Development and Examination of a Model of Science Teacher Identity (STI)

DISSERTATION

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By

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Abstract

In this study, a new conceptual model of Science Teacher Identity (STI) was proposed and examined. The construct dimensions of science teacher identity were conceptualized; a newly developed instrument to measure the level of science teacher identity was tested for validity and reliability; and preliminary evidence in support of the STI model was gathered.

For this study, a 48-item questionnaire was developed in Likert format to measure the nine postulated dimensions of the proposed STI model: science teachers' personal learning experience, having knowledge and skills, community practice, science teaching practice, degree of success, social respect, belief and value in science teaching, intrinsic satisfaction, and representation. To validate the construct validity of nine dimensions, the model of STI was quantitatively and qualitatively examined using a sample of 17 preservice science teachers who were completing a graduate level science teacher preparation program. Techniques used included administration of a questionnaire, interviews, and document analysis. To examine the underlying structural formation of the STI model, subscale score reliabilities and correlations of each dimension of the STI model to a variety of variables were analyzed using survey data from an instrument administered to 414 experienced science teachers.

Results provided empirical evidence that the construct of science teacher identity can be explicitly modeled and reliably measured. Also, preliminary findings supported

the construct validity of the STI model, with several hypothesized correlations implied by the model being documented, and the change in level of STI expected to be associated with professional development experiences being observed.

Dedication

This document is dedicated to my family.

Acknowledgments

"I Love you, O Lord, my strength. The Lord is my rock, in whom I take refuge. He is my shield and the horn of my salvation, my stronghold."(Psalms 18:1-2).

It has been a blessed journey studying at the Ohio State University: the Lord has been with me all the time throughout this journey and I give my greatest thanks to Him with all of my heart and soul.

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Fields of Study

Major Field: Science Education

Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction

Background

Current Status of Science Education in the U.S.

"All Americans, familiar with basic scientific ideas and processes, can have fuller and more productive lives."

This is the goal statement of the National Science Education Standards (National Research Council [NRC], 1996, p. ix). With this goal in mind, science educators have pursued excellence in science education in the United States. However, the current status of science education in the U.S. as evaluated by several national and international assessments seems less than excellent. According to the results of science achievement assessment of the fourth, eighth, and twelfth graders assessed by the National Assessment of Educational Progress [NAEP] [1] from 1996 through 2005, the eighth and twelfth graders' average score of science achievement was not improved from 1996 to 2005 (Grigg, Lauko, & Brockway, 2006). The Trends in International Mathematics and

[1] The National Assessment of Educational Progress (NAEP) is the U.S. national assessment administered to 4th, 8th, and 12th grade students to assess what they know and can do in various subject areas e.g. science, mathematics, reading, writing, the arts, civics, economics, geography, and U.S. history, periodically conducted by the Commissioner of Education Statistics of the National Center for Education Statistics in the U.S. Department of Education. In science, NAEP data has conducted in 1996, 2000, and 2005.

Science Study [TIMSS] [2] (Gonzales et al., 2000) also reported that U.S. students' performance in science was below the international average score in 1995 and 1999. Although TIMSS results in 2003 and 2007 showed that U.S. students achieved above the average score (Gonzales et al., 2004 and 2009), another international assessment, the Program for International Student Assessment [PISA] in 2000 through 2006 [3] indicated contrary results: U.S. students' level in scientific literacy was significantly lower than the average level of Organization for Economic Co-operation and Development [OECD] countries that participated. For the 2006 administration of PISA, the U.S. average score in scientific literacy was ranked as 21st out of 30 OECD countries and 29th out of 57 participating countries. Recent international comparative assessments have revealed inconsistent results of U.S. students' performance in science. These results highlight the fact that U.S. science education has improved significantly as a result of reform efforts, and efforts should be continued to improve student learning of science.

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[2] The Trends in International Mathematics and Science Study [TIMSS] is an international assessment administered to 4^{th} and 8^{th} grade students in approximately 50 countries to assess their science and mathematics performance, periodically conducted in every 4 years by the International Association for the Evaluation of Educational Achievement [IEA] and International Study Center at Boston College [ISC]. In science, TIMSS data has been collected in 1995, 1999, 2003, and 2007. TIMSS 2007 results will be released on December 9, 2008.

[3] The Programme for International Student Assessment [PISA] is an international assessment administered to 15-year-Olds students in approximately 60 countries including all member countries of Organization for Economic Co-operation and Development [OECD] and partner countries to assess their capabilities in scientific literacy, mathematical literacy, and reading literacy, periodically conducted in every 3 years by OECD. In each cycle, PISA assesses intensively one subject area as a primary domain with covering assessments of the other two subject areas. In scientific literacy domain, PISA has collected data in 2000, 2003, and 2006. In 2006, scientific literacy was primary domain.

Needs for Qualified Science Teachers

Through recent national and international comparisons, the science education community has reached consensus that student performance is strongly impacted by teacher quality. Findings drawn from TIMSS surveys of science teachers have shown that the quality of science teaching practices, including content, instruction style, time management, material, and activity, is mainly determined by science teachers (Roth et al., 2006). In poor-performing discipline areas of science such as chemistry and physics, U.S. chemistry or physics teachers do not have adequate academic backgrounds (Kastberg, Roey, Jocelyn, & Williams, 2006). In 2003, only 80% of U.S. science teachers had a teaching licensure or certificate whereas the international average was 87% (Kastberg et al., 2006). The broad consensus regarding the qualifications of teachers has been supported by the research that teachers have greater impacts on students' achievement than do other factors (e.g. school organization, leadership, and financial condition, Kreig, 2006). Recent international collaborative studies of teacher quality have indicated that systemic components (e.g., teacher shortage, preparation program, professional development, social-cultural support, and educational policy) might be hindrances to the success of U.S. science education programs in comparison with those of other high-performing nations (Ingersoll et al., 2007; OECD, 2005). Based on the analysis of TIMSS results in 1999, an exploratory report of U.S. teacher education policy pointed out that the United States has developed fewer and lower-stakes filters of science teacher recruitment and retention than other high-performing nations (Wang, Coleman, Coley, & Phelps, 2003). Additionally, a variety of national reports, such as "Global perspectives for local action: Using TIMSS to improve U.S mathematics and science education" (National

Research Council [NRC], Committee on Science Education K-12, & Mathematical Sciences Education Board, 1999); "Before it's too late" (National Commission on Mathematics and Science Teaching for the 21st Century, 2000); and "Educating teachers of science, mathematics, and technology" (Committee on Science and Mathematics Teacher Preparation [CSMTP] & National Research Council [NRC], 2001) have suggested that science teachers should demonstrate greater proficiency in science in order to improve national competitiveness and strength in global economies. The "No Child Left Behind Act of 2001 [NCLB]" (NCLB, 2002) emphasized that qualified teaching could only be performed by qualified teachers. Since 2001, the NCLB act of 2001 had strongly mandated each state to ensure that the highly qualified teachers would be assigned in every classroom by 2006 (NCLB, 2002). In the early period of the mandate, only 55% of science teachers were deemed to be highly qualified teachers with bachelor's degrees and certification or a major in the subjects taught (U.S. Department of Education, 2002). In the 2006 annual report on teacher quality, 95% of new teachers and 97% of classroom teachers were fully certificated and licensed (U.S. Department of Education, 2006).

Science Teacher Quality and Quantity

Despite the successful mandates of the NCLB act, there remained a challenge to science education. Science education has been identified as a problematic subject area with regard to the distribution of highly qualified teachers (U.S. Department of Education, 2002, 2003, 2004, 2005, and 2006). According to one report, "Teacher shortage areas nationwide listing 1990-91 through 2009-10" (U.S. Department of Education, 2009), the majority of states have suffered from shortages of qualified science teachers during the

past decade. Also, this problem was associated with several factors related to supply and demand of science teachers. Examples include science teacher education (preparation programs, academic courses, and entry rates), teacher certification (licensure and testing), alternative certification, employment (compensation, tenure, and retirement) and professional development (teacher induction and retention) (Arabaugh, Abell, Lannin, Volkmann, & Boone, 2007; Escalada & Moeller, 2006; Friedrichsen, Lannin, Abell, Arabaugh, & Volkmann, 2008; Ingersoll et al., 2007; Shaw, 2008; Wang et al., 2003).

In terms of science teacher supply and demand, science teacher education programs have not provided an adequate number of qualified science teachers to meet the demand (Ingersoll & Perda, 2009). From Ingersoll and Perda's data (2009), the pool of science teacher candidates has not been sufficient to fill the vacancies caused by science teachers leaving the profession (13, 684 vs. 21,627) at the end of academic year 1999-2000. Only 46% of science teacher candidates for academic year 1999-2000 were newly hired in schools (Ingersoll & Perda, 2009). In an attempt to supply adequate numbers of science teachers, many alternative routes of science teacher certification have been established (e.g. regular, alternative, provisional, transitional and emergency certifications) (Zumwalt & Craig, 2005). Science teacher shortages have more often been filled by alternatively certificated teachers than has been the case for other subject areas (Arbaugh et al., 2007; Escalada & Moeller, 2006; Friedrichsen et al., 2008; Ingersoll et al., 2007; Shaw, 2008). Based on the "Science teacher shortage survey" by the National Science Teachers Association (2004), 54% of school districts tried to recruit alternatively certificated science teachers. In fact, 18-20% of all science teachers are prepared not by traditional routes, but by alternative routes (Arbaugh et al., 2007). Also, according to the

"2003-2004 Schools and Staffing Survey [SASS]" (National Center for Education Statistics [NCES], 2005), 88,113 public schools reported difficulties filling vacancies of science teachers: 20.4% reported difficulties in hiring biology teachers, and 26.7% reported difficulties in hiring physical science teachers, both above the average of 20.3% reporting difficulties in hiring needed teachers overall.

Due to difficulties in recruitment, qualifications of science teachers have been lowered (Ingersoll, 2001). Escalada and Moeller's findings (2006) showed that in rural or poverty areas, science teachers teach several disciplines within science. Also, certification requirements of 2.9% of science classroom teachers were waived by departments of education (U.S. Department of Education, 2006). According to indicators of out-of-field teaching analyzed by U.S. Department of Education and NCES (2003), 17% of middle school students and 7 % of high school students were taught by out-of-field science teachers without a science degree or certification. In physical science, out-of-field teaching has been more serious than for other subjects: 42 % of middle school students and 18 % of high school students were taught by out-of-field teachers (U.S. Department of Education & NCES, 2003). Also, the 2000-2001 High School Physics Survey involving over 3,000 schools and physics teachers cited by Escalada and Moeller (2007) indicated that 68 % of physics teachers had no degree in physics. Among these teachers, 28 % had little teaching experience and 40% had extensive teaching experience. This science teacher shortage has negatively influenced student learning of science because of the impact of under-qualified science teachers.

Science Teachers' Dissatisfaction with the Teaching Profession

Science teacher shortages result from not only the short supply of science teachers, but also turnover as well. Science teacher turnover is a more serious problem than maintaining the balance of supply and demand of high-qualified science teachers. Science teacher turnover rate has been above 10% annually: 11.5% in 1988-1989; 12.2% in 1990-1991; 14.2% in 1994-1995; 17.0% in 2000-2001; 13.3 % in 2003-2004 (Ingersoll & Perda, 2009). Of those leaving, many beginning science teachers leave their classroom within the first few years of teaching (CSMTP & NRC, 2001; Ingersoll, 2001). The primary reason given for leaving teaching "dissatisfaction" related to professional issues: lack of leadership; lack of respect from students, parents, and principals; poor support from administrators; overly large classes; insufficient equipped classrooms and laboratories; and an inadequate incentive and wage (Gonzalez, Brown, & Slate, 2008; Ingersoll, 2001; Liu & Ramsey, 2008; NCMST, 2000). According to an analysis of attrition of public school mathematics and science teachers (U.S. Department of Education & NCES, 2008), the top five reasons to leave teaching, with the exception of retirement (34%), illustrate why science teachers have not been satisfied with their profession: Better salary and benefits (25%); the pursuit of a position other than K–12 educator (23%); dissatisfaction with previous school or teaching assignment (21%); dissatisfaction with teaching as a career (18%); and school staffing actions (14%).

This dissatisfaction with the teaching profession might drive beginning science teachers to have low levels of self-confidence, self-respect, and self-esteem as science teachers, possibly weakening their professional identity as science teachers. Beginning science teachers having weak science teacher identities are likely to quickly become disillusioned with their chosen profession. Consequently, beginning science teachers may

be leaving the profession before they have had an opportunity to develop a sound, stable science teacher identity.

Science Teacher Identity

With regard to science teacher recruitment and retention, a sense of self as a science teacher, *science teacher identity*, has received increasing attention as an important construct in science teacher education. As the importance of teacher identity has become apparent in teacher education, research focusing on teacher identity has emerged during the past decade. The three main areas of research on teacher identity to date can be categorized as follows: the formation, characteristics, and representation of teacher identity (Beijaard, Meijer, & Verloop, 2004). Specifically, research has shown teacher identity to be strongly associated with adaptation, motivation, confidence, satisfaction, commitment and efficacy in becoming a teacher (Beijaard, Verloop, & Vermunt, 2000; Beijaard et al., 2004; Jakubowski & Dembo, 2004; Starr, Ferguson, Haley, & Quirk, 2003; Starr et al., 2006). Other research on teacher identity has also shown identity to be a key predictor of teachers' performance, retention, burnout, and turnover (Brown, 2006; Day, Elliot, & Kington, 2005; Snyder & Spreitzer, 1984).

Recent concerns about science teachers' sense of self and professional identity have accelerated the needs for more research on relationships between science teacher identity and science teacher professional development. Several studies have reported that the role of science teacher identity might be critical for science teachers to develop and sustain their teaching profession (Eick & Reed, 2002; Eick, 2009; Friedrchsen et al., 2008; Henderson & Bradey, 2006; Luehmann, 2007 Proweller & Mitchener, 2004; Varelas, House & Wenzel, 2004; Volkmann & Anderson, 1998). In particular, these

studies have found that a strong, well-developed sense of science teacher identity might be associated with a strong motivation, commitment, satisfaction, and effectiveness in becoming science teachers and teaching science.

Greater understanding of science teacher identity would be useful for understanding and addressing issues related to the quality and quantity of science teachers, which is associated with improvement of student performance in science. However, few studies on science teacher identity have been conducted although research interest in the construct of teacher identity has recently increased (Beijaard et al., 2000; Beijaard et al., 2004). Science teacher identity is not explicitly defined; there is no model to explain the construction of science teacher identity; and no instrument, scale, or measure of science teacher identity had yet been developed prior to this study.

Among 25 studies on science teacher identity, there is no consensus on the definition of science teacher identity as several different theoretical frameworks were used to conceptualize science teacher identity.

Very little is known about conceptual models that explain the construction of science teacher identity. There have been only two "models" conceptualized by Helms (1998) and Creighton (2007), and these two conceptual models represent the conception of teacher identity generally rather than science teacher identity. Since no instrument, scale, or measure of science teacher identity had yet been developed, most studies on science teacher identity have employed small-scale and in-depth qualitative research methods such as ethnography, case studies, or phenomenology.

Purpose of Study

In an effort to advance research on science teacher identity, this study focused on developing a model of science teacher identity, designing a new instrument to measure the level of science teacher identity, and examining quantitatively and qualitatively a model of science teacher identity among pre-service science teachers in the context of a graduate-level science teacher preparation program. The purpose of this study was to provide empirical evidence that a conceptual model of science teacher identity can be constructed and the level of science teacher identity can be validly and reliably measured. In addition, predicted changes in the level of science teacher identity in relation to participation in professional development programs and professional experiences were explored.

The study addressed the following questions:

- How can the dimensions of the science teacher identity construct be conceptualized and represented?
- Can the level of science teacher identity be validly and reliably measured?
- What evidence supports the efficacy of the proposed model of science teacher identity?

Significance of Study

This study is significant in terms of both theoretical and practical contributions to the science education discourse community. In theoretical terms, this study represents the first known attempt to develop and examine both a new conceptual model of science teacher identity and an instrument to measure the level of science teacher identity in a specific research context. Though many studies have included consideration of an

assumed attribute of science teachers referred to as science teacher identity, there has been no direct way to measure this supposed attribute, and there has been no prior attempt to indirectly estimate the level of science teacher identity specifically. The results of this study will provide the foundation for developing the conceptual meaning of the science teacher identity construct. In developing an instrument to measure science teacher identity, this study advances the literature regarding relationships between the levels of science teacher identity, varied science teachers' attributes, and professional experiences.

In practical terms, this study explored a potentially useful application of a science teacher identity scale for measuring effects of professional development of science teachers that may be associated with teacher quality and retention. The sense of self as a science teacher, or 'science teacher identity', is thought to play a major role in attracting and retaining science specialists within the teaching profession. As many studies have indicated (Eick & Reed, 2002; Eick, 2009; Friedrchsen et al., 2008; Luehmann, 2007), having a strong sense of self as science teacher would be a firm foundation for preservice teachers acquiring the motivation and commitment to becoming science teachers. Also, it is thought that a well-developed science teacher identity would confer strong resilience among practicing teachers, leading to satisfaction and effectiveness in sustaining and developing their profession (Henderson & Bradey, 2006; Proweller & Mitchener, 2004; Varelas et al., 2004; Volkmann & Anderson, 1998). In this respect, a better understanding of a psychological attribute, science teacher identity, is important to science teacher development. In addition, relationships between science teacher identity and teaching practices have been significantly associated according to the findings of several studies (Beckford-Smart, 2006; Eick & Reed, 2004; Enyedy et al., 2006; Forbes & Davis, 2008;

Helms, 1998; Jita, 1999; Melville & Wallace, 2007; Moore, 2008a, 2009b; Pedretti, Bencze, Hewitt, Romkey, & Jivraj, 2008; Ramseur, 2004; Sowell, 2004; Volkmann & Anderson, 1998). Therefore, for science teachers, the findings of this study may lead to the identification of implicit indicators of potential success in science teaching. This study may inform the way in which professional experiences of science teachers will be designed and implemented by science teacher education programs. This study may also promote greater interest among science teacher educators and researchers in evaluating a broader range of outcomes for teacher education programs.

Finally, this study of science teacher identity may provide key insights to understanding and solving a set of longstanding challenges in the science teacher education discourse community, increasing the quality and quantity of science teachers and the improvement of student learning.

Limitations and Delimitations

The most significant limitation of this study is concerned with the conceptual generalizability of defining of an abstract, psychological attribute of science teachers, 'science teacher identity', in the specific context of science teaching, and establishing the construct validity of this representation. Although there has been to date little formal attention given to science teacher identity, the conceptualization developed here has been based on current, relevant, empirical research and literature. Moreover, the developing and field-testing of an instrument was attempted without a broad foundation of prior research in the science education research community. The novelty of the STI construct and employment of a newly developed instrument to measure STI limits the extent to

which the findings of this study may be generalized, including use of the instrument in educational settings.

Another limitation of this study relates to contextual considerations of field-testing of the instrument and examining of the model of science teacher identity. The only preservice and practicing science teachers participating in the study were examined in a single specific context, e.g. United States. In addition, the examination of the model of science teacher identity was conducted with only preservice science teachers enrolled as a cohort in a graduate level science teacher preparation program.

