response to the reform and compare their perspectives to male teachers' views on this subject. I am also aware that these findings may not represent the views of all science teachers in Taiwan and that the study participants' perspectives might have been

their particular school and community contexts. However, this in-depth exploration offers meaningful insights into their cultural and professional perspectives on the reform.

Implications

This study has important implications for improving science learning and teaching in international contexts. In particular, it can inform future research and professional development initiatives in East Asian contexts. The findings suggest that looking at teachers' understanding of reform policies, their cultural values, epistemological beliefs, and pedagogical commitments is critical to the success of change initiatives. In addition, teachers' active participation in policy formulation would help to bridge the gap between policy and practice. A better understanding of teachers' commitments to their cultural values and traditions would help the policymakers and educational leaders in designing appropriate professional opportunities for their growth and development. Furthermore, providing sustained professional support is key to enhancing the quality of education. At the same time, policy makers need to realize that curricular reform needs to be intimately tied to a transformation in the assessment system because consistent measures in both areas might help teachers to achieve the curriculum goals effectively.

In the context of Taiwan, the implementation of education reform could be strengthened by presenting successful examples of reform-based curriculum in similar cultures and institutions. This would help teachers, parents, and students—who might tend to adhere strongly to their traditional values—to understand and further support the contemporary developments in science teaching and learning.

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Appendix A. Certificate of Ethical Acceptability of Research Involving Humans

McGill

Research Ethics Board Office
James Administration Bldg. room 429
845 Sherbrooke St West
Montreal, QC H3A 0G4

Tel: (514) 398-6831
Fax: (514) 398-4644
Ethics website:www.mcgill.ca/research/researchers/compliance/human/

Research Ethics Board II
Certificate of Ethical Acceptability of Research Involving Humans

REB File #: 410-0313

Project Title: Policy Makers' and Science Teachers' Understanding of the Science Education Policy in Taiwan

Principal Investigator: Ying Huang

Department: DISE

Status: Master's Student

Supervisor: Prof. A. Asghar

This project was reviewed by delegated review.

Richard Koestner, Ph.D.
Delegated Reviewer, REB II

Approval Period: 24 Apr. 2013 - 23 Apr. 2014

This project was reviewed and approved in accordance with the requirements of the McGill University Policy on the Ethical Conduct of Research Involving Human Participants and with the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans.

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* All research involving human participants requires review on an annual basis. A Request for Renewal form should be submitted 2-3 weeks before the above expiry date.
* When a project has been completed or terminated a Study Closure form must be submitted.
* Should any modification or other unanticipated development occur before the next required review, the REB must be informed and any modification can't be initiated until approval is received.

Appendix B: Recruitment of Participants for Science Teachers

An Invitation to Participants in a Study about Science Education Policy in Taiwan

Dear Teachers,

I am currently carrying out a study as part of my Master of Arts thesis at the Faculty of Education, Department of Integrated Studies at McGill University in Canada. This research study aims to learn about policy makers' and science teachers' perceptions of the science education policy goals and implementation plans. I am also interested in learning about how the policy may inform your classroom practices.

I would like to invite you to share your views with me. I plan to interview you once or twice during this study. Your views and insights will help to improve the implementation of the policy, and provide valuable suggestions for future education initiatives in Taiwan.

Every effort will be made to protect your privacy.

If you have any questions, please do not hesitate to contact me (Ying Syuan Huang) at ying.huang6@mail.mcgillca or my supervisor Professor Anila Asghar at anila.asghar@mail.ca. Thank you very much.

Thank you for your consideration.
Sincerely,

Ying Syuan Huang
Department of Integrated Studies in Education
3700 McTavish Street, McGill University
Montreal, QC Canada H3A1Y2
Tel: +1514-443-8469
Email: ying.huang6@mail.mcgill.ca

If you have any questions or concerns regarding your rights and welfare as a participant of this study, please feel free to contact the McGill Ethics Officer, Ms. Lynda McNeil, at lynda.mcneil@mcgill.ca

Research Ethics Board Office (REB I,II, III), James Admin. Bldg. ,845 Sherbrooke St.W.,rm 429, Montreal, QC H3A 2T5
tel:514-398-6193 fax:514-398-4644

(version 11-2010)

Appendix C: Interview Invitation Letter for Policymakers

Interview Invitation Letter for Policymakers

Dear Professor _____,

I am currently carrying out a study as part of my Master of Arts thesis at the Faculty of Education, Department of Integrated Studies at McGill University in Canada. This research study is to learn about policy makers' and science teachers' perception of the science education policy goals and implementation plans. I am also interested in learning about the relevant resources and training available to secondary science teachers in order to achieve the goals set forth by the policy.