This last limitation is also related to a delimitation of this study. For field-testing of the instrument, the demographic profile of participants was restricted to identifying initial licensure or certification. Initial licensure or certification levels vary from state to state in the United States, so grouping of licensure programs and licensure programs by grade level bands was delimited by the researcher in response to the lack of standardization. For example, initial licensure or certification for grade levels P-3, K-3, 1-3, K-4, K-6, K-8, 1-6, 1-8 and 4-6 were categorized into an elementary science teacher group. Grade levels 4-9, 5-8, 5-9, 6-9, 7-9, 5-12, 6-12, 7-12, 8-12, and 9-12 were categorized into a secondary science teacher group. Science teachers who have licensures or certifications in both categories were classified into an elementary and secondary science teacher group. Also, science teachers who marked "K-12" in the grade level were classified into the elementary and secondary science teacher group.

Because the newly developed STI instrument was administered to members of a state and nationwide professional association of science teachers, elementary science teachers as well as secondary science teachers were included as participants for this

study. Thus, participating science teachers ranged from teachers of Preschool students to teachers of science at grade 12.

In addition, the examination of the model of science teacher identity is delimitated to the sample population. Because the model of science teacher identity is only examined among secondary preservice science teachers, this study does not cover the broad range of science teachers including elementary preservice and practicing science teachers as well as secondary practicing science teachers.

Definition of Key Terms

As mentioned above, this study explored how to develop and examine a conceptual model of science teacher identity. Thus, the key terms of this study are identified as following: identity, teacher identity (TI), science teacher identity (STI), science teacher identity model (STI model), science teacher identity instrument (STI instrument), science teacher identity level (STI level), construct, and dimension.

- Identity: The personal and social concept of self, that is, a personal and social sense of self. Identity is reflected, constructed, and represented through internal processes and external interactions within and outside of self.
- Teacher identity (TI): A teacher's personal and collective sense of self as a teacher (e.g., professional role, behavior, emotion, belief and value) in a society, which is individually internalized in a self and socially constructed within a social relation and structure in society.
- Science Teacher Identity (STI): A science teacher's personal and collective sense of self as a science teacher in society. Like the formation of teacher identity,

science teacher identity is personally, internally, and individually constructed in s personal aspect of teacher identity and also collectively, externally, and publicly constructed in a collective aspect of teacher identity.

- Science Teacher Identity Model (STI Model): A schematic description of a psychological construct, science teacher identity (STI), which is conceptually proposed for the investigation of this study through a multi-array of previous theory and research.
- Science Teacher Identity Instrument (STI Instrument): A questionnaire compromising 48-Likert scale item designed to measure the level of science teacher identity, in which nine dimensions of the STI model are underlying.
- Science Teacher Identity Level (STI Level): The degree that reflects difference or strength of science teacher identity, which is measured by the STI instrument in this study (Furr & Bacharach, 2008).
- Construct: An unobservable abstract or theoretical idea inferred or derived from specific observation or investigation about a phenomenon (Furr & Bacharach, 2008). The construct cannot be directly and perfectly measured (Hair, Black, Babin, & Anderson, 2009).
- Dimension: A composite attribute, perception, or idea that may collectively represent for a psychological attribute, e.g., science teacher identity (Furr & Bacharach, 2008; Hair et al, 2009). In this study, the 11 dimensions of the STI model correspond to and reflect in the conception of science teacher identity. Specifically nine dimensions of the STI model underlie as nine factors of the STI instrument.

Organization

This dissertation is organized into five chapters. The next chapter reviews a relevant literature with science teacher identity and teacher development that underlies the conceptual framework. The chapter 3 shows how to propose a conceptual framework, and how to conduct this study including methods, participants, procedures, and data analysis. Collected data are analyzed in chapter 4. According to research questions, discussions and implications of this study are presented in chapter 5.

Chapter 2: Literature Review

This chapter reviews the important literature about the constructs, identity, teacher identity, and science teacher identity, particularly in terms of teacher development and teacher education programs. This fundamental understanding of other researches' findings on identity and teacher identity provides the framework to propose a conceptual model of science teacher identity.

Self and Identity Theory

The "self" is the core concept in understanding and explaining human behaviors and social phenomena in behavioral and social science. According to Leary and Tangney's findings (2003), there are '150,000 abstracts containing a hyphenated "self" term (e.g., self-esteem, self-control, self-disclosure, self-awareness, self-actualization, self-confidence, and self-efficacy)' (p. 11). The "self" is a precursor concept in the understanding of "identity" in historical and conceptual views.

There have been numerous theories and researches on the "self" before the 21st century. The most breakthroughs had been achieved in 1890, by William James. He was the first psychologist who had laid the foundation to conceptualize of the "self." Through the most famous chapter, "The Consciousness of Self" in his book, 'The principles of psychology,' the concept of "self" has been centralized in psychology (James, 1890). James defines the self as "the empirical self of each of us is all that he is tempted to call

by the name of me" (James, 1890, p.291). He explains that "a man's Self is the sum of all that he can call his, not only his body and his psychic powers, but his clothes, and his house, his wife and children, his ancestors and friends, his reputation and works, his lands and horse, and yacht and bank account" (James, 1890, p. 291). From his conception, the "self" has been understood by a whole entity of individuals. His view was an initiator to conceptualize of the "self" in different ways, for example, as a total person, a personality, an experiencing subject, beliefs about oneself, and an executive agent (Leary & Tangney, 2003). He also represented multiple aspects of the self: the material self, the social self, the spiritual self, and the pure Ego. After James emphasized that "a man has as many social selves as there are individuals who recognize him and carry an image of him in their mind" (James, 1890, p. 294), the critical factors of social selves, 'the dynamic of self, others, and society' was formulated by the early theorists Cooley and Mead. Charles Horton Cooley (1902) integrated the conception of "self" in interactions between of others and community, so he theorized a social influence in "self." According to him, there are three elements in constructing self: imagining how to appear to others; imagining how others judge or appraise that appearance; and feeling an emotional response to the appraisal. About this view, George Herbert Mead (1929) noted that Cooley's approach to the self is significant in his view of constructing the self as a psychological process (a mental process) in a social context. Mead conceptualized his conception of "self" by interweaving Cooley's conception with James' conception of the "self." Mead's "self" (1934) is defined as "something which has a development; it is not initially there, at birth, but arises in the process of social experience and activity, that is develops in the given individual as a result of his relations to that process as a whole and

to other individuals within that process." In his view, the self is a crucial social process, and it arises in social experiences. Moreover, Mead (1934) expanded the conceptions of self that James described as 'a knower-self and a known-self.' He explained the self as distinguishable symbols: the self as a subject, "I" and the self as an object, "Me." According to his conception, the "self" consist of an "I" that reacts to the self by taking attitudes toward others and a "Me" that is introduced through these attitudes by reacting to "I." I and Me are not identical but belong together in the sense of being parts of a whole "self" (Mead, 1934). "I" and "Me" are separated in the process and distinguishable phases of "self" (Mead, 1934).

After Mead (1934), the conception of identity is separately understood from the "self" (Holland & Lachicotte, 2007). "Identity" has been conceptualized by two representative researchers: Mead and Erikson (Fries, 2002; Holland & Lachicotte, 2007). Like Mead, Erick H. Erickson gave a great emphasis on "identity" throughout his life and used the term "identity" instead of the self and ego (Straub, 2002). Erickson theorized psychological states of identity development from childhood through adolescence based on Sigmund Freud's theory. In his theory, the identity is more personally and developmentally conceptualized than in earlier discussions of the self or ego (Straub, 2002). He proclaimed to understand "identity" historically in relation to personal biography and experience (e.g. identity crisis). Because of this fundamental difference of the conception of identity, Holland and Lachicotte (2007) divided the concept of identity into two representative research trends, Eriksonian identity vs. Meadian identity. Eriksonian identity is rooted in Erickson's theory of identity, while Meadian identity originates in Mead's theory of the self. As Holland and Lachicotte (2007) pointed out,

Ericksonian identity has stressed more psychological well-being status of identity development, while Meadian identity has focused on the sociological relations, roles, and activities of the self for identity formation. Identity theorists tend to concede that Ericksonian identity comes from psychological and psychoanalytical approaches, while Meadian identity comes from sociological-cultural and anthropological approaches. In fact, Ericksonian identity is labeled as a personal identity, individual identity, and internal identity emphasizing the psychological aspects of identity, while Meadian identity is viewed as collective identity, public identity, and external identity emphasizing sociological aspects of identity. As a result, Ericksonian identity has been concerned about the "coherence and continuity of identity" and the development and maintenance of the self, while Meadian identity has considered the "commonality and comparison" of self and groups in a social structure (Straub, 2002). These two incompatible perspectives have created a certain fallacy in understanding of identity. Ericksonian identity is concerned with the clinical and psychopathological significance of identity so that it has overlooked the anthropological and sociocultural meaning of identity, an "objectivity of identity" that is inevitable to identity development (Straub, 2002). For example, while a preservice teacher develops his/her identity as a teacher, he/she describes who "I" would like to be. He/she collects evidences for this description and then evaluates these evidences to construct a self as a teacher identity. During this process, a preservice teacher perceives and receives social discourse about what a teacher looks like within social structures such as schools, community, and society. This social influence is pertinent to identity development. Based on internal and external evaluation of this self, a preservice teacher seeks a stable and consistent self-identity. In contrast, Meadian

identity has derived its concept from the categorization and depersonalization of group and intergroup behaviors so that it overemphasizes social stability and demands rather than individuality and subjectivity (Hogg, 2003; Holland & Lachicotte, 2007). For example, Meadian identity has explained that a personal identity is a low-level identity among multiple identities since there is a hierarchy of multiple identities within social structures and relations. In fact, Meadian identity has limits to conceptualize of personal identity. In addition, Meadian identity has differentiated several identity theories exploring the functions of social interactions and groups in identity formation, such as social identity theory, role identity theory, and affect control theory (Stets & Burke, 2003). Because of these weaknesses, recent researchers have tried to incorporate both theoretical aspects to build a more coherent and cumulative theory of identity (Stets & Burke, 2003). In this manner, two main perspectives may be able to provide complementary insights to conceptualize identity. Based on this rationale, thus, the term, "identity" should be conceptualized by integrated and reflected perspectives as following: The identity is the personal and social concept of self which is reflected, constructed, and represented in internal processes and external interactions within and outside of self.

Teacher Identity

The construction of teacher identity has emerged as a distinct research topic that has heavily accumulated literature in teacher education over the past few decades. Research has presented the important role of teacher identity in mediating teachers' professional development and performance as a teacher (Beijaar et al., 2000; Beijaard et al., 2004; Brown, 2006; Day et al., 2005; Jakubowski & Dembo, 2004; Snyder &

Spreitzer, 1984; Starr et al., 2003; Starr et al., 2006). Critical professional issues related to teacher identity (e.g., teachers' adaptation, motivation, confidence, satisfaction, commitment efficacy, induction, retention, burnout, and turnover) have been more exhaustively studied. The impact of teacher identity on students' performance and policy implementation has been explored as well (Barret, 2008; Day, Flores, & Viana, 2007; Lasky, 2005; Terwilliger, 2006; van Veen, Sleegers, & van de Ven, 2005). As a rapidly growing area of literature, teacher identity has been signified as a crucial construct in our understanding of teachers and education.

Among this literature, about 70 studies on teacher identity from 1997 through 2008 were used for this study (Table 1). Of those, articles, dissertations, and books were selected, including notable findings about how to construct teacher identity and influences on teacher identity, but excluding teacher identity research related to gender identity, racial identity, or ethnic identity, and also excluding science teacher identity research. Using the three main areas of research on teacher identity as categorized by Beijaard et al. (2004), these studies are categorized as follows: the formation of teacher identity, characteristics of teacher identity, and representation of teacher identity. Table 1 presents a brief research profile of the 70 studies, alphabetically ordered by authors' last name, with publication year and a brief summary of research methods, major findings, notes of teacher identity formation, characteristics of teacher identity, and representation of teacher identity of each study.

As can be seen in Table 1, most studies were empirical studies based on scientific research methods. Of those, one study (McNabb, 2004) was conducted as a meta-narrative study analyzing historic and public discourse with public documents and films.

Only two studies are reviews or critique papers on other studies. The majority of studies employed qualitative research methods using interviews, observations, drawing, films, and documents including public policy documents, essays, journals, portfolios, electronic writings, electronic mails, and academic artifacts (e.g., action research). When conducted as a case study, ethnography, phenomenology, action research, and comparative study, a small number of participants participated in studies, ranged from one through twelve. Other qualitative studies were conducted with a large number of participants ranging from sixteen through seventy-six. Most mixed-methodology studies using quantitative research methods with questionnaires or surveys were conducted with large-scale participant samples, ranging from forty through four thousand seven hundred ninety (Badertscher, 2007; Beijaard et al., 2000; Broyles, 1997; Chan, 2005; Chedzoy & Burden, 2007; Cheung, 2008; Day et al., 2007; Day et al., 2006; Isabell, 2006, 2008; Javis-Selinger, 2002; Lasky, 2005; Malderez, Hobson, Tracey, & Kerr, 2007; Starr et al., 2006; Swedenburg, 2001; Taylor, 2008; ten Dam & Blom, 2006; Tigchelaara, Brouwerb, & Korthagen, 2008).

In spite of this scientific approach to teacher identity, there has been made no agreement on the definition of teacher identity. Moreover, the concept of teacher identity has shown a conceptual ambiguity since most studies have provided only vague theoretical origins of the conception of teacher identity. As discussed above, the concept of identity is mainly divided into two categories, psychological and sociological identity (Ericksonian identity vs. Meadian identity). There are only a few studies that used social identity theory (Varghese, Morgan, Johnston, & Johnson, 2005). In their theoretical conception, teacher identity is rooted in the social identity theory and the role of identity

theory from sociological identity, Meadian identity. From this perspective, teacher identity is defined using the social identity framework stated by Straub (2003): A professional identity, one of a social identity or role identity, which is a sense of categorization of (teaching) professions based on commonality of the self within a professional group (teachers' community) and differences between others in different professional groups associated with group behaviors. However, the concept of teacher identity has not been conceptualized by this one-sided approach in most empirical research. Just as the concept of identity could not be independently conceptualized by one standpoint, that of teacher identity should be interpreted by both its personal (psychological) and collective (sociological) aspects. In fact, most research has been virtually guided by this mixed conceptual approach. There has been a lack of discussion about the precise conceptual framework, including assumptions, concepts, and the practice of teacher identity, so that it may lead to a vague conception of teacher identity and research framework. Thus, in this study, the concept of teacher identity has been discussed not only by personal, psychological aspects but also collective and sociological aspects. In conceptualizing teacher identity, the "personal aspect" refers to how someone sees himself/herself as a teacher and the "collective aspect" refers to how others see him/her as a teacher; both are pertinent to negotiating and constructing teacher identity. In this conceptual and practical conception, teacher identity can be defined as a teacher's personal and collective sense of self as a teacher (e.g., professional role, behavior, emotion, belief and value), which is individually internalized in a self and socially constructed within a social relation and structure in society.

Therefore, the formation of teacher identity has been understood through interaction of the psychological and social aspects of teacher identity. Researchers have tried to find what the influential factors on teachers are and how these factors influence teacher identity. Influential factors on teacher identity are dividend into psychological factors, influencing the personal aspect of teacher identity, and sociological factors, influencing the collective aspect of teacher identity. As seen in Table 1, psychological factors are identified as follows: knowledge, experiences, life history, biography, personality, emotions, concerns, anxiety, attitudes, passion, motivation, satisfaction, commitment, confidence, dreams, and hopes. These factors are mainly categorized into four components: experience, emotion, knowledge, and behavior. Of these, personal experience is the most critical factor identified in many studies, including past biography, life history, learning experience, academic success, memories related to classroom and school, and role models (Brilhart, 2007; J. Brown, 2006; T. Brown, 2006; Dale, 1999; de Fretias, 2008; Dust, 2006; Etheridge, 2005; Johnson, 2003; Larson, 2006; Musanti, 2005; Newman, 1997; Reio, 2005; Sloan, 2006; Travers, 2000; Williams, 2007). The other factor, emotion, has also been described as an influential factor in teacher identity formation (Baderstscher, 2007; Broyles, 1997; Brown, 2006 Chan, 2005; Day et al., 2005; Day et al., 2006; Jarvis-Selinger, 2002; Newman, 1997; Lasky, 2005; Malderez et al. 2007; McMahon, 2003; O'Connor, 2008; Poulou, 2007; Song & Wei, 2007; Zembylas, 2005). In particular, Baderstscher (2007), Broyles (2006), Brown (2006), Jarvis-Selinger (2002), Newman (1997), and McMahon (2003) have suggested that the control and regulation of negative emotions such as concerns, fear, frustration, and anxiety have constituted teacher identity and teaching practice. The importance of knowledge in

teacher identity is identified in a few studies (Andrezejewski, 2008; Beijard et al., 2000; McCormack, Gore, & Thomas, 2006; Musanti 2005). As Beijaard et al. (2004) mentions, although teacher identity formation uses a variety of knowledge sources, professional knowledge, pedagogical knowledge, content knowledge, and pedagogical content knowledge are mainly addressed. Additionally, behavior also has a crucial impact on teacher identity formation, including sub-factors of passion, motivation, satisfaction, commitment, confidence, efficacy, and dreams (Assaf, 2008; Brillhart, 2007; Chan, 2005; Day et al., 2005; Song & Wei, 2007). On the other hand, these components have been prescribed as an indicator of the state of teacher identity since they are not only reflected in but also regulated by affective and cognitive evaluations of the self. These factors are characterized as products of the self-reflection and self-evaluation of teacher identity. In particular, dreams, and hopes are cognitive factors which form a future-oriented representation of the self. Gohier, Ghevrier, and Anadon (2007) and Williams (2007) have found that these components have a positive driving force in teacher identity formation.

For sociological factors, collective interaction and contexts are revealed e.g., culture, schools, institutions, policy, reform movements, and relationship with students, colleagues, and staff (Table 3). These sociological factors are also classified as contextual factors and relational factors. Contextual factors refer to the sociological environment surrounding teachers, as established by social structure. These are schools (Flores & Day, 2006; McCormanck et al., 2006), institutions (Campbell, 2005; Chedzoy & Burden, 2007; Cheung, 2008; Cohen, 2001; Cohen, 2008; Flores & Day, 2006; Javis-Selinger, 2002; ten Dam, 2006; Tsui, 2007), cultures (Choi, 2007; Nguyen, 2004), and policies

including reform movements (Assaf, 2008; Barret, 2008; Brilhart, 2007; Day et al, 2007; Lasky 2005; Osborn, 2008; Reio, 2005; Terwillige 2006; van Veen, Sleegers, & van de Ven, 2005). Relational factors refer to interactions between teachers and others, represented by social relations. For example, they include collaboration (Musanti, 2005; Williams, 2007), support from colleagues (McCormack et al., 2006; Williams, 2007), mentoring (Hand, 2007; Johnson, 2003), and rapport or relationship with students (Lasky, 2005; Travers, 2000).

In addition to various factors of teacher identity formation, "how teacher identity is constructed" has been differently examined by either psychological or sociological approaches. In psychological approaches, the clinical state of teacher identity has been examined to determine whether teacher identity has been stably developed (T. Brown, 2006; Day et al., 2006). By contrast, in sociological approaches, teacher identity formation has been considered as a process of socialization: how teachers become a teacher in a society and how others perceive them as a teacher (Isbell, 2006, 2008; Nguyen, 2004, 2008; Flores & Day, 2006). Hung (2008) pointed out that reflection is an important process in both psychological and sociological aspects of teacher identity formation.