I need your valued input via an interview to further understand the policy and practice goals as explained in the "White Paper on Scientific Education." I am inviting you to participate in my research because of your expertise and experience in the Education Reform Council in Taiwan. Your participation will help to improve the implementation of the policy, and provide valuable suggestions for future education initiatives in Taiwan.

The interview will last about 45-60 minutes.

I look forward to your participation in this research and would greatly appreciate your time and contribution in this endeavor.

If you have any questions, please do not hesitate to contact me at ying.huang6@mail.mcgillca or my supervisor Professor Anila Asghar at anila.asghar@mail.ca.

Thank you for your consideration.
Sincerely,

Ying Syuan Huang
Department of Integrated Studies in Education
3700 McTavish Street, McGill University
Montreal, QC Canada H3A1Y2
Tel: +1514-443-8469
Email: ying.huang6@mail.mcgill.ca

If you have any questions or concerns regarding your rights and welfare as a participant of this study, please feel free to contact the McGill Ethics Officer, Ms. Lynda McNeil, at lynda.mcneil@mcgill.ca

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tel:514-398-6193 fax:514-398-4644

Appendix D: Informed Consent Form for Policymakers (front page)

訪談同意書/Informed Consent Form for Policymakers

親愛的受訪者，您好，

我目前的研究是為我於麥基爾大學教育學院的碩士論文，我的論文指導教授是為 Professor Anila Asghar；此研究的目的為了解國民中學科學教師對於目前台灣科學教育之內容以及推動的看法，有您的參與，將幫助此研究的進行，此研究成果也會成為未來的相關研究，為未來台灣科學教育的相關執行以及推動，有極大的貢獻。

為了協助未來的資料分析，此訪談將全程錄音，我會極力地確保您的隱私以及權利，錄音檔、逐字稿，以及其後的翻譯稿將不會有任何能辨識出訪談者的資料，錄音檔將會被鎖放在安全的地方，只有我本人有鎖匙能夠取得。所有能連結您個人資料與訪談內容的電子檔案，將會存放在我的私人電腦內，只有我本人能夠取得這些電子檔。所有檔案將會在資料分析以及研究結束（大約一年後）被全部消除。您的姓名以及任何個人資料不會出現在所有相關出版品以及研究結果中。此訪談為全程自願性質，過程中，若有任何您不方便回答的問題，您有權利選擇不回答，您也有權利在任何時候放棄此訪談意願。

若您有任何問題，請聯絡我或是我的指導教授（anila.asghar@mail.ca. ）。我們也非常樂意與您分享之後的研究成果以及相關出版品。非常感謝您願意接受此訪談，我們誠心地感謝您的付出。

恭請 大安 盈瑄 敬上

Dear Participant,

I am currently carrying out my Master of Arts thesis, which is supervised by Professor Anila Asghar, at the Faculty of Education, Department of Integrated Studies at McGill University. This research study aims to learn about policy makers' and science teachers' perceptions of the science education policy goals and implementation plans. Your participation will help to improve the implementation of this policy, and provide valuable suggestions for future education initiatives in Taiwan.

The interview conversation will be audiotapes to help with data analysis. Every effort will be made to ensure your confidentiality and protection of your privacy. The audio recordings will be used for only transcription purpose. Interview transcripts and field notes will be de-identified. The audiotapes of the interviews will be stored in a cabinet with lock and only I will have the access to it. A record file linking your real names to the pseudonyms and institutions will be kept in my personal computer and it will be password protected. Only I, the principal investigator, will have access to the identifiable data (i.e., audiotapes and record file). The master file and the audiotapes will be erased after data analysis (approximately 1 year after ta collection). Your name and identifiable information will not be recorded or disclosed in our research reports and published articles. Any identifiable information will be stored in a safe place separated from collected data and only I will have access to this information. Your participation is entirely voluntary. Please know that if you feel uncomfortable with any questions during the interview, you do not have to answer those questions. You will always have the right to withdraw at any time without any penalty or prejudice.

If you have any questions, please do not hesitate to ask me or contact my supervisor Professor Anila Asghar at anila.asghar@mail.ca. We will be more than happy to share our findings with participants, and our results will be submitted for peer review and publication in professional journal(s) and/or newsletters. The data will be used in future related studies. Thank you for participating in this interview. We would greatly appreciate your cooperation in this endeavor.