Further teacher identity characteristics have found in various subject matters and states of teacher development. In terms of subject matter, teacher identity is differently characterized by each subject (parenthesis indicate the number of studies), particularly art (1), dance (1), mathematics (5), medicine (2), music (2), language (8), literature (3), physical education (1), and social studies (1). Among teaching professions, these subjects require more teachers to have specifically advanced knowledge and skills in teaching the

subject. This nature of subject matter has influenced teachers' sense of a self not as an expert but as a teacher, e.g., how much teachers know subject contents, how they teach effectively and confidently, and how teachers interact with students in teaching (Baderstcher, 2007; Broyles, 1997; Chedzoy & Burden, 2007; Hallman, 2007; Isbell, 2006; Miller, 2005; Williams, 2007). For teachers of English as a second language, Choi (2007) and Nguyen (2004, 2008) found that they have struggled more with cultural context than do other subjects' teachers.

In teacher development, many studies have claimed that teacher identity is an essential role in becoming a teacher (Assaf, 2003; Broyles, 1997; Brown , 2006; Campbell, 2005; Chedzoy & Burden, 2007; Cohen, 2001; Goos & Bennison, 2008; Hale, 2005; Hand, 2007; Hung, 2008; Isbell, 2006, 2008; Jarvis-Selinger, 2002; Malderez et al., 2007; McCormack et al., 2006; Miller, 2005; Newman, 1997; Nguyen, 2004, 2008; Poole, 2002; Poulou, 2007; Roberts & Graham, 2008; ten Dem, 2006; Travers, 2000; Williams, 2007). These studies have argued that teacher identity is critical for preservice teachers and first-year teachers in particular, in determining to commit in teaching profession. For preservice teachers, teachers' learning is significantly considered as a process of identity formation. In a longitudinal study of the preservice year through the first-year period by Cohen (2001) and Goos and Bennison (2008), teacher identity development has been explored for art teachers and mathematics teachers. Also, for career changers through alternative certification, teacher identity formation is very essential in becoming a teacher (Tigchelaar et al., 2008).

Regarding self- presentation as a teacher, teaching practice is associated with teacher identity formation (Andrezejewski, 2008; Cohen, 2001; Etheridge, 2005; Jones-

Walker, 2008; Newman, 1997; O'Connor, 2008; Poulou, 2007; Robert & Graham, 2008; Williams, 2007). Poulou (2007) and Williams (2007) view teaching practice as playing a role in shaping teacher identity so that teaching experience is crucial in teacher identity formation. On the other hand, O'Connor (2008) argues that teaching practice is reflected by teacher identity.

For teacher identity representation, verbal and graphical representation has been explored. Verbal communications through story-telling, conversation, and writings are important in the construction, reflection, and representation of teacher identity, such as narration (J. Brown, 2006; Cohen, 2006; Dale, 1999; De Fretias, 2008; Levitt, 2007; Musanti,2005) and writing (T. Brown, 2006, Poulou, 2007; Terwilliger, 2006; Tsui, 2007; Urzua & Vasquez, 2008). Particularly, Assaf (2008), Goos and Bennison (2008), Hallman (2007), and Hung (2008) have studied representations of the self as a teacher using online communications, writings, and portfolios in an online context. In Campbell (2005) and Etheridge (2005), graphical representation was used to present teacher identity.

Authors	Year	Methods	Findings	Formation	Characteristics	Representation
Andrezejewski	2008	Dissertation, Qualitative: Observation and interview with 4 practicing secondary teachers.	• Teacher identity and knowledge are foundation for teachers' practice. • Expert teachers' identities are composed of several identities, advocate for students, challenger, classroom manager, learner, teacher leaner, and mentor. • Expert teachers aligned identity priorities and expenditure of time and energy in class; are generative for student, novice teachers, the teaching profession and the community; acted on the integration of knowledge. • Dance teacher preparation programs are characterized of four tenets: focus on the whole person, integrated curriculum, explicit identity development, and apprenticeships in relevant communities of practice.	• Multiple role • Teacher knowledge • Practice		Teaching Practice
Assaf	2008	Case study from a reading specialist.	• High-stakes testing pressures affect not only teachers' instruction and responses to students' needs but teachers' professional identity and ethnical sense. • A teacher struggled with tensions about how to stay her own professional identity.	• Tension from professional belief with district and policy • Commitment • Responses to students • Ethnics	ELL Testing Pressure	
Assaf	2003	Dissertation, Qualitative data: Interviews, journals, portfolios, electronic messages, and course response from 6 preservice teachers participating in reading specialization	• The authoring of self: Looking at preservice teachers' professional identities as reflected in an online environment	• Online	Online course	

Continued

Table 1. Summary of Research on Teacher Identity

Table 1 Continued

Authors	Year	Methods	Findings	Formation	Characteristics	Representation
Barrett	2008		• Capturing the Difference: Primary School Teacher Identity in Tanzania	• Teacher identity responded to the change of school's policy. • The change of teacher identity had impact on teaching practice.	Tanzania	Teaching practice
Badertsch-er	2007	Dissertation: Interviews, surveys, journal responses, classroom observations, and e-mail communications with 2 elementary certificated middle school teachers	• Feelings of confidence and frustration as a result of identity formation mediate in personal ways of knowing and doing of mathematics, e.g. how content is experienced and valued and how teachers' identities are reflected in the school mathematics practice.	• Emotion: confidence, frustration, and anxiety • Personal school experiences • Personal process to know and do mathematics • Contexts	Mathematics	
Beijaard, Verloop, & Vermunt	2000	Questionnaire; 80 Practicing teachers	• Teachers perceived themselves as combinational image of three experts; didactical, subject matter and pedagogical experts. • Subject matter expertise and didactical expertise are mostly appeared than pedagogical expertise.	• Knowledge • Subject matter expert, • Didactical expert • Pedagogical expert		
Beijaard, Meijer, & Verloop	2004	Literature reviews	• Identified research trends on teachers' professional identity • Summarized the findings of research on teachers' professional identity.		Literature Review	
Brilhart	2007	Dissertation, Qualitative, Case study: Interviews & Observation from 10 charter school teachers	• Teachers Conceptualization of teaching: Integratig the personal and the professinal • Teachers conceptualize school's philosophy through teaching practice.	• Demographic experience: Personal qualities and K-12 experiences Exploration of self as teacher: Developing about a view of valuable teaching • Relational links: Passion & motivation		
Broyles	1997	Dissertation: Qualitative study: Questionnaire, videotaped student-teaching segments,	• In early student-teaching, preservice teachers revealed self concerns related to self-as-teacher desired to improve their teaching skills. After student-teaching, they developed concerns for pupil learning, began to feel like teachers, strengthened	• Concerns(Fuller's model) • Teacher identity development stages(Caper's model)	Music Undergradua te	

Continued

Table 1 continued

Authors	Year	Methods	Findings	Formation	Characteristics	Representation
		observation instrument, and journals from 12 undergraduate music education students, 20 public school teachers, 8 university supervisors.	their commitment to improve teaching tasks and skills.			
Brown, J.	2006	Dissertation, auto-ethnographic methodology: Interviews with 4 high school teachers including an author	• The teacher-self: The role of identity in teaching • Teacher Identity is socially constructed; TI is difficult to define; The conception of TI is purely artificial but still important to consider. Teacher's experiences can be viewed using the paradigm of the hero's journey; Teachers can potentially learn who they are form their painful experiences; Storytelling is a constructive methods of exploring TI.	• Personal social context		Narrative
Brown, T.	2006	Psychoanalytic theory, Case study: Interview, personal writing from Preservice teacher	• In transition and emergence of professional identity, the process of becoming a teacher was analyzed through psychological lens.	• Intra-psychic disturbance		Personal writing shows how a preservice teacher explored her emerging teacher identity.
Campbell	2005	Dissertation, Ethnography and Comparative study: Interviews, observation, (Video/Audio recording, field notes-computer note taking) documents with 55	• The three components, habitus, stories, and the apprenticeship of observation contribute to development of teacher identity. • The development of teacher identity is different at two teacher education programs, MU and PC-MU presents three types of models, worker bee, Hummingbird moth, collector caterpillars, and PC presents a spider. At MU, teacher education programs play a role of a sieve as a catalyst to show	• Identity formation and development for preservice teachers: • Habitus: Individual's reality, constructed of second-nature behaviors and thought in accordance with their environment. • Stories: stories from family,		Graphic novel

Continued

Table 1 continued

Authors	Year	Methods	Findings	Formation	Characteristics	Representation
		preservice teachers(34 enrolled at MU/ 21 enrolled at PC), graphic novel as an elicitation tool from 3 preservice teachers (1 elementary and 2 secondary school teachers)	a reality, practicality, and morality for teaching profession to preservice teachers to be a teacher. As a result, many preservice teachers remain to be a teacher. At PC, teacher education programs emphasize ideology so that it may prepare a few preservice teachers left to be a teacher.	friends and other people and stories from the popular culture. • The apprenticeship of observation: thoughts about teaching based on what leaned from past academic experience • Teacher preparation programs		
Chan	2005	Questionnaire with 106 practicing teachers	• Three motivation factors to teach were identified: intrinsic/Altruistic, followed by Extrinsic/Job condition and Influence from others. • Four commitment factors to teach were identified: Teaching as a career choice; students' learning and school development; ;teacher - pupils interaction and attitudes; demands on teaching and school practices.	• Motivation • Commitment		
Chedzoy & Burden	2007	Questionnaire (Pre-Post test during a course) With 89 preservice elementary dance teachers	• The study found that self-identity influenced and predicted preservice teachers' intention to teach dance: there is a strong relationship between self-identity, self-efficacy, and attitude towards the behavior; • Dance course had an impact on preservice teachers' intention to teach dance.	• Relation between planned behavior and TI • Behavioral beliefs, attitudes towards teaching dance, normative beliefs, control beliefs, self-efficacy, and self identity.	Dance	
Cheung	2008	Questionnaire, 170 practicing teachers (80 pilot/ 90 main)	• Developed the 19 item-questionnaire for professional teacher Identity of Hong Kong Practicing Teachers.	• Student needs/ school issues/ personal growth	Hong Kong	
Choi	2007	Dissertation, Qualitative 3 non-native English speaking teachers(TA)	• Non-native English speaking teachers' English competency was related to their professional identity. • Their identity was formed by their own life history, linguistic and cultural background, personality, and classroom context..	• Life history, linguistic, and cultural background, personality, classroom context	ESL	Discourses in classrooms and society Thoughts and Belief system

Continued

Table 1 continued

Authors	Year	Methods	Findings	Formation	Characteristics	Representation
			• Their identity interacted with discourses in classrooms and society. • Their identity affected their thought and belief systems.			
Cohen	2008	Interdisciplinary framework Discourse Analysis with 3 practicing teachers	• Teaching profession change affects teacher professional identity. • In identity talk, teachers revealed that they posed themselves in relationship with others and institutions and negotiated their professional roles, e.g., knowledge producers (than delivers), collaborators (than isolated roles), and agents of changes in discourse.	• Narrative-Identity Talk: language is a key resource in teacher identity construction. • How to use specific discourse strategies: reported speech, mimicked speech, pronoun shifts, oppositional portraits, and juxtaposition of explicit claims		Language is a cultural practice.
Cohen	2001	Dissertation: In-depth case study (6-year longitudinal study): During student-teaching, mentoring meeting, observation(Field notes), interviews, reflective writings from 4 preservice art teachers/ After graduation, questionnaire, observation, documents, E-mail, interviews teachers	• The beginning art teachers constitute their identity as a teacher by shaping beliefs and practices in the school contexts. • They sought to be a meaningful art teacher through using their diverse practice. • Different conflicts between their role given or expected from others and their teaching identities based on their belief and teaching practice are negotiated with their realities and contexts	• Art teacher, 6 years, track.. Challenges..		
Dale	1999	Dissertation: In-depth biographical interviews with 4 practicing elementary teachers	• Teachers have formed their identity since adolescence by recognizing their real imagoes represented in ideological settings. • Teachers' identity is developmental to organize and integrate their life pieces through a lifespan. • Teacher Identity influences and reflects on	• Adults' identity development: • Narrative tones • Imagery • Theme • Ideological setting • Character		Narrative tone influences teacher development of identity, attitude, and

Continued

Table 1 continued

Authors	Year	Methods	Findings	Formation	Characteristics	Representation
			classroom pedagogy and educational philosophy.	• Imago • Generativity		approach toward teacher roles.
Day, Elliot, & Kington	2005	In-depth interviews, field notes, and documents 20 practicing teachers in England and Australia	• The characteristics and factors of commitment were identified as four categories, personal, school contextual, system contextual, and professional factors..	• Commitments	England Australia	
Day, Kington, Stobart, & Sammons	2006	Literature, Established survey data(N=300 teachers)	• Identities are neither intrinsically stable nor non-stable. • Teachers' life, career, and situation make a different status of identities.	• Social structure and individual agency • Cognitive identity and emotional identity		
Day, Flores, & Viana	2007	Questionnaire with 240 practicing teachers; Focus group interview	• The national politics influenced negatively on teachers' sense of professionalism by bureaucracy, change of expectations of professionals, a lack of ownership and understanding of changes; school leadership on the motivation, commitment and quality of teacher works. • importance of continuing learning • Collaborative cultures, the relevance of project-oriented work at school and an integrated perspective of the curriculum and a broad understanding of schools' and teachers' work are positive influence on their professionalism.	• Policy change • professionalism	Portugal England	
de Fretias	2008	Action research projects (Discourse analysis from classroom observations, auto-ethnography essay writing) by 12 preservice mathematics teachers	• The discourse analysis assignment showed the power relations within the classroom. • The auto-ethnographic assignment presented emotional reflection on their commitment and identity in becoming a mathematics teacher.	• Discourse • Critical pedagogy: Diversity and social justice • School mathematics experiences	Mathematics Social justice	Narrative

Continued

Table 1 continued

Authors	Year	Methods	Findings	Formation	Characteristics	Representation
Dust	2006	M.Ed. dissertation: Multiple case studies: Interviews with 6 practicing secondary music teachers	• A well-developed music teacher identity is based on a) expert knowledge of music and the instrument, (b) musical experience, and (c) recognition and validity from others. • Negotiation of between musician and teacher identity is based on creation and maintenance of a well-developed musician identity. • The self concept of musician and teacher formed for music teacher identity. These relationship is a mutually beneficial to reinforce and support each other.	• Expert knowledge of music and the instrument; musical experience; and recognition and validity from others	Music	
Etheridge	2005	M.A. dissertation: Qualitative: Observation and discussion about drawing or writing activities; Activities (Among 4 activities, participants chose 3 activities: Drawing or writing about school memories; written description about the third person in a specific memory when participants were students; drawing a former teacher; written description about a photograph related to academic past.; 3 practicing secondary teachers	• The image-based and text-based memories are used in constructing an identity. • There is a connection in between memories and teaching practice: memories and reflections as sources for understanding teacher identity. • In construction of teacher identity, four emergent themes are identified: • Teacher as nurturer, teaching as a performance, the physical appearance of a teacher, and • subject matter	• Teacher as nurturer: Teacher identity includes a sense of approachability, caring, and compassion. • Teaching as a performance: Teacher identity is associated with performance and teaching practice. • The physical appearance of a teacher: Teachers' body type, facial expression, and clothing show teachers' power, control for students, professionalism, personality, and respects from students as pedagogical strategies and role models for students. • Subject matter: Subject matter is important for teachers in becoming a teacher but it is not enough to embrace and provide morals and values for students' growth.		Image Text

Continued

Table 1 continued

Authors	Year	Methods	Findings	Formation	Characteristics	Representation
Flores & Day	2006	Semi-structured interviews with 14 new teachers; Questionnaire from 627 school staffs(18 schools); writing essay from 891 students;	• Highlighted the powerful interaction between personal histories and the contextual influences of the workplace. • Identities were deconstructed and (re)constructed over time according to the relative strength of the key influencing contexts of biography, preservice programs and school culture.	• Pre-teaching Identity: Image, implicit theory • Past Influences: Personal biography, initial teacher training, teaching practice • Contexts of teaching: Classroom practice, school culture, leadership • Reshaped identity: Conservatism vs. proactivism.		
Gohier, Ghevrier, & Anadon	2007	Questionnaire with 405 students (Marcia et al, 1993); Semi-structured interview with 76 Preservice elementary teachers(Assigned for each 6 status groups),	• Preservice teachers represented dynamically and empathically both current and future professional teachers by Marcia's identity status.	• Current Identity vs. Future Identity. • Marcia's Identity Status		
Goos & Bennison	2008	Qualitative: Online discussion board; e-mail interviews; 19 Preservice and beginning teachers	• Based on Wenger's theory, during a preservice to the first year teaching, they emerged their community practice by establishing their professional goals and values through online community.	• Mathematics teachers • Socialization	Online communica-tions	
Hale	2005	Dissertation: In-depth interviews and documents with 6 beginning teachers	• Teachers' understanding of the multiple complexities of teaching deepen within the first years of teaching; teaching is emotional work; and the context of teaching heavilty influences teachers' practice of teaching regardless of their beliefs about teaching. • There is little change in personal belief and values since beginning teaching. The half of participants shared their practice aligned with their identity belief, and values.	• Teacher identity construction: Personal belief, attitudes, and emotion		

Continued

Table 1 continued

Authors	Year	Methods	Findings	Formation	Characteristics	Representation
Hallman	2007	E-portfolios and interviews from 2 preservice ESL teachers	• Preservice teachers negotiated to present either competent beginning teachers or inquisitive college students and introduce their Identity based on context, self, and text through e-portfolios	• Context • Self • Text	ESL Electronic portfolio	E-portfolio is a important tool to talk about teacher identity.
Hand	2007	Dissertation: Qualitative: In-depth interview 12 beginning physical education teachers and 4 mentors	• The induction of beginning teachers is compromised of beginning teacher identity, learning your role and responsibilities, the uniqueness of becoming a physical education teacher, and sources of teaching efficacy. • The beginning teacher identity included personal attributes and teaching behaviors. • Comparison to preservice teachers' experiences and self-presentation concerns how to present self to others in school with expectation from others also influenced to their construction of teacher identity. • Mentoring is compromised of role of a mentor who provides emotional and information support and mentoring effectiveness included mentors' content area, time availability, and training .	• Teacher identity, efficacy, and mentoring • Teacher identity: personal attributes and teaching behavior • Personal attributes: a disciplinary teacher; respected and fair teacher; a fun motivator; and a relationship builder. • Teaching behavior: disciplinary, active, reflective, and adaptable behaviors. • Learning your teaching role and responsibilities: previous teaching, job training, and mentor/supervisor assistance. • Uniqueness of a beginning teachers: school culture and school environment. • Teaching efficacy: Mastery experiences, verbal encouragement, physical demands, and modeling.		
Hung	2008	Qualitative study: Classroom observations, portfolios, Online writings from 10 preservice ESL teachers	• Online reflective practice enables preservice teachers to construct their teacher identity. • Teacher learning is considered as a process of identity construction.	• Reflective practice	ESL Online learning community	Online writing

Continued

Table 1 continued

Authors	Year	Methods	Findings	Formation	Characteristics	Representation
Isbell	2008	Questionnaire, 578 preservice music teachers	• Relationship of secondary socialization and occupational Identity are stronger than primary socialization with occupational identity. Experience is more influential to construct occupational identity than people. • The occupational identity of music teachers consists of three constructs: musician identity, self-perceived teacher identity, teacher identity from others.	• Primary and secondary socialization: Primary socialization influential people: parents, school music teachers, private lesson instructors,	Music	
Isbell	2006	Dissertation: questionnaire with 578 preservice music teachers	• The occupational identity of preservice music teachers has two facets: musician and teacher. • Teacher identity consists of two constructs: self-perceived identity and the perception of identity from others. • Self-perceived teacher identity is the predictor of career confidence in music teaching. • Teachers' concerns are self/task and task/impact. • Commitment to their subject area, music is prior to a decision to be a teacher.	• Individual difference of occupational identity factors: • No impact: gender, major applied area, • Significant impact: Musician and teacher role models, year in school, field experience		
Jarvis-Selinger	2002	Dissertation: Survey, interviews, with 23 preservice secondary teachers	• The analysis of the Teaching perspectives inventory (TPI) survey that investigates transmission, apprenticeship, developmental, and nurturing and social reform perspectives in teaching showed a shift of their perspectives that potentially shows change of teacher identities during teacher education program. • Through interview, teacher identity and commitment level of preservice teachers are categorized as four levels so that it classified four groups of them (low commit-TI, low commit-high TI, high commit-low TI, and high commit-TI). After teacher education, the level of commitment	• Categorization of the level of TI and commitment • Challenges in becoming a teacher: structural, professional, and role. • Structural challenge: related to teacher education programs or classroom settings • Professional challenge: related to duties in their profession (e.g., discipline, classroom management, and the politics of the profession).		