Thank you for your consideration.
Sincerely,

Ying Syuan Huang
Department of Integrated Studies in Education
3700 McTavish Street, McGill University
Montreal, QC Canada H3A1Y2
Tel: +1514-443-8469
Email: ying.huang6@mail.mcgill.ca

If you have any questions or concerns regarding your rights and welfare as a participant of this study, please feel free to contact the McGill Ethics Officer, Ms. Lynda McNeil, at lynda.mcneil@mcgill.ca

Research Ethics Board Office (REB I,II, III), James Admin. Bldg. ,845 Sherbrooke St.W.,rm 429, Montreal, QC H3A 2T5 tel:514-398-6193 fax:514-398-4644

Appendix D, continued: Informed Consent Form for Policy Makers (back page)

Informed Consent Form for Policy Makers (continued)

For the researcher: I have discussed with _____ (participant's name) the details in the informed consent form. I have asked if any questions remain and have answered their questions as best as possible.

_____ _____
Date Investigator's Signature

For the participant:
Please select the following section to see if you agree to give consent to participate in this study.
_____ I will participate in the first interview.
_____ I will participate in the second interview.

Please select the following section to see if you agree the audio recording during the interviews in this study.
_____ Yes / _____ No, I agree the audio recording during the interviews in this study.

Please select the following section to see if you agree to give consent to the further studies with a different purpose or different research questions does require additional Research Ethical Board review and approval.
_____ Yes / _____ No, I agree the data from my participation of this research can be used in future related studies.

Name (in print): _____

Signature: _____ Date:_____

If you have any questions or concerns regarding your rights and welfare as a participant of this study, please feel free to contact the McGill Ethics Officer, Ms. Lynda McNeil, at lynda.mcneil@mcgill.ca

Research Ethics Board Office (REB I,II, III), James Admin. Bldg. ,845 Sherbrooke St.W.,rm 429, Montreal, QC H3A 2T5 tel:514-398-6193 fax:514-398-4644

Appendix E: Informed Consent Form for Science Teachers (front page)

訪談同意書／Informed Consent Form for Science Teachers

親愛的受訪者，您好，

我目前的研究是為我於麥基爾大學教育學院的碩士論文，我的論文指導教授是為 Professor Anila Asghar；此研究的目的為了解國民中學科學教師對於目前台灣科學教育之內容以及推動的看法，有您的參與，將幫助此研究的進行，此研究成果也會成為未來的相關研究，為未來台灣科學教育的相關執行以及推動，有極大的貢獻。

您將有可能參與一至兩次的訪談，為了能更深入了解您的教學經驗，第二次的訪談中，我們將有可能邀請您一同討論您的課程規劃。第一次的訪談，將會持續大約 30 分鐘；第二次的訪談，將會持續大約 45 至 60 分鐘。

為了協助未來的資料分析，此訪談將全程錄音，我會極力地確保您的隱私以及權利，錄音檔、逐字稿，以及其後的翻譯稿將不會有任何能辨識出訪談者的資料，錄音檔將會被鎖放在安全的地方，只有我本人有鎖匙能夠取得。所有能連結您個人資料與訪談內容的電子檔案，將會存放在我的私人電腦內，只有我本人能夠取得這些電子檔。所有檔案將會在資料分析以及研究結束（大約一年後）被全部消除。您的姓名以及任何個人資料不會出現在所有相關出版品以及研究結果中。此訪談為全程自願性質，過程中，若有任何您不方便回答的問題，您有權利選擇不回答，您也有權利在任何時候放棄此訪談意願。

若您有任何問題，請聯絡我或是我的指導教授（anila.asghar@mail.ca. ）。我們也非常樂意與您分享之後的研究成果以及相關出版品。非常感謝您願意接受此訪談，我們誠心地感謝您的付出。

恭請 大安
盈瑄 敬上

Dear Participant,

I am currently carrying out a study as part of my Master of Arts thesis at the Faculty of Education, Department of Integrated Studies at McGill University in Canada. This research study aims to explore policy makers' and science teachers' perceptions of the science education policy goals and implementation plan. Your participation in this study will help provide valuable perspectives and practical suggestions for future science education initiatives in Taiwan.

Your participation will involve 1 or 2 interviews. In order to deeply understand your teaching and learning experience for this study, we may also invite you to provide and discuss your lesson plans in the second interview. The first interview will take approximately 30 minutes whereas the second interview will last about 45-60 minutes.