Continued

39

Table 1 continued

Authors	Year	Methods	Findings	Formation	Characteristics	Representation
			and teacher identity of each four groups is changed: low commit-TI moved mostly low-commit and high TI; high commit-low TI and low commit-high TI moved diverse groups. high commit-TI is reinforced. • There are 3 challenges in becoming a teacher: structural, professional, and role challenges. The beginning teacher identity of preservice teachers has differentiated their challenges. Preservice teacher having a low-teacher identity mostly mentioned structural challenges.	• Role challenge: related to their roles, a teacher role or a student role.		
Johnson	2003	A self-reflection study through mentoring with a preservice ESL teacher	• Mentoring experience come up with several critical reflection issues provides both a mentor and student to grow their identity. • A non-native speaker, preservice ESL teacher's self-confidence comes from not only fluency of language expertise. • Personal and religious values influence on teacher identity. • Narrative sharing of teachers' experiences is important to develop preservice teachers' professions.	• Mentoring • Experiences: Preposition(Language expertise), Mentoring(pair works), and religious requests(prayer time),		
Jones-Walker	2008	Dissertation: Ethnographic study: Documents, observation and interviews with 2 practicing mathematics teachers(focal participants) and 6 practicing teachers belonged to a study group; 2 focal groups with each 5 students	• Teachers' biographies shaped their belief systems that interacted with teacher identity and teaching practice. • Teacher identities are critical in teaching and learning process so that it may influence to implement pedagogical practice..	• Teacher identity, • Belief, Action • Biography • Classroom practices(Goals) • Context	Mathematics	

Continued

Table 1 continued

Authors	Year	Methods	Findings	Formation	Characteristics	Representation
Larson	2006	Dissertation: Qualitative(Poststructural Feminism research): Documents including course materials, teachers' notes, field placement, e-mail, journals, action research papers, and work samples; Focus group; Observations; Interviews with 30 preservice literacy teachers	• Discourse Preservice literacy teachers identified discourse as a way of representing their teacher identity and a process of developing it. • Their teacher identity development is a complex and continued process transformed by several factors: literacy experiences, discourse with experts, teaching opportunities and so on.	• Factors of preservice literacy teacher identity development are identified: • Authentic, meaningful experiences with Literacy • Time with "experts" reading, writing and dialoguing • Opportunities to negotiate and teach authentic, meaningful literacy • Opportunities to deconstruct personal literacy experiences, what one learned from the experts, and literacy teaching experience with others • Opportunities to reconstruct based upon deconstruction with others		
Lasky	2005	Questionnaire from 59 practicing teachers; Interviews with 4 practicing teachers; Documents	• A social and political context, e.g., reform policy of states, school culture, as a mediational system to influence a teacher identity. • The purpose of teaching profession is to teach curriculum and academic skills and the whole child in order to help students' social and emotional developments • Professional vulnerability includes emotional and risk-taking aspects based on interaction and relationship with students. • Conflicts or pressure to implement new reformed curriculum between teacher identity and policies influence their role of an agency to move their professions.	• Identity, • Agency, • Vulnerability including emotion, risk, and openness • Rapport relation • Social and political context. • Reform context,	Canada Educational reform(Secondary school reform)	

Continued

Table 1 continued

Authors	Year	Methods	Findings	Formation	Characteristics	Representation
Levitt	2007	Dissertation: Qualitative Observations, documents, interviews with 16 practicing secondary teachers	• Teachers represented their teacher identity through narration about how they become a teacher, what teachers they want to be and what goals and hopes they have for future in relation with students and school contexts. • The changes of their identity have been processed over the course of their whole career. • Identity development or change patterns were not clearly identified.			Narrative
Malderez, Hobson, Tracey, & Kerr	2007	Longitudinal research: In-depth interviews with 85 preservice teachers; self-completion questionnaires(N=4790)	• There is a relationship between teacher identity, the role of relationships, the notion of relevance and the central presence of emotion	• Teacher identity, the role of relationships, the notion of relevance and the central presence of emotion.	U.K.	
McCormack, Gore, & Thomas	2006	Semi-structured journals and interviews from 16 beginning teachers	• Early career teachers showed that they had a difficult in developing their teacher identity although they increased their ability and confidence to teach students and manage classroom. • Support, feedback, recognition, praise and perceived values from mentors, supervisors, school staffs, students, and parents are important to develop a their identity • Additional responsibilities, difficult classes and unrealistic teaching • expectations together with lack of status and professional feedback hindered their professional learning.	• Professional learning at early career • Construction of professional knowledge and practice • Development of professional identity	Australia	
McMahon	2003	Dissertation: Qualitative (Phenomenological/Heuristic research): In-depth interviews	• Teachers identified the hardest parts of being a teacher: System, building, workload, emotional labor, student and parent issues, lack of respect as a profession so that it may cause reconsidering or leaving the profession.	• Teacher formation: Teacher identity, teacher integrity(role and soul), vocational clarity(calling to teach). • Discouragement factors:		

Continued

Table 1 continued

Authors	Year	Methods	Findings	Formation	Characteristics	Representation
		with 11 veteran educators	• Teachers found four rewarding of teaching to bring deep satisfaction as a teacher: Love of kids, a passion for pedagogy, watching their students learn, and building community. • Teachers valued teacher formation process to renew their profession through interaction of identity, integrity and calling with their students, colleagues, and school supports. • Teachers shared their in or outside of school experiences to enable them to stay in their profession.	• System, building, workload, emotional labor, student and parent issues, and lack of respect as a profession. • Rewarding of teachers: Love of kids, passion for pedagogy, watching their students learn, and building community. • Staying renewed experiences: renewal experience in schools(e.g., supportive personal and professional relationship, inspirational sharing through journaling, reflections, and poetry, interaction with students in classrooms), renewal experience outside of school,(e.g., deep introspection-reflection, physical activities, creative expression, interpersonal relationship from spouses, children or friends, nature, and travel).		
McNabb	2004	Dissertation: Meta-narrative study (Analysis of history, public discourse and film) Selected political documents: Nation at risk Selected films: Dangerous Minds; Stand and Deliver;	• There are four meta-narratives about teachers in history, public discourse, and film: Teachers are recognized as professional, called to teach, dysfunctional and teaching is an occupation. • In the film, teachers are described as a professional, idealist or dysfunctional teachers. As professional teachers in films, they can become a master teacher who can teach all students and change lives without adequate training or preparation. Also, they are described as empathetic, dedicated, altruistic, perseverant idealist as well as	• Analyzed a lack of authority of TI in film		

Continued

Table 1 continued

Authors	Year	Methods	Findings	Formation	Characteristics	Representation
McNabb	2004	Lean on Me; Dead Poet's Society; Mr. Holland's Opus; Ferris Bueller's Day Off; 187; Finding Forrester	either an entertainer or motivator. In contrast as a dysfunctional teacher, they have no passion, fail to connect with their students, just work for paycheck, deceit people, and abuse power. In addition, their teaching is boring. Teachers are not empowered/ • The meta-narrative undermines teachers to create different sense of their collective identity. It may cause a gap about good teachers in between public discourse and internal definition of identity.			
Miller	2005	Dissertation: Comparative case study: Documents, observations(students and researcher's logs and reflections), semi-structured and unstructured group and individual interviews with 5 preservice secondary language art teachers	• Preservice teachers saw themselves being constructed through their own critique of teacher practices or beliefs of either cooperating teacher, veteran teachers or administrators. • Also, they saw other aspects of their identity that others appreciated them as a teacher or what they desired as a teacher. • Preservice language art teachers' identities are defined in emergent themes: meaning, value system, expectation about the profession, communities of learning that apprentice teacher, and policy, research, its interpretation, and its impact on communities of learning.	• Space-time web of teacher identity: program expectations, federal expectations and laws, state expectations, standards, mission statements, curriculum, research and its interpretation, school sites, social groups, prior schooling, socio-political issues, instructors/teachers, media, parents, students, clinical supervisors, cooperating teachers, communities of faith, and cohort.		
Musanti	2005	Dissertation: Observations, participants' written documents, interviews and project documents from 14 practicing ESL teachers	• Resistance against new changes by professional development showed the complex articulation of teachers' knowledge construction, identity development and changes in practice. • Teachers' knowledge developed through collaboration and peer conversations. • Personal history, desire, and ways of knowing contributed to teacher identity. • Collaboration has a positive impact on teachers' identity increasing confidence in their knowledge and teaching skills.	• Professional Development program: collaboration (Team teaching) and introduction to new theory and practice • Knowledge: General pedagogical knowledge, knowledge of students, knowledge of self. • Teacher identity: Personal history, desire, and ways of knowing	ESL	Narrative

Continued

Table 1 continued

Authors	Year	Methods	Findings	Formation	Characteristics	Representation
			• The change of teaching practice was supported by relationship with others and reflection on their teaching.	• Practice		
Newman	1997	Dissertation: Case studies: Interviews with 5 preservice teachers and 1 professor	• Professional teacher identity of preservice teachers is strengthened and clarified through self-as-student and self-as-teacher voice. • Professional teacher identity was built on self-as-teacher consisting preservice teachers' history of academic success and marginalization and then, formed by self-as-teacher based on teaching platforms, professional concerns, dream and goal language, dream and goal organization, and dream and goal revision. • Preservice teachers (1) Carried their academic success into their teaching practice, (2) Implied coherent teaching platforms, (3) Began to take charge of their professional development, (4) Used their experience with marginalization to shape their dreams and goals, (5) Mentioned goals more frequently than dreams, (6) Organized their dreams and goals in ways to facilitate accomplishment, and (7) Backgrounded/Foregrounded reassessed, and refined their dreams and goals.	• Professional teacher identity: • Self-as-student and self-as-teacher • Self-as-student: academic success and marginalization • Self-as-teacher: teaching platforms, professional concerns, dream and goal language, dream and goal organization, and dream and goal revision.		
Nguyen	2004	Case studies : Interviews, written reflections, meeting, seminar, group meeting with five preservice teacher who are Vietnamese Americans	• Socialization into communities and profession had impact on five teachers' development of a cultural model of teacher and teaching and on their personal professional growth • Cultural frame drives five teachers to perceive teaching as a moral enterprise and teachers as moral agent. • Their minority status exacerbated their chance of becoming teacher in U.S.	• Socialization • Culture • Minority		

Continued

Table 1 continued

Authors	Year	Methods	Findings	Formation	Characteristics	Representation
Nguyen	2008	Case study: Interviews, written reflections, meeting, seminar, group meeting with five preservice teacher who are Vietnamese Americans	• As same above	• Socialization	ESL	
O'Connor	2008	Interpretive study, 3 secondary teachers	• Teachers' caring behavior represents professional, performative, and philosophical dimensions of performing a professional identity.	• Emotional experiences		
Osborn	2008	Review of case studies	• Reform movement has impacts on teachers' professional identity by challenging classroom practice.	• Reform movement		
Poole	2002	Dissertation: Observations, interviews, pupil interactions, mini-conference, researcher journal, academic works, committee memos, and peer debrief notes with 3 preservice teachers	• Three physical, professional and personal spaces are coordinated, connected and integrated to develop a teacher identity in order to see outside of self, reality. • Teacher's voice is an internal and personal expression to define a self. Through it, preservice teachers are participated in the process of becoming teachers. • Networking to be connected and connect is an action to promote the development of a teaching self. • Pupil voice is a mean to promote preservice teachers' learning through teaching practice. It is a bride of networking with internal an external components of teacher identity development. • In a sustainable ecology of learning to teach, four components of teacher identity development were developed and influenced each others at the population, community, and ecosystem level.	• Teacher identity: Space, voice, networking, and pupil voice • Space: Physical, professional, and personal • Voice • Networking: • Pupil voice		

Continued

Table 1 continued

Authors	Year	Methods	Findings	Formation	Characteristics	Representation
Poulou	2007	Journals from 59 preservice elementary teachers	• Preservice teachers' concerns about teaching process and profession and emotions about teaching practice influences on shaping their professional identity. • The teaching process contributes to the awareness of personal identity and professional development. The student-teachers' pattern of concerns are the interplay between self and others; cognition and affection; present, past and future.	• Concern, • Emotion for present and future • Mission,		Writing
Reio	2005	Literature Review from 5 papers published in the journal "teaching and teacher education.'	• Emotions as a Lens to explore teacher identity and change. • Five papers showed emergent four themes: -Teachers' emotional experiences of school reform influence their risk taking and their identity formation. -Reform and change affect teacher learning and development by creating an environment of uncertainty. -Change theory could be a valuable guide to the implementation of reform. -There are individual similarities and differences in the response to change.	• Background • Reform • Emotional experiences • Risk Taking • Learning and Development		
Roberts & Graham	2008	Interview with 32 trainees	• Proactive strategies were identified: tactical compliance, personalizing advice, and seeking out opportunities to exercise control. • Through self-directed development, personal teaching identity is constructed.	• Self-directed development (Exercise to control)		
Sloan	2006	Case studies with 3 practicing elementary teachers: Classroom observation and interviews	• Teacher identities are powerful means to understand their varied experiences with and responses to accountability-explicit curriculum policies. • Current understandings of teacher agency vis-à-vis accountability- explicit curriculum policies as merely a capacity to resist obfuscates important	• Accountability • TI • School life, experiences and life as a teacher • Images, metaphors as a teacher		

Continued

Table 1 continued

Authors	Year	Methods	Findings	Formation	Characteristics	Representation
			issues of teacher quality and equity.			
Song & Wei	2007	Pilot test with 30 practicing secondary teachers Survey research with 177 practicing elementary and secondary teachers	• The33-item questionnaire of TI wad developed using 6 factors(Reliability: .85) • Gender, title of positions, teaching grade level, and salary impacted on difference of TI score.	• Biography, professional cognition, emotion, will, skill, expectation and value	China	
Starr et al.	2003	Qualitative study: Focus group interviews from 35 preceptors	• Preceptors identified 7 elements to contribute an identity as a teacher: feeling intrinsic satisfaction, having knowledge and skills about teaching, belonging to a group of teacher, being a physician means being a teacher, feeling a responsibility to teach medicine, and sharing clinical expertise.	• Feeling intrinsic satisfaction, having knowledge and skills about teaching, belonging to a group of teacher, being a physician means being a teacher, feeling a responsibility to teach medicine, and sharing clinical expertise	Physicians (Preceptors)	
Starr et al.	2006	Mixed methods: Questionnaire with 127 physicians / Focus group interviews with 49 attendees of faculty development program, who participated in a pilot-test of a 32-item questionnaire.	• Developed an instrument of physician teacher identity by adding two themes, desired outcomes and global identity based on their previous study.	Feeling intrinsic satisfaction, having knowledge and skills about teaching, belonging to a group of teacher, being a physician means being a teacher, feeling a responsibility to teach medicine, and sharing clinical expertise; desired outcomes; and global identity	Physicians (Preceptors)	
Sweden-burg	2001	Dissertation: Qualitative: Questionnaire, focus group interviews, in-depth interviews with 6 practicing social study teachers and 1 social study specialist who taught social study	• Teacher professional identity is dynamic, changing throughout the course of a career. • Teacher identity is not fully integrated until much later in the career. • Once teacher identity is firmly established, teachers sustain and maintain it in spite of what others perceive them as low expectation. • Work culture, professional norms, and collegial relationships are influencing teacher identity.	• Factors to sustain and maintain teacher identity: influence of significant others, perception of the work environment and degree of control over institutional constraints, opportunities for creativity and self-satisfaction	Social study	

Continued

Table 1 continued

Authors	Year	Methods	Findings	Formation	Characteristics	Representation
		before.				
Taylor	2008	Dissertation: Mixed methods: Questionnaire with 89 practicing teachers and 7 retired teachers(total 135 female)	• The impact of the No Child Left Behind on teacher identity was not supported by results. • Teacher identity is intact under mandate of NCLB. • Teachers stated that teaching is rewarding job.	• Survey includes three dimensions: professional identity (1-15), personal belief (1-9), and professional behavior (10-15)	Survey	
ten Dam & Blom	2006	Socio-cultural theory; retrospective analysis; Documents and group interviews from 5 preservice teachers; questionnaire from 12 tutors, mentors, and staffs	• Through school-based teacher education, social and cultural practice is a stimulating context for preservice teachers to develop a professional identity.	• Teacher education program • Learning		
Terwilliger	2006	Dissertation: Case study (Post-structural Feminist) : Individual and group interviews with 3 practicing elementary teachers, interviews with administrators and professional development committee, documents, policy documents and reports	• Discourse of educational policy under standard movement guided what professionalism is needed, the obscuty of discussion rooted in masculinity made an ambiguity and tension for female teacher to accept teacher identity and to control and standardize their teaching. Also, community and parents are barrier to them to establish their teacher identity.	• Standard movement • Race, gender, and class		
Tigchelaara, Brouwerb, & Korthagen	2008	Semi-structured interviews and questionnaire with 6 supervisors Semi-structured biographical interviews	• 5 types of career changers enrolled in ACP are identified. • In career changers' transition to teach, five factors are identified: Complexity and workload, dealing with groups of adolescents, sharing subject matter expertise, autonomy and team work and long-	• Six levels of the onion model: environment, behavior, competencies, beliefs, professional identity and mission.	Netherlands Alternative certification programs of teachers (ACP)	