The interview conversations will be audiotapes to help with data analysis. Every effort will be made to ensure your confidentiality and protection of your privacy. The audio recordings will be used for only transcription purpose. Interview transcripts and field notes will be de-identified. The audiotapes of the interviews will be stored in a cabinet with lock and only I will have the access to it. A record file linking your real names to the pseudonyms and institutions will be kept in my personal computer and it will be password protected. Only I, the principal investigator, will have access to the identifiable data (i.e., audiotapes and record file). The master file and the audiotapes will be erased after data analysis (approximately 1 year after data collection). Your name and other identifiable information will not be disclosed in our research reports and published articles. Any identifiable information will be stored in a safe place separated from collected data and only I will have access to this information. Your participation is entirely voluntary. Please know that if you feel uncomfortable with any questions during the interview, you do not have to answer those questions. You will always have the right to withdraw at any time without any penalty or prejudice.

If you have any questions, please do not hesitate to ask me or contact my supervisor Professor Anila Asghar at anila.asghar@mail.ca. We will be more than happy to share our findings with participants, and our results will be submitted for peer review and publication in professional journal(s) and/or newsletters. The data will be used in future related studies. Thank you for participating in this interview. We would greatly appreciate your cooperation in this endeavor.

Sincerely,

Ying Syuan Huang
Department of Integrated Studies in Education
3700 McTavish Street, McGill University
Montreal, QC Canada H3A1Y2
Tel: +1514-443-8469
Email: ying.huang6@mail.mcgill.ca

Appendix E, continued: Informed Consent Form for Science Teachers (back page)

Informed Consent Form for Science Teachers (continued)

For the researcher: I have discussed with _____ (participant's name) the details in the informed consent form. I have asked if any questions remain and have answered their questions as best as possible.

_____ _____
Date Investigator's Signature

For the participant:
Please select the following section to see if you agree to give consent to participate in this study.
_____ I will participate in the first interview./
我願意接受第一次的訪談。
_____ I will participate in the second interview./
我願意接受第二次的訪談。

Please select the following section to see if you agree the audio recording during the interviews in this study.
_____ Yes / _____ No, I agree the audio recording during the interviews in this study./
我同意訪談過程中全程錄音。

Please select the following section to see if you agree to give consent to the further studies with a different purpose or different research questions does require additional Research Ethical Board review and approval.
_____ Yes / _____ No, I agree the data from my participation of this research can be used in future related studies./
我同意此次的訪談□容在未來的相關研究中被使用。

Name (in print): _____

Signature: _____ Date:_____

If you have any questions or concerns regarding your rights and welfare as a participant of this study, please feel free to contact the McGill Ethics Officer, Ms. Lynda McNeil, at lynda.mcneil@mcgill.ca
Research Ethics Board Office (REB I,II, III), James Admin. Bldg. ,845 Sherbrooke St.W.,rm 429, Montreal, QC H3A 2T5 tel:514-398-6193 fax:514-398-4644

Appendix F: Interview Questions Guide for Policymakers

訪談問題大綱 Interview Questions Guide for Policymakers

日期 Date: ___/___/_____ 城市 City: _____

首先，我誠心地感謝您願意接受此訪談，這對於我的論文以及未來相關研究有無現的貢獻，感激不盡。

此訪談的結果將成為我在 McGill University 碩士論文的主軸；您的意見與想法，將幫助我以及未來相關研究學者，深入了解台灣科學教育政策的實施過程以及影響。 訪談內容大致上為您個人對目前台灣科學教育政策的想法，因此，您無須擔心您的回答是否正確。

為了確保往後訪談內容分析以及翻譯的正確性，此訪談將會全程錄音；往後，只有我本人會有此訪談的錄音檔案，研究完成後，我會親自刪除銷毀此訪談的錄音檔案。

為了尊重您的隱私權以及意願，研究過程以及訪談過程為完全匿名；若訪談過程中，有任何問題讓您感到不便，您有權選擇不回答；抑或，您也有權選擇放棄參與此訪談。

請問您有任何疑問嗎？過程中， 若有任何疑問，請隨時提出。若目前沒有疑問，我們將開始進行訪談。

First of all, thank you very much for your participation in this study. I greatly appreciate your time for participating in this interview. As you may know, this is my Master's Thesis research project at McGill University in Canada. Your opinion is vital to help us to understand the relevance, impact, and implementation of science education policy in Taiwan.

You will be asked semi-structured questions regarding your perspectives on the current science education policy in Taiwan. Therefore, there is no right or wrong answer.