Continued

Table 1 continued

Authors	Year	Methods	Findings	Formation	Characteristics	Representation
		and in-depth interviews with 8 second career changers(ACP preservice teachers)	standing aspirations. In particular, autonomy and team work had an impact to change the level of identity.			
Travers	2000	Dissertation: Qualitative (Self-study): Class sessions, class assignments, presentations, projects, e-mail, journals, and interviews with 5 preservice elementary teachers	• Preservice teachers experienced the moment of change in becoming a teacher which is a transition from students to teachers during teacher preparation program. • Their initial teacher identity has been changed or transformed before and after a teacher education program course. • "Learning process to teach" included concept, knowledge, values, beliefs, experience, teacher education and social context. • Teacher identity consists of three conceptual domains: Self in relation to others, self in relation to knowledge and self in relation to the teaching profession.	• Conceptual domains of teacher identity: self in relation to others, self in relation to knowledge and self in relation to the teaching profession. -self in relation to others: relationship with students -self in relation to knowledge: subject matter knowledge (the most important to science secondary teachers), pedagogical content knowledge -self in relation to the teaching profession: professional development • Literature review: prior knowledge and experience, personal beliefs and values, subject matter, teaching experiences, professional commitment, and future goals of preservice teachers		
Tsui	2007	A Chinese English Teacher	• Identity Formation includes identification and negotiation of meaning and institutional and personal reconstruction of identity.	• Membership, competence, legitimacy of access to practice, appropriation and ownership, centrality of participation and mediating role of power relationship.	EFL	Narrative

Continued

Table 1 continued

Authors	Year	Methods	Findings	Formation	Characteristics	Representation
Urzua & Vasquez	2008	Observation and transcripts from mentoring and supervisory meeting of two cases (two teachers and one supervisors; one teachers and two supervisors)	• During mentoring, preservice teachers represented their plan, outcomes, and possibilities, and reflected on evolving pedagogical practice so that it may influence teacher identity.	• Mentoring meeting • Reflective thinking.	ESL	Future-oriented talk produced a discursive space for preservice teachers to construct a teacher identity.
van Veen, Sleegers, & vad de Ven	2005	Case study: Semi-structured interviews form an practicing teacher	• By conflicts between situational demands and cognitive affective process, a teacher's negative emotions e.g. anxiety, anger, guilty, and shame reduced a positive emotion e.g., enthusiasm to implement reformed curriculum. • This emotional changes influenced on concerns and professional identity of a teacher.	• Emotion • Reform context	Netherlands Reform	
Varghese, Morgan, Johnston, & Johnson	2005	3 data-based studies	• Theorized a language teacher identity from three perspectives, social identity theory, situated learning, and concept of the image-text.	• Theoretical frameworks: social identity; situated learning, and concept of the image-text		
Williams	2007	Dissertation: Qualitative(Phenomenological study): Phenomenological interviews and journals from 6 preservice secondary mathematics teachers Pilot study: Qualitative(Phenomenological study): Interview, survey and journals from 1	• Through pilot study, positive mentoring experience is useful for preservice teachers to prepare to be effective in an urban context and for urban learners. • The construction of identity is a process that changes in experiences and discourses. • Academic success, hopes for classrooms and students, relationship, group membership, characteristics, and experiences are influential for professional identity. • Student teaching provided progression in continual stages of identity development and ideologies about classroom management and pedagogy. • Through student teaching, preservice teachers had	• Academic success, hopes for classrooms and students, relationship, group membership, characteristics, experiences, student teaching	Mathematics Urban teaching	

Continued

Table 1 continued

Authors	Year	Methods	Findings	Formation	Characteristics	Representation
		preservice teachers and 2 cooperating teachers Georgia State University United States- Georgia	opportunities to decide pedagogy, develop skills of classroom management, and discover anxiety. • Preservice teachers' urban teaching can be affected by several factors: a)mentoring versus lack of mentoring; b) individual versus collective behaviors; relating to characteristics of an urban teacher; d) to stay or not to stay in urban schools; e)influencing factors; f) anxieties; g)classroom management and h) pedagogical style.			
Zembylas	2005	Ethnography study: In-depth interviews, observation(field notes and video tapes), documents, study with a teacher	• Teacher identity is constituted in emotion in their teaching context.	• Emotion, culture, relations, and ideology		

Science Teacher Identity

Before 1998, little research on science teacher identity had been published. Building on two articles, "Creating Professional Identity: Dilemmas and metaphors of a First-year chemistry teacher" (Volkmann & Anderson, 1998) and "Science and me" (Helms, 1998), a number of studies in relation to science teacher identity have emerged from 1998-2008. Table 2 shows a summary of 25 recent studies on science teacher identity, alphabetically ordered by the authors' last names. The columns of Table 2 present the author, publication year, participants, methods, theoretical frameworks of Science Teacher Identity [STI], and findings of each study. As can be seen in Table 2, only two studies were not empirical studies that reviewed or examined documents. The other studies were empirical and qualitative studies except for two mixed methodological studies. Most studies have sought an in-depth understanding of the formation or development of science teacher identity. Data sources were descriptive interviews, observations, questionnaires, journals, and academic artifacts, while mixed methodology studies included survey data. As small-scale studies, the number of participants was ranged from one to 47. Nine studies were conducted with practicing secondary science teachers, four studies with preservice secondary science teachers, three studies conducted with practicing elementary science teachers, and three studies conducted with preservice elementary science teachers. Additionally, one study was conducted with all type of participants, one with a college lecturer, and two studies were conducted with preservice students who were not identified by teaching grade level. Therefore, three research trends of science teacher identity and four characteristics of science teacher identity are identified. These research trends are specifically:

- Science teacher identity is not explicitly defined.
- There is no model to explain the construction of science teacher identity.
- No instrument, scale, or measure of science teacher identity had yet been developed.

Even though 25 studies have been published, "science teacher identity" is not yet explicitly defined. Several different perspectives on teacher identity have been used as a theoretical framework so that a consensus conception of science teacher identity has not been reached. The representative theoretical frameworks mostly used to conceptualize identity have been socio-cultural perspectives: "communities of practice" proposed by Wenger (1998), "Identity and agency in cultural world" by Holland et al., (1998), and "four types of Identity" proposed by Gee (2001). Based on Wenger's perspective, Enyedy et al.(2006), Friendrichsen et al. (2008), Henderson & Bradey (2008), Melville & Wallace (2007), and Moore (2008a) assume that identity is the nexus of multi-level membership shaped and developed by the practice of community. They attempted to understand the "identity of science teachers" as developed in community of science teachers, science teacher education institutions, classrooms, or by teaching practice. Also, these studies argue that identity is an individual and social process of experiencing, doing, belonging, and learning to become a teacher in the context of communities. Additionally, Moore (2008a, 2008b) and Creighton (2007) emphasize the importance of cultural contexts discussed by Holland et al. (1998). Goldberg & Muir (2006), House & Wenzel (2005), Luehmann (2008), Moore (2008a), and Varelas et al.(2005) have been influenced by Gee's (2001) conceptions of the four types of identity: Identity socially and culturally constructed by nature (N), institutions (I), discourse (D), and affinity groups

(A). In this perspective, social contexts are emphasized in the construction of science teacher identity, e.g., not only classrooms, schools, and institutions, but also relationships with students, colleagues, the discipline, and administrators.

Another theoretical framework is the "poststructural perspective, including feminist and critical theory." According to this perspective, a positional identity classified by race, ethnicity, gender, culture, and socioeconomic background is used to view the identity of science teachers (Jita, 1999; Moore, 2008a, 2008b; Ramseur, 2004; Sowell, 2004). These studies point out how the gender, race, culture, and socioeconomic class of science teachers could be hindrances toward becoming a science teacher, and how this impacts teaching science. Most research found that the positional identity of science teachers has influenced them to transform multicultural pedagogy or to reform science teaching practices. For example, Jita (1999) observed that the positional identity of three African American science teachers is critical to shape their transformative pedagogy. Moore (2008b) stressed that elementary science teachers can develop their identity as an agent of change having the power to improve social justice in urban classrooms.

Among diverse conceptual approaches toward identity, a few studies have tried to define an "identity" of teachers. Helms (1998) defined "a sense of self, that is, identity" as the experienced self in a context of the interaction of four dimensions of self, actions, others' expectations, values and beliefs, and a future self. Helms's work is the first noteworthy attempt to define an identity of science teachers. However, although she emphasized the role of subject matter to shape science teacher identity in her research findings, her definition doesn't include an influential relationship between subject matter and science teacher identity. Beckford-Smart (2006) and Enyedy et al.(2006)

conceptualized "identity" as a sense of self, knowledge, beliefs, dispositions, interests, and orientation toward work and change. In particular, Enyedy et al. (2006) included more psychological and sociological components, a teacher's institutional relationship to his/her students, the classroom community, the discipline, representatives of the school administration, and institutional relationships in the conception of "identity." They are likely not to give a definition of science teacher identity but rather a conceptualization of identity of teachers. Their conceptualization of "teacher identity" shows how psychological and sociological aspects of "identity" are situated and contextualized. Also, Creighton (2007) used similar approaches to conceptualize an identity in which personal aspects and social aspects of identity are interwoven. She viewed identity as informed by both the self and the social, historical, and cultural world. Luehmann (2008) defined teacher professional identity as being recognized by the self or others as a certain kind of teacher based on Gee's definition (2001). She argued that an identity as science teacher is developed by understanding, interpretation, and recognition by the self and others as a certain kind of science teacher. Forbes and Davis (2008) defined "curricular role identity" as those dimensions of an individual's professional teaching identity that are concerned with the use of curriculum materials and suggest this construct is a useful tool to better understand preservice and practicing teachers' use of science curriculum materials. Their definition focused on elementary teachers' identity, particularly what role elementary teachers have when starting to teach using curriculum materials. Their definition is limited to this specific context and situation, however. In spite of the lack of consensus to define science teacher identity, these studies have contributed to conceptualizing the "identity" of science teachers in this study.

There are no models to explain the construction of science teacher identity among preservice and practicing science teachers. There were only two "models of identity" proposed by Helms (1998) and Creighton (2007). These two models mainly explained the conception of teacher identity rather than science teacher identity. Helms's model was a conclusive framework proposed through her study's findings, which focused on practicing secondary science teachers; meanwhile, Creighton's model was a theoretical framework proposed to guide her research, which used preservice elementary science teachers. These two conceptual models are contrastive and complementary in understanding the science teacher identity of preservice teachers compared with practicing science teachers, and elementary compared with secondary science teachers.

Helms (1998) generated "a model of identity" consisting of four major dimensions: (a) actions; (b) institutional, cultural, and social expectations or what people think others expect; (c) values and beliefs; and (d) where people see themselves going or the kind of people they want to become. As can be seen in Figure 2, in addition to these four dimensions, this model includes experience, culture, and society as contextual factors despite the lack of explanation of these. As her model was conclusively proposed as a practical framework at the end of her article, what she found in her observations of five secondary science teachers was discussed in her model. However, she excluded her notable finding that subject matter is a part of self-sensing as a teacher in this conceptual model. Because she believed that subject matter is not a final determinant of teacher identity, she didn't pose "subject matter" as a factor of teachers' sense of self in this model. She mentioned the effect of subject matter or discipline that could have a relation to influence on other dimensions, such as what kind of person a given teacher is or wants

to be. As she noted, this model is not about "science teachers' sense of self" but "teachers' sense of self," and she suggested that her inductive framework could contribute to a better understanding of teacher identity more than any particular interest in subject matter.

Although this first model of identity is significant to understand teacher identity in the context of science teaching, there are limitations to implicate her model directly for science teachers, to develop science teacher identity. Otherwise, Creighton's proposed model is more straightforward to explain science teacher identity than Helms's model (1998). Adapting the double helix model of DNA from Watson and Crick, Creighton (2007) proposed a social and self double helix model of identity. She conceptualized four steps as four bases to connect the social and the self helix: (a) activities/practices; (b) experiences; (c) sense of self; and (d) the future self, or the kind of person one wants to become. Using this conceptual model, she applied these conceptions for a subject specific identity, science identity. Four bases of a science identity that connect the science self and science identity in the social practice helix involve (a) activities/practices of science and science teaching; (b) science experiences; (c) sense of self as a science person, as one's values, beliefs, desires, motivations, and self-identifications with science; and (d) future science teacher self, or the kind of science teacher one wants to become. In spite of this distinguishable conceptualization of identity, she didn't provide a copious explanation of what science self and science identity in social practice are in terms of science teacher identity, and how the four bases connect between these double helix. In addition to this lack of conceptualization of science identity, her findings offered limited

evidence to validate this model because of a constraint in generalization of small-scale data and a lack of interest in science of participants who are elementary teachers.

Likewise, their conceptual models are important to better understanding of the construct of science teacher identity despite several limitations of applying the model of teacher identity to science teacher identity. While still embracing Helms and Creighton's great work, a more comprehensive model of science teacher identity is urgently needed to understand the science teacher identity of all-preservice and practicing science teachers, and that of elementary and secondary science teachers.

No instrument, scale, or measure of science teacher identity had yet been developed. Most studies were a small-scale and in-depth qualitative research to describe what happens or what can be seen using ethnography, case studies, or phenomenology because many researchers believed that the construct, 'science teacher identity' is a psychological and sociological construct that is not easily measured by an instrument, scale, or measure. In addition, most studies have a tendency to assume that science teacher identity could be constructed throughout narratives. Most data sources were written and verbal narrations including interviews, journals, reflections, and field notes. As a result, a narrative and deep understanding of science teacher identity has been achieved, but few generalizations of findings have been qualified to be transferred to other contexts or other groups. Therefore, a more complementary perspective to explore different aspects of science teacher identity is necessary. Based on the characteristics of science teacher identity observed in previous research, a newly developed instrument could provide the potential for measuring the level of science teacher identity. Likewise, this study could replenish these limitations of qualitative research by involving a large

scale of participants and using the interpretation of numerical data so that research on the construction of science teacher identity may be applied to broader and more extensive contexts and participants.

The major findings on science teacher identity are as follows:

- Science is pivotal in constructing science teacher identity.
- Several personal, institutional, and administrative influences are identified as factors to influence the construction of science teacher identity.
- Science teacher identity matters for all science teachers, both preservice and practicing science teachers and both elementary and secondary science teachers.
- Science teacher identity could be very tightly associated with the teaching practice of science.

Science is pivotal in constructing science teacher identity. In the beginning of their studies about science teacher identity, Volkmann and Anderson (1998) and Helms (1998) found that science plays a pivotal role in self-sensing and constructing science teacher identity. Volkmann and Anderson (1998) emphasized the importance of science as content and pedagogical content knowledge by showing that a lack of science subject knowledge was a threat for a preservice science teacher to have a professional identity. Helms (1998) specifically researched the relationship between science and the identity of practicing science teachers by seeking answers about how science contributes to how people define themselves or see themselves as scientists or science teachers. Many subsequent studies have achieved results corresponding to results of both of these early

studies (1998) (Creighton, 2007; Jita, 1999; Kozoll & Osborne, 2004; Enyedy et al., 2006; Eick & Reed, 2002; Forbes & Davis, 2008; Melville & Wallace, 2007; Varleas, House & Wenzel, 2005). For instance, Eick and Reed (2002) stressed that how preservice science teachers experienced science before starting to teach science is related to how they construct a science teacher role identity. They emphasized the relationship of teaching practice to preservice science teachers' experiences through learning and doing science. Kozoll and Osborne (2004) showed that science is deeply linked to identity, and self, and varies between college students who majored in science education and those who did not major in relevant areas to science. Their findings reinforced Helms's suggestion (1998) that science is a way to view others and understand the world. Varleas et al. (2005) distinguished differences between science as practice and as community practice, influencing the negotiation between the scientist and science teacher identity of preservice science teachers. They characterized that science teachers recognized science as a fact rather than a process and as a public rather than private meaning. Enyedy et al. (2006) asserted that understanding of science content knowledge is essential to develop the pedagogical content knowledge as part of the construction of teacher identity. Melville and Wallace (2007) revealed the same conclusion on subject matter knowledge: those non-educated science teachers without subject matter knowledge struggled to build attitudes, values, identity, and practices toward science teaching, as did Volkmann and Anderson's study (1998). Creighton (2007) and Forbes and Davis (2008) suggested ways in which science could directly influence preservice elementary science teachers to become science teachers. Creighton (2007) emphasized the contextual influence of science method courses, while Forbes and Davis (2008) focused on the utilization of

science curricular materials. Creighton (2007) and Forbes and Davis (2008) explored how science is utilized through curriculum materials as a piece of learning to preservice elementary teachers in becoming a science teacher. Forbes and Davis (2008) suggested that science curricular materials, as well as a science methods course, play a fundamental role for preservice elementary teachers to construct a science teacher identity.

In addition, several personal, institutional, and administrative influences are identified as factors that influence the construction of a science teacher identity. These include coursework; preparation programs; professional development programs; student teaching; apprenticeships; relationships with colleagues, mentors, and administrators; life history; learning experience; and educational policy. To measure the impact of courses on the construction of science teacher identity, a science teaching methods course and reflective seminar course were used as research contexts. Using a science teaching methods course, Forbes and Davis (2008) observed that the curricular self and role identity of preservice elementary science teachers' score increased and Creighton (2007) also observed that a preservice elementary science teacher experienced a change of teacher identity. Moore (2008a) observed preservice teachers' change of identity and teaching practice throughout a book club reflection seminar course. As a field placement, student-teaching is also considered a situated context with influence on the construction of science teacher identity (Eick & Reed, 2002; Proweller & Michener, 2004). Additionally, an apprenticeship was used a context to support preservice science teachers and to bring authentic experiences of doing science in classrooms (Varelas et al., 2006). Melville and Wallace (2007) and Proweller and Mitchener (2004) emphasized relationships with others including students, colleagues, and administrators in

community. Personal life history including family background, biography, religion, and educational history is also shown as a latent factor to influence the construction of science teacher identity (Eick & Reed, 2002; Jita, 1999; Kozoll & Osborn, 2004; Ramseur, 2004). Eick and Reed's study (2002) involved diverse experiences of doing science, learning from science teachers, and working into learning experiences, by comparing different teaching performances of preservice science teacher who had contrasting learning histories. Friendrichsen et al. (2008) suggested that prior career experience is crucial for preservice science teachers enrolled in alternative science teacher certification program to construct science teacher identity. Educational policy, curriculum structure, district/school administration, and social justice were also identified as influential factors on the construction of science teacher identity, both in implementing policy and curriculum and in the learning and teaching practice of science (Barret, 2003; Beckford-Smart, 2006; Jita, 1999; Melville & Wallace, 2007; Moore, 2008a; Soreide, 2005).

Science teacher identity matters for all science teachers, both preservice and practicing science teachers and both elementary and secondary science teachers. Among 22 studies conducted with science teachers, 63% of those (fourteen studies) were conducted with secondary science teachers, and 27% (six studies) of with elementary teachers (Two studies of those did not clarify the grade level.). Science teacher identity might be considered more by secondary science teachers who teach particular sub-science areas than elementary science teachers who teach general science. However, science teacher identity could matter for elementary teachers as well, as can be seen in the STI research trend (Table 2). Many researchers have reported that science teacher

identity is problematic for elementary teachers in teaching science (Creighton, 2007; Forbes & Davis, 2008; Varelas et al, 2005). Because they have poorer content, pedagogical, and pedagogical content knowledge in relation to science than secondary science teachers do, their science teacher identity has been weak and vulnerable. Although these studies have tried to show impact of teacher education programs or teaching practice on science teacher identity, little impact on elementary teachers' development of science teacher identity as a professional identity has been reported.

The development of science teacher identity has also been more intensively studied for preservice science teachers than for practicing science teachers (Creighton, 2007; Eick & Reed, 2006; Forbes & Davis, 2008; Friendrichsen et al., 2008; Grider & Johnston, 2008; Kozoll & Osborne, 2004; Moore, 2008a; Pedretti et al., 2008; Proweller, 2000; Varelas et al., 2008). The construction of science teacher identity is critical for becoming a science teacher and teaching science, so that preservice science teachers can decide to become a science teacher. Through an alternative certification program, preservice science teachers need practical support and help in developing their own science teacher identity (Proweller & Mitchener, 2004; Friendrichsen et al, 2008). Additionally, for beginning science teachers, science teacher identity is important during the first-year of teaching science because they have trouble constructing their own respective science teacher identities (Melville & Wallace, 2007; Varelas et al., 2005; Volkmann & Anderson, 1998). For practicing science teachers, many findings reported that science teacher identity is related to their teaching practice, how to teach science, and how to act as a science teacher in their classroom (Beckford-Smart, 2006; Helms, 1998;

Jita, 1999; Melville & Wallace, 2007; Moore, 2008b; Ramseur, 2004; Sowell, 2004; Volkmann & Anderson, 1998).

Science teacher identity could be very tightly associated with the teaching practice of science. Many studies have provided evidence that the development of science teacher identity interacts with the teaching practice of science (Beckford-Smart, 2006; Eick & Reed, 2004; Enyedy et al., 2006; Forbes & Davis, 2008; Helms, 1998; Jita, 1999; Melville & Wallace, 2007; Moore, 2008a, 2008b; Pedretti et al., 2008; Ramseur, 2004; Sowell, 2004; Volkmann & Anderson, 1998). The salient studies on this relationship have shown that science teacher identity may reflect teaching practice. Helms (1998) argued that teachers' identity influenced curricular choices, pedagogy, and career trajectory. Melville and Wallace (2007) pointed out that the process of building a science teacher identity might determine the quality of how to implement and reform the teaching practice of science, using a case study of a non-university educated science teacher. For example, as found in Eick and Reed's (2004) study, a preservice science teacher having a weaker role identity as an inquiry-oriented teacher showed difficulty in understanding, guiding, and implementing inquiry-based hands-on instructions during student-teaching. Enyedy et al. (2006) described how practicing secondary science teachers who constructed a science teacher identity could be influenced by setting goals, knowledge, and beliefs about teaching practice to implement a new inquiry-based curriculum. This study found that science teachers implemented differently strategies of curriculum and classroom practice in accordance with their own identities. In Moore's study (2008b), a teacher's positional identity contributes to connect with how they teach science and interact with students. In his other findings (Moore, 2008a), a social justice

science teacher identity is essential for science teachers' teaching practice to improve science teaching and learning in urban classrooms. In particular, Beckford-Smart (2006), Creighton (2007), Enyedy et al. (2006), Eick and Reed (2002), and Pedretti et al. (2008) observed that science teacher identity is crucial in the implementation of a "reformed curriculum." Also, Luehmann (2008) analyzed a conceptual framework for reform-minded science teachers' development of professional identity based on a literature review.

On the other hand, it has been revealed that teaching practice can shape science teacher identity. Varlelas et al., (2005) asserted that the practice of doing and teaching science have an impact on the development of science teacher identity. Volkmann and Anderson (1998) showed that a beginning science teacher constructs a professional identity with struggling with challenges, dilemmas, and conflicts through the first-year teaching practice. Forbes and Davis (2008) found that as preservice elementary teachers develop their own curricular role identity as a science teacher, they become more experienced teachers through teaching practice by using appropriate curriculum materials in teaching an inquiry-based curriculum. They suggested that classroom-based field experience might provide preservice elementary teachers with opportunities to construct their curricular role identity and translate their knowledge and belief into teaching practice.

Authors	Year	Target population		Methods	STI	Findings
		Preservice/ Practicing	Elementary/ Secondary			
Abell	2000	Practicing	Elementary	Narrative self-study(Phenomenology)- 3 participants (professor, 3rd & 6th grade teachers)	Social Identity(Sarbin and Scheibe1983)	• Examined how collaboration or collaborator identity was presented in university or school context between a professor and a teacher. • There are tensions and then, lead and know about the nature of collaboration.
Barrett	2003	Practicing	Secondary (High)	Dissertation; Qualitative case study of 3 teachers: journals, interviews, group meeting, questionnaire, observation, document analysis in curriculum writing project	STI model (Helms, 1998)	• The conflict between teachers' own identity and administrative reform policy could not make a meaningful reform. The hierarchy of systems can have influenced in crafting teachers' own identity.
Beckford-Smart	2006	Practicing	Elementary (5-6th grade)	Dissertation; Ethnography and narrative study: Interviews, learning log, observation of 18 participants(1st interview)/7 participants(2nd interview)		• Social interactions of curriculum structure, district/school policy and teacher identity are influential implementing science instruction. In particular, teachers' own identity is crucial in teaching practice.
Creighton	2007	Preservice	Elementary (Grade 3 and 5)	Dissertation: Qualitative study of interview, questionnaire, observation, artifacts; 5 focal participants of 23 cohort	A proposed model of STI like DNA double helix model: Personal strand (Palmer, 1997) and Social strand (Holland, etal. 1998)	• Preservice elementary students have not received a positive impact in becoming a science teacher or teaching science form science teaching method class. Science can not provide a room to connect inner self of them as a science teacher.

Continued

Table 2. Summary of Research on Science Teacher Identity

Table 2 continued

Authors	Year	Target population		Methods	STI	Findings
		Preservice/ Practicing	Elementary/ Secondary			
Enyedy, Goldberg, & Muir	2006	Practicing	Secondary (Middle)	Comparative Qualitative study: Interview/ learning outcome pre & posttest/ Video analysis/ 2 participants: 6-7th grade vs. 7th grade teacher /EE	Socio cultural perspective: Goodson(1991), Holland(1998), Gee(2001), Wenger(1998)	• Teacher identity including belief, goals & knowledge does matter for teaching practice. Teachers' multiple identities are related to their implementation of a science curriculum.
Eick & Reed	2002	Preservice	Secondary (Mid/High)	Comparative two cases/ qualitative study: Interview, lesson plan, reflections/ 10 participants of 12 cohort	Teacher role identity (Kagan, 1992)	• Belief system, life history, and teaching experience influence to form a teacher role identity. • Learning experiences including past experience in schools, experience in teaching and doing science can help to develop a novice teachers' PCK..
Forbes & Davis	2008	Preservice	Elementary	Mixed study: interviews, observations, survey 47 preservice elementary teachers	Curricular role identity/ Identity relation to knowledge, belief, self-efficacy, dispositions toward teaching practice	• Curriculum materials influence forming a teacher's curricular role identity. Through survey for self and role identity for use, learning, use in context of curriculum materials and scientific inquiry, there is a finding that preservice teachers' role identities can be reinforced by curriculum materials in method classes and classroom practice.
Friendrichsen et al.	2008	Preservice		Case study of 19 participants: interviews and pie chart drawing of autobiography	Wegner(1998): community of practice	• ACP (alternative certificate program) teachers are divided into 3 groups: always a teacher; late decider, and career explorer in the beginning of ACP.
Helms	1998	Practicing	Secondary (Mid/High)	Qualitative study of 6 participants, 12 interviews	Teacher identity	• Science subject matter is an important factor in teacher's sense of self. That is, the nature of science plays an important role of shaping a self of who I am.. Model of identity: actions, institulation, cultural and social expectations ; values and beliefs and where people see themselves going or want to become..

Continued

Table 2 continued

Authors	Year	Target population		Methods	STI	Findings
		Preservice/ Practicing	Elementary/ Secondary			
Henderson & Bradey	2008	Lecturer	College	Longitudinal study of one lecture, 5 subject areas	Wenger(1998): Community of practice	• Identity and pedagogy construction process between teaching practice and pedagogical belief, identity construction are examined. TI impacts on their teaching practice.
Grider & Johnston	2008	Preservice	Secondary	Qualitative study of 3 participants: interviews, field observations, coursework artifacts	Identity through relationship and support from family and Preparation	• Through course work and student teaching, preservice teachers have become a teacher with finding family and colleague's support and educational program
Jita	1999	Practicing	Secondary	Dissertation: Lifelong study of 3 African American Teachers: Interview, observation		• The relationship between of identity and resources of biography(Life histories, growing-up experiences, cultural experience of social, political, religious or professional activities) are crucial in crafting a transformative pedagogy.
Kozoll & Osborne	2004	Preservice College students	N/A	Qualitative study: Interview with 3 college students(non-science majors)/ A preservice teacher		• From students' stories, how science education approach to them and how science is meaningful to students are found. Science is a way for preservice teacher to confront, understand and have a relationship with people and the world.
Luehmann	2007	N/A	N/A	Literature review: Identity Development as an analytical Lense to Science Teacher Preparation	Professional identity	• Conceptual analysis: As a reform-minded science teacher, how to become a kind of teacher having developed a professional identity
Luehmann	2008	Practicing	Secondary (Middle)	Using Blogging in Support of Teacher Professional Identity Development: A Case Study with 1 participant	Professional identity	• Classroom practices influence in development of teaching profession. The recognition of a self and other has forced her commitment in teaching profession. • Blogging is beneficial for professional development.

Continued

Table 2 continued

Authors	Year	Target population		Methods	STI	Findings
		Preservice/ Practicing	Elementary/ Secondary			
Melville & Wallace	2007	Practicing: First year	Secondary (High)	Longitudinal and Narrative study of non university educated science teacher with 10 participants: Staff meeting lesson observations and departmental conversation,	Wenger(1998): community of practice	• Subject matter knowledge is important to STI. • Subject, relationship and identity are interacted with each other.
Moore	2008a	Preservice	Elementary	23 participants of Book club reflections, interview with 5, survey(diversity and background)	Wenger(1998), Goodson (1980), Gee(2002) Elbaz(1991) Cooper and Olson (1996)	• As a agent of changes, preservice elementary science teacher interplay identity, agency, and social justice to be prepared.. • Concerns and fears are connected with their identity. • There are six levels of agents of change as a science teacher teaching in urban classrooms.
Moore	2008b	Practicing	Secondary	Narrative and life history study of 3 African Americans: 5 Interviews and researcher journal	Holland et al.(1998)	• Positional identity including racial culture and gender identity have an influence on professional development. • The model of Positional and teacher-centered professional development
Pedretti etal	2008	Preservice	Secondary	Pre/Post-questionnaire, survey, reflective writing, worksheet, interviews	STI: Talbert (1995), Helms (1998), Varelas et al. (2005)	• STI plays a role in adopting of STSE.
Proweller & Mitchener	2004	Preservice	Secondary	Qualitative, year-long study of 15 interns : Interviews, observation, field notes		• Crafting a professional identity with urban youth students: Development of professional identity involves creating a culture around science instruction driven by implicating science content, teaching methods, community practice, and relationships with their students.

Continued

Table 2 continued

Authors	Year	Target population		Methods	STI	Findings
		Preservice/ Practicing	Elementary/ Secondary			
Ramseur	2004	Practicing	Elementary	Dissertation; Narrative study of 3 participants: Interviews	Science, gender, and race	• Life histories and past and present experiences are connective shaping their role identity as a teacher.
Soreide	2005	N/A	N/A	Document analysis of three public policy documents	STI: Narrative constructions: Poststructuralist	• From documents analysis, the categories of teacher identity construction are identified: the socially oriented and cooperation-orientated teacher, the teacher as a bearer of the cultural heritage, the knowing teacher, the self-assured, flexible and innovative teacher and the including and pupil-centred teacher. Documents have a narrative empowerment to show teacher identity underwritten about what normal, right, good and valuable teacher and teaching looks like.
Sowell	2004	Practicing	Secondary	Dissertation; Ethnography: A feminist poststructural analysis of 2 participant;	Gender identity	• Explicating teacher identity as effects of these pedagogical approaches proved insightful finding their resistance, frustration, enthusiasm, and agency as the teachers reflected on their practice.
Varelas, House & Wenzel	2005	Preservice to first-year	Elementary Secondary	4 interviews of 3 fellows	Gee(2000-2001): N-identity, I-identity, D-identity, A-identity	• Apprenticeship contributes to both teachers' identities as a scientist or science teacher. • As science is practice, community of practice, there is an interplay between of science teacher identity and scientist identity based on Gee's view.
Volkmann & Anderson	1998	Practicing (first year)	Secondary	Phenomenological research: Journal of a first-year teacher	Goffman (1959, 1967)	• A first year teacher struggled to create a professional identity integrated with personal identity and teaching dilemmas and tensions: Being a teacher and a role model for student, caring students, and having subject matter knowledge and pedagogical knowledge.

Teacher Development and Teacher Education Program

"The teaching profession is the most demanding vocational journey."

(Lipka & Brinthaupt, 1999, p. 1).

The decision to become a teacher means to travel a new journey of the self as a teacher, because becoming a teacher requires intellectual, affective, and social devotion of the self to the teaching profession. This process means exploring another self as a teacher, the "teacher identity." However, in education literature, to become a teacher has generally been understood as teacher development, not as teacher identity development. As Lipka and Bringthaupt argued in *The role of self in teacher development* (1999), teacher identity is implemented by the decision and transition to become a teacher, and by reexamining the mastery experience of the teaching profession. For example, Bullough and Baughman (1997) found that a female teacher having a child struggled to construct her classroom teacher identity in terms of her other self-conceptions and roles, e.g., "female identity," "teacher identity," and "mother identity." As in this case, becoming a teacher and performing a teaching profession is the process of constructing and representing teacher identity. Thus the process of being a teacher is not only teacher development but also teacher identity development.

However, a model of teacher identity development has not yet been developed: there is only research on teacher development (Hale, 2005). Among this research, Ryan (1986) and Fuller and Brown (1975)'s teacher development model is noteworthy in considering how teachers develop teacher identity. In their model, there are four stages to the teaching profession: fantasy, survival, mastery, and impact. At the first stage, the fantasy stage, teachers have a dream that they will be able to be a wonderful teacher.

Although the fantasy stage is interrupted by student-teaching, they continue on becoming a teacher. However, most teachers come face to face with their broken fantasy within a few years of beginning their teaching. Concurrently, teachers enter into the second stage, the survival stage. In this stage, they have inappropriate experiences with their professional identity, often causing confusion and conflict between their ideality and reality. Thus, they have to determine whether they will continue on their profession. If they pass the survival stage, they have a more steady profession and move into the mastery stage. Because they learn practical knowledge and skills to perform their profession, their profession is more adjusted to the teaching profession. After completing these three stages, they arrive at the final stage, the impact stage. Reaching this stage takes a few years. In this stage, a teacher can be a master, expert, mentor, supervisor, and leader for a novice teacher, one who has an influence on others in the teacher community. This four-stage teacher development model-- fantasy, survival, mastery, and impact-- might be helpful to understanding and exploring preservice and practicing teachers' teacher identity formation stage in this study.

In the early stage of teacher development, institutional programs and systemic support, such as intern-mentor programs, are significant for preservice teachers in order to help teachers to identify and develop their profession. Institutions provide preservice teachers with courses, field experience, colleagues, faculty, staff, and resources to develop a teaching profession. Danielwicz (2001) suggested that institutions are social structures embodying numerous social relations and authority so that they may influence preservice teachers to identify teacher identity. However, she also claimed that institutions are not an agent of teacher identity development even though institutions have

the authority to encourage preservice teachers to take the opportunity to develop teacher identity by participating in institutional programs and forming relationships with faculty, staff and colleagues. Only the individual can develop himself or herself as a teacher. In teacher identity development, the agent is the individual preservice teacher. This perspective provides a contextual assumption to examine how preservice teachers develop teacher identity in the context of preservice teacher education program in this study.

Chapter 3: Methodology

This chapter describes the research contexts, settings, and processes associated with development of an STI model, development and field-testing of a new instrument to measure STI, and using the new STI model and instrument to examine effects of professional development experiences on STI within a cohort of preservice science teachers. This chapter consists of three sections: Conceptualization of a new model of Science Teacher Identity (STI), development and field-testing of the STI instrument, and examination of the STI Model within a science teacher preparation program.

The first section presents the procedure for addressing the first research question, "How can the dimensions of the science teacher identity construct be conceptualized and represented?" through conceptualizing a new model of STI.

The second section presents the methods used to examine research questions 2: "Can the level of science teacher identity be validly and reliably measured?" This phase of the study consisted of two stages: a pilot study of an initial instrument, and the field testing of a newly developed instrument. During the pilot study, an initial instrument was developed based on the new conceptual model of STI, and evidence of content validity was sought. The initial instrument was then refined and reformatted, followed by field-testing to examine the reliability and validity of the revised instrument.

The third section, of this chapter describes the methods used to explore research question 3, "What evidence supports the efficacy of the proposed model of science

teacher identity?" In particular, the impact of a teacher preparation program on the levels of science teacher identity constructed among preservice science teachers was studied. Specifically, two subsidiary questions guided work described in this section: "How well does the new STI instrument measure the levels of science teacher identity among preservice teachers?" and "How does student teaching impact the construction of science teacher identity among preservice science teachers?"

Conceptualization of a New Model of Science Teacher Identity (STI)

The first section of this chapter presents the procedure of proposing a model of science teacher identity as a conceptual framework. The model of science teacher identity has been proposed through a four-stage procedure: Conceptualization of science teacher identity, classification of factors of science teacher identity, identification of potential dimensions of science teacher identity, and illustration of the model of science teacher identity. The proposed model of science teacher identity in this study is a conceptual framework providing a perspective to understand research questions and to illustrate research constructs. Additionally, assumptions, definitions, practices, and values of "science teacher identity" are justified through this conceptual framework.

Conceptualization of Science Teacher Identity

The conceptual framework is grounded in the research of identity and professional identity in fields within and outside of education, and in previous qualitative studies focusing on science teachers as discussed in chapter 2.

Initial Formulation of Science Teacher Identity

The initial formulation of the conceptual framework was based on the ten principles of teacher identity proposed by Danielwicz (2001), with modifications influenced by the four dimensions of identity in a model suggested by Helms (1998) and the seven elements of physician teacher identity identified by Starr et al. (2006), along with previous research findings on science teacher identity. The relevant parts of these studies are discussed below. .

Danielsicz's ten principles of teacher identity development

Within us, there are multiple identities which coexist independently and dependently. We behave differently with different identities in each different context. For example, when we are science teachers, we can be also students in schools, parents or daughters/sons at home, employees at work, and/or members in a community. In particular, science teacher identity is a professional identity, which is personally, socially, and contextually constructed through the profession. This is different from a positional identity, which is formed by race, gender, ethnics, and socioeconomic class. Thus, the conception of science teacher identity is explained by a set of antithetical categories in terms of agency, context, and relationships, such as personal vs. collective identity, internal vs. external identity, and individual vs. public identity (Danielwicz, 2001) (See Figure 1). By an agent who recognizes him/herself as a science teacher, identity is categorized as personal and collective identity. The personal identity is a being recognized by the self, while the collective identity is a being recognized and accepted by collective others. For "science teacher identity," an individual might combine a personal identity—how he/she thinks about him/herself as a science teacher—with a collective identity involving how other teacher colleagues, students, administrators, and parents see

that person as a teacher. In addition, a personal identity is an internal and individual perception of the self as a teacher; but a collective identity is an external and public perception of the self as a teacher (Danielwicz, 2001). Depending on what context constructs a science teacher identity, science teacher identity can be internally or externally constructed. Likewise, science teacher identity can be individual or public meaning constructed through a relationship with society. The most important factor of constructing a collective identity is social interaction in a variety of social contexts. The social classification of teachers that other people judge as a member of a group is relevant in constructing professional identities (Danielwicz, 2001). Thus, a personal identity is called an internal identity or individual identity; by contrast, a collective identity is called an external identity or public identity.