In order to ensure that this interview can be reviewed during the data interpretation process, this interview will be audiotapes. Only I will have access to the audio-recordings.

This individual interview is completely anonymous and voluntary. You may refuse to answer any questions that you may feel uncomfortable with. Also, you may withdraw at anytime without any penalty or prejudice.

Do you have any questions before we begin? Also, please do not hesitate to let me know if you have any questions at anytime during the interview. May I start the recorder and begin the interview?

Understanding of the Science Education Policy

1. 您覺得，哪些為台灣科學教育的重要關鍵？科學教育白皮書中，強調了哪些重點？
   In your view, what are the key goals of science education in Taiwan? What are the goals that the "White Paper on Science Education" (2004) emphasizes?
2. 哪些因素，可能造成科學教育政策在實施上的困難？
   What factors could inhibit or negatively effect the implementation of the science education policy in Taiwan?
3. 針對台灣國民中學程度的科學教育，您認為，在實施教育政策的過程中，是否有任何的困難或是挑戰需要特別去克服？
   What were the challenges/difficulties in implementing the secondary science education policy in Taiwan?

4. 相較於亞洲地區其他國家，台灣的科學教育目標有何相似以及不同之處？
   Compared science educational goals with other countries in the East Asian region, what are the similarities and differences?
5. 您認為，傳統儒家思想是否對台灣目前的科學教育改革有任何的影響？
   What do you think about Confucian legacy in relation to science education?
6. 哪些行政單位，是特別負責制定科學教育政策？在實施政策方面，您認為，有哪些重要角色，參與相關科學教育政策的實行？
   Which institutions have been specifically responsible for developing science education policies? What are their roles in the actual implementation of the policy in science classrooms?
7. 哪些資源應該提供給國民中學教師，以利朝向科學教育改革的目標邁進？就您所知，有哪些資源，已存在於教育環境中？
   What kinds of resources should be provided to the secondary science teachers? Are they currently being provide
8. 就您對目前台灣教育環境的觀察，您認為，科學教育白皮書的重大目標是否有反映在目前的教育現況？若無，請問有哪些落差可以再進步？
   From your observation, does the current education environment reflect the goals indicated in the "White Paper for Science Education" (2004)? If no, what are the differences and what can be improved?

科學素養 Science Literacy

9. 對您而言，何謂科學素養？
   What does "Science Literacy" mean to you?
10. 就您所知，有何明確的政策目標提供給科學教師作為依據，以利提升學生的科學素養？
    What are the concrete goals set in the policy for science teachers to improve students' scientific literacy?
11. 就您所知，有何教師培訓的管道或資源，提供科學教師相關訓練，以利教師在課堂中，提升學生的科學素養？
    What kinds of training can the relevant institutions provide to teachers to help them implement the science literacy objectives in their classrooms?
12. 目前國民中學的科學教學大綱中，是否有反映教育政策目標之提升學生科學素養？
    Does the current curriculum for secondary science education reflect/match the policy goals for science literacy?
13. 您認為，該如何評量教育政策目標之提升學生科學素養的實施成果？
    How do you evaluate the implementation of the scientific literacy objectives in the secondary science classrooms?

探索式學習 Inquiry-based Learning

14. 對您而言，何謂探索式學習？
    What does "Inquiry-based Learning" mean to you?
15. 就您所知，有何明確的政策目標，提供給科學教師作為探索式學習環境的依據？
    What are the concrete goals set in the policy to achieve "Inquiry-based Learning" in secondary classrooms?
16. 您認為，該如何評量探索式學習環境之實施成果？
    How do you evaluate the implementation of inquiry-based teaching and learning in the secondary science classrooms?
17. 就您所知，有何教師培訓的管道或資源，提供科學教師相關訓練，以利在課堂中，實

行探索式學習的教學方法？ What kinds of training can the relevant institutions provide to teachers to help them implement inquiry-based teaching in their classrooms?

18. 您認為，實行探索式學習的教學方法時，教師與行政人員可能面臨哪些困難？
    What challenges/difficulties did you foresee in implementing the "Inquiry-based Learning" approach?