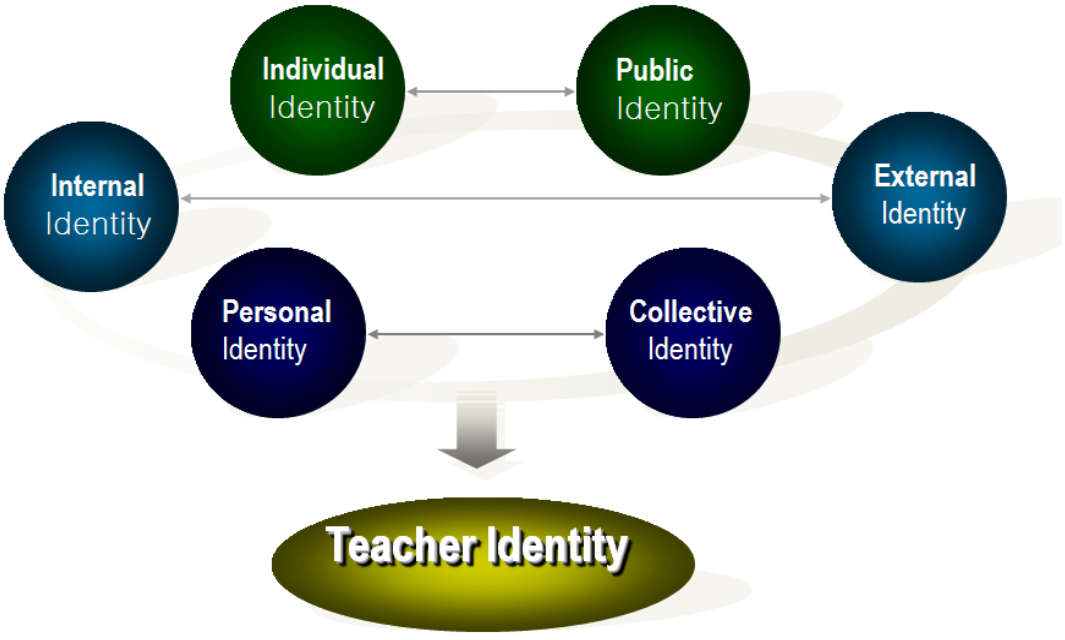


Figure 1. Conceptualization of teacher identity

Each process of constructing personal or collective identities involves interactions between the individual-self and others (Danielwicz, 2001). For instance, during student-teaching, preservice science teachers can recognize themselves as science teachers at the same time mentors, faculties, and colleges or universities recognize them as science teachers. As can be seen in figure 1, personal and collective identities are developed cooperatively by each parallel process. The relationship between a personal and collective identity is not mutually exclusive but complementary to each other. In fact, while constructing an internal and individual identity, a collective identity is necessary to construct a personal identity in the self. In the process of establishing an external and public identity, a personal identity is also important to intensify a collective identity. Danielwicz's description (2001) of preservice teachers clarifies the reciprocal relationship of personal and collective identities. According to her description, despite self-conviction as a teacher, preservice teachers needed acceptance by institutional recognition as a teacher. Their personal identities as a teacher would be magnified by conformity with external and public identities. The process of constructing and forming a comprehensive identity for an individual is a complex interaction of personal, internal, and individual identity with a collective, external, and public identity. There are dynamic and reciprocal interactions to weaken or strengthen personal or collective identity.

For teacher identity formation, Danielwicz (2001) assumed that the process of constructing a teacher identity is developed by educational institutions or programs of teacher education. Based on her assumption, it is believed that teacher education, including teacher preparation programs and professional development, should be able to guide and encourage individual students or teachers to develop their teacher identities.

Furthermore, she believed that the pedagogy of teacher education plays a role of shaping and developing teacher identities (Danielwicz, 2001). Hence, pedagogy could be defined as a structural and formative process that reconstructs activities, interactions, and projects to prompt the development of teacher identities. For example, in science teaching and learning theories such as the learning cycle, the Vee diagram, and the concept map, there are distinctive pedagogies of science education from other disciplines or subject areas. These unique pedagogies allow teachers to learn how to be a science teacher and how to perform as a science teacher. Likewise, pedagogy is the most useful and effective foundation to enable teachers to develop their teacher identity.

As Danielwicz proposes in her book (2001), there are ten principles of pedagogy for teacher identity development. These principles of pedagogy include structural principles, such as a curriculum, classroom environment, and course design and method, as well as performative principles related to individuals' performance and interactions. In structural principles, there are five principles: discourse richness and openness, dialogue and a dialogic curriculum, collaboration, deliberation, and reflexivity. Likewise, there are five performative principles: theorizing in practice, agency, recursive representation, authority, and enactment. These principles are related to transforming identities and understanding changing identity, because they are descriptors between the theory and practice of teacher identity development that shape the individual teacher's teaching philosophy, beliefs, attitudes, and experiences. Especially noteworthy are the four principles of collaboration, reflexivity, agency, and recursive representation, which may be the most essential to understand the development of science teacher identity.

"Collaboration" means cooperative efforts to share teachers' vision, philosophies, responsibilities, and social values for the development of identities. Collaboration varies social interactions and affects our collective identities. As a result, the collective, public, and external identities of individual teachers could be reinforced when they have an opportunity to work together (Danielwicz, 2001). Collaborative environments are open-ended, flexible, and responsive to engage members of a group with individual and collective identities.

Reflexivity is the act of self-conscious consideration (Danielwicz, 2001). Reflexivity focuses on what and how one did in the past rather than what one needs to do or be in the future. Through backward reflexivity, teachers deeply reconsider how to understand themselves and others in social relations. As a method for increasing self-knowledge, reflexivity leads people to be better aware of social situations which influence their identity. That is, teachers are reflexive if they think not only of their internal, psychological, or mental states but also of their outer conditions, others, and themselves in social context. For teachers, reflexivity is an opportunity to reflect on their experiences, beliefs, philosophy, and attitudes about their teaching. Teachers' reflective thinking is a starting point to reform and refresh their teaching lives. Reflexivity is a necessary and valuable commitment to themselves in order to advance their teaching practice. Thus, reflexivity is fundamental to develop a teacher identity.

Agency is the external or internal power and source of making a teacher be a teacher and teach (Danielwicz, 2001). Agency can be an external institution or organization, such as a university or college that educates teachers, and can also be an internal feeling or will to recognize and to act as teachers. A teacher's real life can be

affected by various agencies because agencies might give a possibility for the development of identity. There is‘negative agency’ which interrupts identification as a teacher (e.g., a failure experience, conflict, and distress) and ‘positive agency’ which encourages awareness of teacher identity (e.g., university, school, and colleagues). The internal or external agency acting on teachers is important for the development of teacher identity.

The last essential principle, recursive representation, creates identities (Danielwicz, 2001). “How are selves represented?” is a crucial question for the development of identity. In focusing on selves, the relationship of representation and identity is more interdependent than other principles. In fact, in a university or college for teacher education, the representation of teachers is central to students preparing for a profession as a teacher. This ideal representation is a keen desire of students to be a teacher and to act as a teacher. Their representation involves personal visions, thoughts, experiences, and ideas about the ideal image of a teacher. It is interpreted in visual, audible, tangible, and intangible forms, such as written debate, essays, journals, lesson plans, photos, drawings, sculptures, body language, gestures, facial expressions, postures, clothing, voice, conversation, and music (Dainewicz, 2001). However, when multiple self-representations are created, multiple representations exist in a diverse real situation. Representation goes through a process of review with reality, that is, recursive representation is produced. Recursive representation is closer to a real and present configuration of selves. Recursive representation represents an intrinsic identity, like a mirror.

Besides the most essential four principles, the other six principles are also relevant to understanding how to inform and inspire teachers to develop their own science teacher identity. In "discourse richness and openness," discourse is defined as a language activity that constitutes and constructs experience and reality (Dainelwicz, 2001). Through discourse, students can perceive their presence and selves in becoming a teacher. Discourse connects speakers and listeners and transitions between culture and relations in context. In fact, discourse always exists in self vs. self, self vs. things and self vs. others, e.g., teacher educators and preservice teachers, teachers and students, and teachers and subject matters. Danielwicz (2001) emphasized that discourse is crucial in pedagogy to teach and learn to become a teacher. Especially, she showed how discourse plays a role for preservice teachers who engaged in writing activities related to their teaching philosophy and who struggled with informing, reflecting, sharing, arguing, and discussing. Since discourse varies in accordance with forms and modes of languages, topics, and audiences, it is natural that discourse is characterized by richness and openness (Danielwicz, 2001). With great acceptance based on richness and openness, discourse is centralized in the teaching and learning process.

In addition to discourse, dialogue and a dialogic curriculum is an inherent trait of teaching and learning to become a teacher. Dialogue is a means of communicating through language and social interaction (Dainelwicz, 2001). Also, it is a form and structure of pedagogy. Through dialogue, knowledge, experience, values, beliefs, and cultures are socially and collectively shared and re-compromised between participants. Dialogue is powerful to foster voices, inclusive to open up perspectives, and creative to reconstruct knowledge and experiences. Through dialogue, teachers may have an

opportunity to assert and construct identities by interacting, comparing, and contrasting with diverse individuals.

Deliberation is a dramatic and active process in which we speak what we have on our minds (Danielwicz, 2001). Dainelwicz (2001) suggested that deliberation could be a conceptual framework and method for teacher education programs that may bring students from a productive and real exercise to becoming a teacher. Through deliberation, preservice teachers invest themselves in deep contemplation to design courses and make lesson plans.

As a performative principle, "theorizing in practice" is practical and useful in shaping the teaching profession. As Dainelwicz (2001) claimed that "to teach is to theorize," teaching is embedded in an individual's creative way to adapt a theory and rebuild a practice by bridging the difference between theory and practice using their experiences. Theorizing in practice is very personalized for an individual preservice teacher. Through theorizing in practice, individual preservice teachers may justify and personalize their own theories in practice.

Authority is a present power and voice obtained, given, or generated from social relations, according to Dainelwicz's discussion (2001). In a classroom, teachers have the authority to speak, command, and force students to do something. However, a teacher's' authority is not only given but also obtained through practice. In classroom discourse, it is often observed that preservice teachers do not have a powerful voice although they have their authority as a teacher because they may not have had the opportunity to practice to construct a voice. Practicing a voice can affirm authority. The development of

teacher identity informs teachers who they are, including having an authority and voice in the classroom.

Enactment is defined as embodied ideas, theories, and principles in a pedagogy, including curriculums, activities, evaluations, and discourse (Danielwica, 2001). A teacher's self and beliefs are reflected in their classrooms by the enactment embodied in teaching. Enactment is a practical method by which students may experience who teachers are, what teachers believe, and how teachers enable students to act in classrooms.

Helms's model of identity

In science education, "the model of identity" is the first conceptual model of identity proposed by Helms (1998) (Figure 2). This model was inductively and conclusively conceptualized from her study on the influences of subject matter on science teachers' sense of self. As a result, the model of identity consists of four major dimensions based on contexts including experience, culture, and society: (a) actions; (b) institutional, cultural, and social expectations or what people think others expect; (c) values and beliefs; and (d) where people see themselves going or the kind of people they want to become. The dimension of "values and belief" lies in the middle of the model as the center of gravity, while the other three dimensions are linked through this center dimension. Because "values and belief" is the core by which to interact with other dimensions, the "sense of self" ultimately flows through this core dimension. Each link represents a relationship between dimensions: an arrow represents the directionality of the relationship and thickness represents the importance of the relationship. Thus the strongest relationship lies between values/beliefs and the future self, while that between

values/beliefs and others' expectations and actions is weak but still important, because action may or may not reflect on our values or beliefs. Between others' expectations and action, there is an important link. These links are established by research findings from interviews with five practicing secondary science teachers.

The dimensions and links of this model are very practically identified and supported. This characteristic of the model is a strength as well as weakness. As can been seen in Figure 2, the model of identity neglects to find all relationships between dimensions. For instance, in the relationship between future self and others' expectation and action, there is no link although "future self" may influence "action" and may be influenced by "others' expectation." Her model was founded only on the observed evidences from her research. In contrast, her model does not present a relationship between subject matter and a sense of self, although one of her research questions was "How does subject matter influence a science teacher's sense of self?" in this study. In fact, she found that subject matter has a powerful influence on a teacher's sense of self. Additionally, she pointed out that subject matter can influence negatively on a sense of self because, she observed, subject matter may isolate a teacher's sense of others who teach in different subject areas and cause a confusion of the sense of self to teachers who teach various subject areas at the same time. Despite the influence of subject matter, she did not identify "subject matter" as an independent dimension of her "model of identity" but as an element crossing the dimensions of "future self" or "value and belief." That is, in her model science as subject matter affects what kind of person a teacher is or wants to be, and that person's values and beliefs would also include what makes science special or gives it value. She contended that subject matter means what teachers do and what they

teach, that is, subject matter is “the practice.” As she argued that the teacher’s sense of self cannot be easily described or identified by his or her practice, she disregards the role of subject matter to construct teacher identity in her “model of identity.” Throughout this model of identity, she stressed not “science teachers’ identity” but “teachers’ identity” by excluding the specific subject matter, “science.” Her exclusive view of subject matter generated a critical limitation of her model for attempts to conceptualize science teacher identity.

This study adapts Helms’s research to form a conceptual model of science teacher identity.

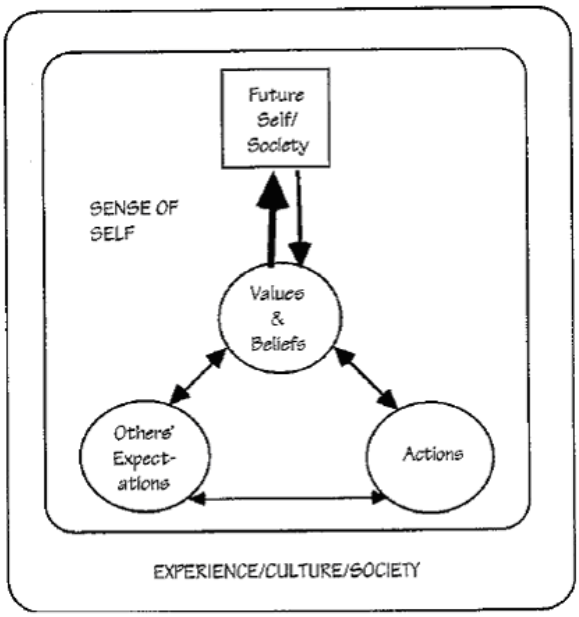


Figure 2. Helms's Model of Identity (Helms, 1998)

Instrument of teacher identity for physicians

Starr et al. (2006) have showed what elements comprise teacher identity and how these elements are included in an instrument to measure teacher identity. Starr et al. (2006) developed a 37-item questionnaire, consisting of seven elements for physician teacher identity: (a) feeling intrinsic satisfaction from teaching, (b) having knowledge and skill about teaching, (c) belonging to a group of teachers, (d) feeling a responsibility to teach, (e) sharing clinical expertise with learners, (f) receiving rewards for teaching, and (g) believing that being a physician means being a teacher. These seven elements had been identified in their previous study, "physician's view on their teacher identity" (Starr, et al., 2003). Of those, four elements, "feeling intrinsic satisfaction from teaching," "having knowledge and skill about teaching," "belonging to a group of teachers," and "receiving rewards for teaching" were revealed as crucial elements to facilitate professors' commitment to teaching in Snyder and Spreitzer's study (1984). Starr et al. (2003) revealed similar findings to Snyder and Spretizer's suggestions (1984) that these elements contributed concurrently to increase physicians' commitment to teaching roles. The remaining three elements, "feeling a responsibility to teach," "sharing clinical expertise with learners," and "believing that being a physician means being a teacher" were emergently identified through a focus group discussion about physician teacher identity (Starr et al. 2003). Starr et al. (2003) argued that these three elements would be distinguishable to characterize physician teacher identity because when physicians faced patients, students, and residents, they may feel a strong responsibility to teach, inform, and share their knowledge with their patients, students, and residents. As discussed in Starr et al.'s study (2003), physicians may believe that their behaviors of teaching and informing others are ways of becoming a physician and also a teacher, even though when

they conducted clinical responsibilities. Likewise, they found necessary elements of physician teacher identity that enable physicians to be like physicians (Starr et al., 2003).

This novel finding of characteristic elements in a specific discipline's teacher identity is a basis for initiating the development of an instrument to measure the teacher identity of physicians. Starr et al. (2006) had developed an initial instrument of physician teacher identity based on their previous study (2003) and pilot testing. In the process of development, two complementary elements were included in the initial physician teacher identity in addition to the previously mentioned seven elements: "global teacher identity" and "desired outcomes." For pilot testing, "global teacher identity" was included in a pilot instrument while "desired outcomes" was added to the initial instrument to reflect the result of focus group discussion, after the pilot testing, about the questionnaire. Through an initial testing of this instrument of physician teacher identity, its reliability was analyzed but not the validity of its construction because of the small sample size. However, this study was valuable because it placed an initial foothold of research on teacher identity to show that teacher identity could be measured. Their findings on the components of physician teacher identity and establishing an instrument are adopted here as a framework for developing an initial format of the instrument of science teacher identity.

Constructing Science Teacher Identity

Personal and collective Identity

Danielwicz (2001) represented the same formulation of identity, in accordance with research on self and identity theory and teacher identity. As discussed above, the construction of science teacher identity can be divided into personal and collective

aspects. In personal aspects, science teacher identity is personally, internally, and individually constructed; in collective aspects, it is collectively, externally, and publicly constructed. A sense of science teacher identity is a self-identification from the self as well as from collective others. Due to this dual nature of identity, science teacher identity can be defined as a science teacher's personal and collective sense of a self as a teacher in society. While constructing science teacher identity, science teachers use diverse knowledge sources from the self and collective others. The knowledge from self is personal, internal, and individual, based on subjectivity, while the knowledge from others is collective, external and public, based on objectivity. Through these personal and collective knowledge sources, science teacher identity is reconstructed, reflected and represented.

Science matters for Science Teacher Identity

As much research has suggested (Abell, 2000; Eick & Reed, 2002; Enyedy, Goldberg, & Welsh, 2006; Kozoll & Osborne, 2004; Proweller & Mitchener, 2004; Varelas et al., 2005; Volkmann & Anderson, 1998) in chapter 2, Helms (1998) has also shown a consensus that science is inseparable from the conceptualization of science teacher identity. Volkmann and Anderson (1998) presented that having an interest in science and enjoying science is fundamental to teaching it. Science is a core to develop science teacher identity, and thus science as a subject matter is involved in the construction process of science teacher identity for this study.