以學生為中心的教學方式 Student-centered Pedagogy

19. 對您而言，以學生為中心的教學環境應該俱備哪些特質？
    What does "Student-centered Pedagogy" mean to you?
20. 就您所知，有何明確的政策目標，提供給科學教師作為以學生為中心之教學方式的參考依據？
    What are the concrete goals set in the policy about student-centered pedagogy in the science education policy?
21. 您認為，該如何評量以學生為中心之教學成果以及實施成效？
    How do you evaluate the implementation of the student-centered pedagogy in the secondary science classrooms?
22. 就您所知，有何教師培訓的管道或資源，提供科學教師相關訓練，以利在課堂中，實行以學生為中心的教學方法？
    What kinds of training can the relevant institutions provide to teachers to help them implement the student-centered pedagogy in their classrooms?
23. 您認為，實行以學生為中心的教學方法時，教師與行政人員可能面臨哪些困難？
    What challenges/difficulties did you foresee in implementing student-centered-pedagogy?

Appendix G: First-round Individual Interview Guide for Science Teachers

訪談問題大綱 First-round Individual Interview Guide for Science Teachers

日期 Date: ___/___/_____ 城市 City: _____

首先，我誠心地感謝您願意接受此訪談，這對於我的論文以及未來相關研究有無現的貢獻，感激不盡。

此訪談的結果將成為我在 McGill University 碩士論文的主軸；您的意見與想法，將幫助我以及未來相關研究學者，深入了解台灣科學教育政策的實施過程以及影響。 訪談內容大致上為您個人對目前台灣科學教育政策的想法，因此，您無須擔心您的回答是否正確。

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為了尊重您的隱私權以及意願，研究過程以及訪談過程為完全匿名；若訪談過程中，有任何問題讓您感到不便，您有權選擇不回答；抑或，您也有權選擇放棄參與此訪談。

請問您有任何疑問嗎？過程中， 若有任何疑問，請隨時提出。若目前沒有疑問，我們將開始進行訪談。

First of all, thank you very much for your participation in this study. I greatly appreciate your willingness and time to participate in this interview. As you may know, this is my Master's Thesis research project at McGill University in Canada. Your opinion is vital to help us to understand the relevance, impact, and implementation of science education policy in Taiwan.

You will be asked semi-structured questions regarding your perspectives on the current science education policy in Taiwan. Therefore, there is no right or wrong answer.

In order to ensure that this interview can be reviewed during the data interpretation process, this interview will be audiotapes. Only I will have access to the audio-recordings.

This individual interview is completely anonymous and voluntary. You may refuse to answer any questions that you may feel uncomfortable with. Also, you may withdraw at anytime without any penalty or prejudice.

Do you have any questions before we begin? Also, please do not hesitate to let me know if you have any questions at anytime during the interview. May I start the recorder and begin the interview?

Background

1. 請問您在哪種類型的學校任教？
What kind of school do you teach at?

公立學校 Public school　　私立學校 Private school
另類學校 Alternative school　　其他 Other

2. 請問您有幾年的科學教育任教經驗？
How many years have you been teaching science in secondary schools?

<1 year 1-4 years 5-9 years
10-14 years >15 years

3. 請問您有教過哪些年級？
Which grade(s) do you teach? (Please choose all that apply)

Grade 7 Grad 8 Grad 9

4. 請問您持有教師執照幾年？
How long have you had your teaching license?

I don't have a license <1 year 1-4 years
5-9 years 10-14 years >15 years

5. 請問您從哪個師範體系畢業？
Which teacher training institution/program did you graduate from?

國立師範大學 Normal University system
教育大學 University of Education
一般大學教育學程 Educational Program for Secondary Teachers in University
教師培育中心 Center for Teacher Education
其他 Other

6. 請問您目前在哪裡任教？
Where do you teach?

Understanding of the Science Education Policy

1. 就您所知，台灣的科學教育目前強調哪些重點？
In your view, what are the key goals of science education in Taiwan?

2. 您大多從何處得知台灣的教育政策？
Where do you obtain information about the current education policy in Taiwan?

3. 就您所知，哪些單位特別負責發展台灣的教育政策？又，哪些負責台灣的科學教育政策？
Which institution is responsible for developing the education policies in Taiwan? Which is specifically responsible for science education policies?

4. 在您任教時，您大多使用哪些教學策略？請舉例。又，您從哪裡得知這些教學策略？
What kinds of teaching approaches do you use for teaching science? (Ask for examples)
Where did you learn about them (e.g. pre-service or in-service)?

5. 請問您知道科學教育白皮書嗎？若是，請問您對科學教育白皮書的看法為何？
Are you aware of the "White Paper on Science Education"? If yes, could you please share your views about it.

6. 您認為，現在的科學教育政策，是否符合現況以及是否能夠成功地落實？
Do you think that this policy is appropriate and practical for implementation in real classrooms?

7. 請問現在的科學教育政策是否有幫助您設計您的課程規劃？請說明原因。

Does this policy help you, if at all, to design your curriculum/lesson plans? If yes, how so? If not, why not?

8. 您有接受到任何能幫助您落實教育政策的資源嗎？若有，請說明有哪些資源。若無，請問您需要哪些協助？
Do you get any help/support in implementing the policy goals and pedagogical practices? If yes, what are they? If not, what kinds of resources do you need?

9. 您認為，您需要哪些資源來協助您落實科學教育政策？
What kinds of support do you think you need to implement the science education policy well in your classroom/school?

Teachers' Epistemology

10. 請描述您所記得的科學學習經驗。有哪些是您喜歡的？有哪些是您不喜歡的？
What do you remember about your school science learning experience? What did you like? What you didn't like?

11. 請問，您自身的學習經驗和您現在的教學模式，有任何差異嗎？
What, if any, are the differences between your own experience of learning science in school and your science teaching practice in class?

12. 您認為，傳統儒家思想與目前科學教育理念，有無相關連？
What do you think about Confucian legacy in relation to the current vision of science education as explained in the policy?

Pedagogical Practices

13. 請回想您使用教學手冊的經驗，您有遇到任何困難嗎？
Do you face any obstacles when teaching according to the teacher's manual?

14. 請提供幾個你覺得最有效提高學生學習的方法或是課堂活動。
Please provide some examples of teaching activities that you feel are effective in promoting student learning in your science class.

Section 2 (Supplemental)

Perceptions about Science Education

1. In your science class, what do you expect your students to learn?
2. In your science class, how do you assess students' learning?
3. What do students' examination scores mean to you in your science class?

Teachers' Understanding of Science Literacy

4. What does "Science Literacy" mean to you?
5. Where did you learn about "Science Literacy"? Did you receive any professional training to implement the current scientific literacy goals?
6. What does learning science with real-life issues mean to you in science education?
7. Do you have enough time/resources to teach students to apply scientific knowledge in their daily lives in your science class?

Teachers' Understanding of Inquiry-based Learning

8. What does inquiry-based science learning mean to you in science education?
9. Please provide some examples of how you use the inquiry-based approach in your science class.
10. What do you think about the use of textbooks in teaching science?
11. What does problem-based science learning mean to you in science education? How do you evaluate your students' problem-solving skills?
12. How do you feel about students learning science by using their daily tools? Do you help your students learn science through the use of their daily life tools?

Teachers' Understanding of Student-centered Pedagogy

13. How do you feel about teaching science through lectures?
14. What are your views about student-centered learning environment?
15. From your experience, what are the advantages/challenges in creating a student-centered learning environment in your science class?
16. Would you like to share some examples of your science lesson plans?

Appendix H: Journal Questions and Second-round Individual Interview Guide for Science Teachers

訪談日誌與第二次訪談問題大綱
Journal Questions and Second-round Individual Interview Guide for Science Teachers

日期 Date: ___/___/_____ 城市 City: _____

首先，我誠心地感謝您願意參與本研究，這對於我的論文以及未來相關研究有無現的貢獻，感激不盡。

此訪談的結果將成為我在 McGill University 碩士論文的主軸；您的意見與想法，將幫助我以及未來相關研究學者，深入了解台灣科學教育政策的實施過程以及影響。日誌內容大致上為您個人對於教育的想法，因此，您無須擔心您的回答是否正確。

往後，只有我本人會有此日誌檔案，為了尊重您的隱私權以及意願，研究過程為完全匿名；若對於日誌內容，有任何問題讓您感到不便，您有權選擇不回答；抑或，您也有權選擇放棄參與此訪談。

First of all, thank you very much for your participation in this study. I greatly appreciate your willingness and time to participate in this interview. As you may know, this is my Master's Thesis research project at McGill University in Canada. Your opinion is vital to help us to understand the relevance, impact, and implementation of science education policy in Taiwan.

You will be asked three questions regarding your perspectives on education. Therefore, there is no right or wrong answer.

Only I will have access to this journal file. This journal writing is completely anonymous and voluntary. You may refuse to answer any questions that you may feel uncomfortable with. Also, you may withdraw at anytime without any penalty or prejudice.

Journal Questions

1. 何謂"學習"？
   What does science learning mean to you?

2. 在您心中，課室學習環境是什麼樣子呢？可以畫出課室學習環境在您心中的印象。
   What does your classroom teaching look like?

3. 儒家文化中鼓勵或是提倡什麼？
   What are your views about Confucianism?

4. 您認為，何謂儒家教育文化？
   What does Confucian teaching and learning culture mean to you?

Second-round Individual Interview Question Guide

Confucian Learning Philosophy and Teachers' Epistemology

1. 學生為什麼需要學科學？
   Why do you think students should learn science?
2. 在科學教育中，何謂成功的學習？
   What does academic success in science education mean to you?
3. 課室環境中，教師的角色為何？學生的角色為何？
   What is a teacher's role in education? What is a student's role in education?
4. 您如何知道學生的學習狀況？
   How do you know when a student is learning?
5. 您的教學目標為何？
   In your science class, what do you expect students to learn the most?

Teachers' Practice

6. 請描述您的教師職業訓練過程？又，您如何把專業訓練中所學的知識應用到目前的教學現場？
   What did you learn from pre-service teacher training program? How do you integrate what you learnt with your classroom practices?
7. 課室教學中，您是否有運用任何教育哲學或理論？
   Do you apply any of the educational theory from pre-service teacher training program in your classroom practice?
8. 對您而言，身為一位科學教師，需要哪些特質或專業技能？
   In your opinion, what skill sets or characteristics does a teacher need?
9. 老師應該如何增進自我的專業技能
   How can a teacher improve his/her teaching skills?
10. 當遇到教學困難時，請問您會求助於誰？
    Where or whom do you turn to help when you experience dissatisfaction or barriers related to your teaching career?

Journal Follow-up Question (Supplemental)

1. Do you believe in behavior reform (i.e. learning and studying can help students become better human-beings)?
2. How can students'' critical thinking be developed? Do you think you can promote your students' critical thinking through teaching science?

Appendix I. Policymakers' and Teachers' Perspectives on Challenges to Learner-Centered Approaches

Policymakers	Science Teachers
Confucianism emphasizes harmony and respect. Also, it leads to collectivism, family, and community notions, which conflict with the notion of individualism in Western cultures (Huai-guo, interview, May 17, 2013).	Policymakers have to know how parents think. Parents only care about exam scores. No matter how much effort a teacher puts in, parents will blame the teacher for not helping students improve their exam scores. However, I think the policies and experts in the field of education don't really know our actual teaching practices, thus, I don't even want to look at these policies since they don't speak to our needs (Hei, interview, May 31, 2013)
The science education system, its norms and traditions are based on Collectivism. All teachers want students to be well behaved and follow stepwise instructions and procedures (Huai-guo, interview, May 17, 2013).	I think improving students' hands-on skills is too idealistic. The funding and resources are not enough for this kind of science education (Bao, interview, May 29, 2013).
Teachers cannot persuade parents to change the values of society. . . . Teachers are afraid of changing teaching methods. . . . I don't know what we could do to help teachers. Teachers choose teaching methods that are acceptable within the society (Yang-ming, interview, June 5, 2013).	Ministry of Education and in-service teacher training programs always promote some new policies, but they are not practical (Ren interview, June 04, 2013). It is very challenging . . . if we want to improve students' thinking, teachers have no time to train students to learn how important it is to think in science, more time is needed to check their answers to open ended questions. I wanted to try, but in the end, I was trained to provide standardized answers. (Xiao, interview, May 20, 2013)
Of course teachers are influenced by the society's values, which is why their only goal is to get their students to pass their exams, even though they say that increasing students' scientific literacy is their teaching objective (Yang-ming, interview, June 5, 2013).	The Ministry of Education doesn't have a clear and concrete goal. Without professional support, teachers felt overwhelmed with having to explain these policy changes to parents (Yi, Interview, May 31, 2013)
The emphasis on discipline and social order has prevented the implementation of nontraditional teaching methods in the formal education system. . . . It's difficult for the society to accept the new methods of developing inquiry skills (Yang-ming, interview, June 5, 2013).	I think I don't have enough training and time to try different teaching methods. . . even now with just lectures, I feel like I already need to rush through things (Jing interview, May 31, 2013).
In Confucian cultures, functionalism, collective thinking, acting according to tradition . . . are important characteristics . . . knowledge, professional education and credentials are valued more than technical, hands-on skills. These are obstacles to scientific advancement . . . and the reason why science in Asia cannot advance (Qian-hua, interview, June 5, 2013)	Student-centered [approach] was a mess and I had a hard time monitoring students' learning progress. . . . After my experience of trying group learning methods, I [now] stick to the traditional teaching methods (Zhong, interview, May 21, 2013)