Classification of Factors of Science Teacher Identity

Components of Science Teacher Identity

As can be seen in Helms's model of identity (1998), Starr et al.'s elements (2006), and other research findings relevant to teacher identity, there are a number of components relating to science teacher identity. For example, Helms's model of identity includes a context consisting of society, culture, and experience expressed in four dimensions: (a) actions; (b) institutions, cultural, and social expectations or what people think others expect; (c) values and beliefs; and (d) where people see themselves going or the kind of people they want to become. Starr et al. (2006) proposed seven elements of physician teacher identity: (a) feeling of intrinsic satisfaction from teaching, (b) having knowledge and skill about teaching, (c) belonging to a group of teachers, (d) feeling a responsibility to teach, (e) sharing clinical expertise with learners, (f) receiving rewards for teaching, and (g) believing that being a physician. Later, they included two additional elements in the instrument, (h) global teacher identity and (i) desired outcomes.

Through research in science education, personal, institutional, and administrative influences were identified: coursework, preparation programs, professional development programs, student teaching, apprenticeships, life history, learning experiences, educational policy, and relationships with colleagues, mentors, and administrators. In research on teacher identity, there are psychological factors and sociological factors. Psychological factors are identified as the following: knowledge, experiences, life history, biography, personality, emotions, concerns, anxiety, attitudes, passion, motivation, satisfaction, commitment, confidence, dreams, and hopes. For sociological factors, there are culture, schools, institutions, policy, reform movements, and relationships with students, colleagues, and staff.

Both science teacher identity and teacher identity showed a strong association with teaching practice in the formation and representation of professional identity. Teaching practice is an influential component. Additionally, as reported in research outside education, other factors related to professional identity include background, environment, experiences, interests, choice goals, choice actions, performance, confidence, commitment, satisfaction, burn-out, retention, retirement, turn-over, self-efficacy, self-esteem, self-worth, self-evaluation, self-satisfaction, and self-criticism.

The Classification Process

These components of teacher identity and science teacher identity formation were categorized by each synonym. As a result, 14 components were categorized as follows.

- Experiences, personal backgrounds, biography, life history, learning experiences related to science (e.g. learning science, doing science, knowing science, and understanding science), academic success, memories in relation to classroom and school, praise from teachers, parents and colleagues, and role models
- Emotions, concerns, fear, frustration, and anxiety
- Knowledge, professional knowledge, pedagogical knowledge, content knowledge, pedagogical content knowledge, pedagogy, and having knowledge and skills about teaching
- Degrees, licensures, and certification status
- Collaboration, belonging to a group of science teachers, sharing their expertise, and building a knowledge base
- Teaching practice, actions, performance, difficulties or challenges in teaching science, and characteristics of teaching science (e.g., inquiry and nature of

science)

- Desired outcomes, students' performance, and rapport with students
- School; institution (e.g. a coursework, preparation programs, professional development programs, student teaching, or apprenticeships); policies including reform movements; institutional, cultural, and social expectations; receiving rewards for teaching; recognitions; and relationships with colleagues, mentors, and administrators
- Belief and value in science teaching and believing that being a physician means being a teacher
- Interest, confidence, commitment, satisfaction, and intrinsic satisfaction from teaching
- Representation, dreams, hopes, future goals, ambitions, ideal image of science teachers, and identifying the kind of people they want to become
- Reflexivity, reconstruction, and reflection
- Burn-out, retention, retirement, turn-over, and professional development
- Self-efficacy, self-esteem, self-worth, self-evaluation, self-satisfaction, and self-criticism

From the 14 components identified above, 12 components (the first through twelfth) were empirically identified as influential components. The two remaining components were not used in establishing the conceptual model. These are not components of science teacher identity but rather a continuum state of science teaching as a profession.

The main 12 components were divided into structural components and procedural components. Structural components are building blocks and consist of the first through

eleventh components. Procedural parts are linkages to connect cognitively and psychologically between various components. Reflexivity, reconstruction, and reflection are classified as procedural components.

Among the 11 structural components, the eighth through eleventh were categorized as intrapersonal response domains to the self; these are used to lead cognitive and affective responses to a sense of self as a science teacher.

Eight structural components were categorized as an informative domain to the self, and were divided into personal factors and collective factors. Accordingly, the first through forth components (e.g., experience, emotion, knowledge, and degree) were classified as personal factors and the fifth through eighth (e.g., collaboration, teaching practice, desired outcomes, and schools) as collective factors.

From these structural components, emotionally relevant components were excluded as components of a model of science teacher identity. Although an emotional component has been considered as an influential factor in teacher identity formation, most empirical research has presented a short-term impact on teaching practice and teacher identity change in "a situated specific context," such as reform policies, classroom interaction, and relation with others. For this study, since teacher identity formation has been considered as part of the teacher development process rather than a situated change, emotion that is 'a short-term evaluative, affective, psychological state including internal feeling' (Colman, 2006, p. 248) has been excluded from the framework.

Identification of Potential Dimensions of Science Teacher Identity

Finally, 11 components were identified as factors in constructing a conceptual model of science teacher identity. These 11 components were interpreted as a dimension of science teacher identity. First, each component (except the procedural components) was interpreted as an inclusive concept including all elements. As a result, ten structural components were presented as follows:

- Personal experiences: experiences, personal backgrounds, biography, life history, learning experiences related to science (e.g. learning science, doing science, knowing science, and understanding science), academic success, memories in relation to classroom and school, praise from teachers, parents and colleagues, and role models
- Having knowledge and skill: knowledge, professional knowledge, pedagogical knowledge, content knowledge, pedagogical content knowledge, pedagogy, and having knowledge and skills about teaching
- Qualification: degrees, licensures, and certification status
- Community practice: collaboration, belonging to a group of science teachers, sharing their expertise, and building a knowledge base
- Science teaching practice: teaching practice, actions, performance, difficulties or challenges in teaching science, and characteristics of teaching science(e.g., inquiry and nature of science)
- Degree of success: desired outcomes, students' performance, and rapport with students
- Social respect: school; institution (e.g. a coursework, preparation programs, professional development programs, student teaching, or apprenticeships);

policies including reform movements; institutional, cultural, and social expectations; receiving rewards for teaching; recognitions; and relationships with colleagues, mentors, and administrators

- Belief and value: belief and value in science teaching; believing that being a physician means being a teacher
- Intrinsic satisfaction: interest, confidence, commitment, satisfaction, intrinsic satisfaction from teaching
- Representation: representation, dreams, hopes, future goals, ambitions, ideal image of science teachers, and identifying the kind of people they want to become.

Next, the divided structural components were interpreted in a "self-knowledge" dimension for informative domains to the self and a "self-reflection" dimension for intrapersonal response domains to the self.

The self-knowledge dimension involves personal experience, having knowledge and skill, qualifications, community practice, science teaching practice, degree of success, and social respect. As the perception of the self is processed through the organization of self-knowledge in the self and identity theory (Mischel & Morf, 2003), science teacher identity is constructed by the organization of self-knowledge. Thus, self-knowledge is operationally defined as knowledge relevant to the self, which is collected from the self or outside of the self, and interpersonally or intrapersonally constructed for self-concept in this study. A self-knowledge dimension comes from two sources: personal sources and collective sources. As discussed, the self consists of a knower-self as a subject (I-self) and a known-self as an object (Me-self). The self-knowledge is also

conceptualized into two parts, personal self knowledge for a knower-self (I-self) and collective self knowledge for a known-self (Me-self). The personal self knowledge is individual and subjective, whereas the collective self knowledge is public and objective. In this study, personal experience, having knowledge and skill and qualifications, are included in the personal self- knowledge dimension. The personal self-knowledge has been obtained and accumulated by the self. On the other hand, the collective self-knowledge is established through collectivity from a group, community, society, culture, subject matter, and relationship with others. The collective self-knowledge dimension consists of community practices, science teaching practices, degree of success, and social support.

The self-reflection dimension is defined as an individual's intrapersonal reflection of the individual's sense as a science teacher in relation to a specific context, science teaching, which is a positive or negative attribute of a self (Tesser, 2003). This dimension includes "beliefs and values, intrinsic satisfaction, and representation." Through this dimension, self-knowledge may be reconstructed and then presented a self as a science teacher.

Overall, the dimensions of the model were conceptually compared with its initial conceptual foundations: Danielwicz's ten principles (2001), Helms's model of identity (1998), and Starr et al.'s an instrument of physician teacher identity (2006) (See Figure 3 and Table 3).

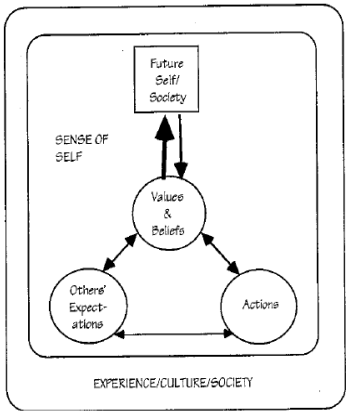
This study	Danielwicz (2001)	Helms (1998)	Starr et al. (2006)
STI model	10 principles of pedagogy	Model of Identity	Instruments for PTI
Structural components *Self-knowledge dimensions* *Personal self-knowledge* a. Experience b. Qualifications c. Having a knowledge and skill *Collective self-knowledge* d. Community practice e. Science teaching practice f. Degree of success g. Social respect *Self-reflection dimensions* h. Belief and value in science teaching i. Intrinsic satisfaction j. Representations *Procedural components* k. Reconstruction & Reflection	*Structural principles* a. Discourse b. Dialogue c. Collaboration d. Deliberation e. Reflexivity *Performative principles* f. Theorizing in practice g. Agency h. Recursive representation i. Authority j. Enactment	 *Figure 1.* Model of identity. a. Actions b. Institutional, cultural, and social expectations, or what people think others expect; c. Values and beliefs d. Where people see themselves going, or the kind of people they want to become	a. Feeling intrinsic satisfaction from teaching b. Having knowledge and skill about teaching c. Belonging to a group of teachers d. Believing that being a doctor means being a teacher e. Feeling responsibility to teach f. Sharing clinical expertise g. Receiving rewards for teaching * Global TI * Desired outcomes *Items are added after pilot study.

Figure 3. Conceptual Framework of Science Teacher Identity (STI)

STI model			Danielwicz's 10 principles of pedagogy (2001)										Helms's model of TI (1998)					Starr's Instruments for PTI (2006)								
Items			Structural principles					Performative principles					4 Dimensions				Con-text	7 Elements of teacher identity							After pilot	
			Discourse	Dialogue	Collaboration	Deliberation	Reflexivity	Theorizing in practice	Agency	Recursive representation	Authority	Enactment	Actions	Expectations	Value & Belief	Future	Experience / culture / society	Intrinsic Satisfaction	Knowledge & Skills	Belonging to a group	Responsibility to teach	Sharing expertise	Receiving rewards	Believing a being a teacher	Global TI	Desired outcomes
Self-knowledge	Personal	Experiences	✓														✓									
		Qualifications															✓									
		Knowledge & skills															✓		✓							
	Collective	Community practice		✓	✓				✓				✓							✓						
		Sci teaching practice		✓		✓		✓					✓													
		Degree of success		✓					✓				✓									✓				
		Social respect		✓					✓		✓			✓									✓			
Self-reflection		Belief & value													✓						✓			✓		
		Intrinsic Satisfaction																✓							✓	
		Representation								✓						✓								✓	✓	✓
Process		Reconstruction					✓		✓	✓		✓	✓													
		Reflection	✓				✓		✓	✓		✓	✓													

Table 3. Conceptual Comparison of Science Teacher Identity (STI)

Illustration of the Model of Science Teacher Identity

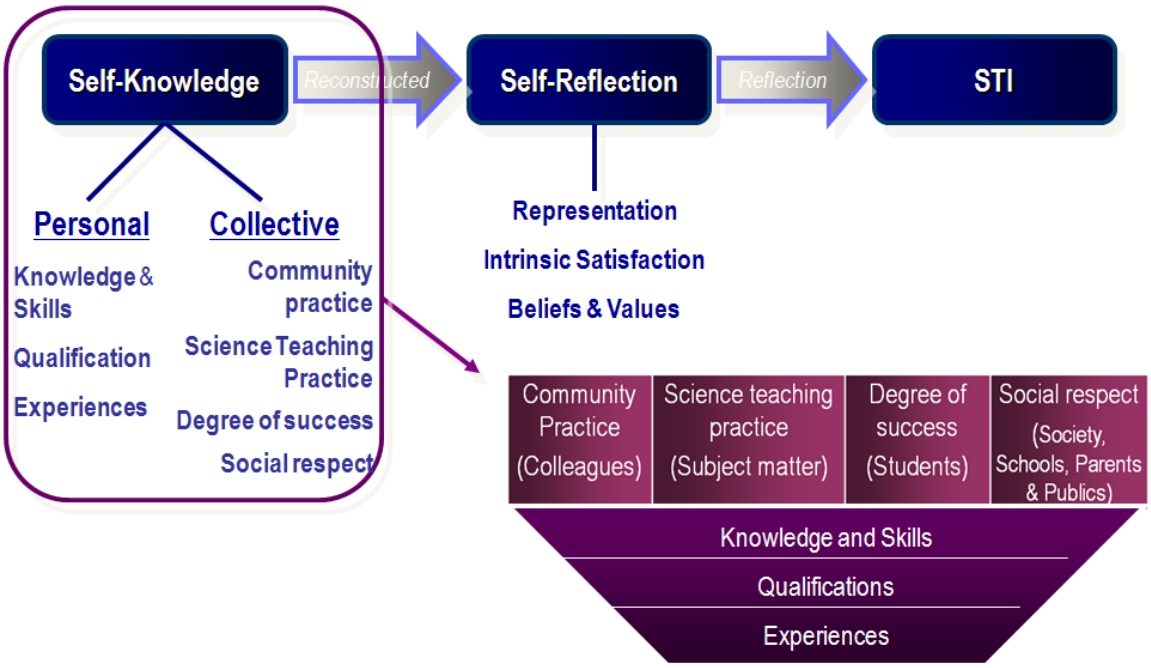


Figure 4. Science Teacher Identity Model (STI Model)

Therefore, science teacher identity, then, is conceptualized in a new model consisting of two components: a structural component including self-knowledge and self-reflection dimensions, and a procedural component (See Figure 4). In this new model, science teacher identity is based on a construction of self-knowledge, including personal and collective self-knowledge; reconstructed by self-reflection dimension; and then, reflected on self to form an individual science teacher identity. An essential aspect in construction of science teacher identity is characterized by the subject matter, "science." The importance of science in conceptualizations of science teacher identity is supported by many studies (Abell, 2000; Eick & Reed, 2002; Enyedy, Goldberg, & Welsh, 2006;

Helms, 1998; Kozoll & Osborne, 2004; Proweller & Mitchener, 2004; Varelas, House & Wenzel, 2005; Volkmann & Anderson, 1998). In particular, Helms (1998) and Volkmann and Anderson (1998) have suggested that science plays a crucial role in shaping the images of the science teaching profession and science teacher careers. Also, it has been emphasized that the influences of learning experiences, knowledge and skill, collaboration, social respect, success, beliefs and values, and intrinsic satisfaction in relation to "science" are significant in shaping science teacher perceptions on selves (Abell, 2000; Eick & Reed,2002; Enyedy et al., 2006; Helms, 1998; Kozoll & Osborne, 2004; Lederman, 1992 & 1996; Lunn, 2002; Proweller & Mitchener, 2004; Solomon, Scott, & Duveen, 1996; Solomon 2000; Varelas et al., 2005; Volkmann & Anderson 1998).

The Self-knowledge dimension of science teacher identity includes both personal self-knowledge and collective self-knowledge. Personal self-knowledge is gained through life experiences, growth history, personal background, and education; whereas collective self-knowledge emerges from factors outside of self, such as expectations of others, classifications, recognitions, interactions, and collaboration with others and agencies. Therefore, personal self-knowledge is constructed through learning experiences, gaining qualification, and acquiring knowledge and skills, while collective self-knowledge is constructed from community practice through collaboration with colleagues, science teaching practice driven by the nature of the subject matter, degree of success as a result of interactions with students, and the social respect afforded science teachers by institutions, parents, and the general public.

While constructing self- knowledge, self-reflection dimensions are also reciprocally constructed (e.g. beliefs and values in science teaching, intrinsic satisfaction and representation) leading individuals to form beliefs about "who I was, am and will be." Positive beliefs, values, and intrinsic satisfaction from science teaching reflect positive images, ambitions, visions, goals and attitudes related to science teacher identity. Through the process of reflection on selves based on self-knowledge and self-reflection, science teachers construct a science teacher identity.

Development and Field-Testing of the STI Instrument

In this section, the purpose of the study was to develop a new instrument that could be used to measure the levels of science teacher identity among preservice and practicing science teachers. In particular, the aim was to develop an instrument using a Likert scale based on dimensions of Science Teacher Identity proposed above, refine the instrument through a process of content validation, and field-test the instrument for evidence of reliability.

Pilot Study of the Initial Instrument

The purpose of this pilot study was to examine the content validity of a new instrument for measuring the Science Teacher Identity of preservice and practicing science teachers. To ensure the validity of the instrument, the content of items was verified by comparing with interview data about rating the validity of each item and personal comments on their understanding each item from respondents.

This pilot study was designed to examine a new instrument to measure a psychological construct, science teacher identity. Data was collected from directly

administered questionnaires and personal interviews. The participants were drawn from a specific population who are preservice and practicing science teachers enrolled in or graduated from a major Midwestern research University.

Participants

Participants' representatives of the target population of interest: preservice and practicing science teachers. This pilot study included nine participants who were graduate students enrolled in or graduated from science teacher education programs or advanced science education programs at the major Midwestern research university. All participants were adults, over the age of 18.

Participants were randomly recruited by verbal request. All graduate students enrolled a cohort of science teacher education program were invited to participate. Advanced graduate students enrolled advanced science education program were recruited through individual contacts, using a random list of enrolled students who are experienced science teachers.

Instrument

For this study, an instrument of science teacher identity was developed in order to measure the level of science teacher identity of preservice and practicing science teachers (Appendix A.). The questionnaire instrument was developed by reviewing literature on teacher identity (Abell, 2000; Eick and Reed, 2002; Enyedy et al., 2006; Helms,1998; Vareals et al, 2005; Volkmann & Anderson, 1998), revising the Helms's multidimensional model of identity (1998), and following the format of "Instrument of Physician Teacher Identity (Starr, et al., 2006)." As a result, a 46-item questionnaire measured nine dimensions of the STI model: science teachers' personal learning

experience, having knowledge and skills, community practice, science teaching practice, degree of success, social respect, belief and value in science teaching, intrinsic satisfaction, and representation. The instrument was scored on a 5-point Likert scale from "strongly disagree" to "strongly agree."

To validate the content of each item, the instrument of STI was modified as a questionnaire to rate the validity of each item (Appendix B). The content validity of each item for measuring science teacher identity was rated on a 4-point Likert scale (not at all, somewhat, important, and critical).

Data Collection

The data were collected in two ways, a directly administered questionnaire and personal interview. It took approximately five weeks to conduct this pilot study including recruitment of participants, consent process, administration of a questionnaire and interview. The 46-item instrument of STI was administered to participants including preservice and practicing science teachers. After this administration, the respondents were asked to rate the validity of each item for measuring science teacher identity using a questionnaire for content validity. They were interviewed to state personal comments on their understanding of what each item meant and thoughts of how they rated each item. The interviews were recorded on audio tape and transcribed by the researcher. After data collection, a revision process of an initial instrument of STI was followed with feedback from a panel of experts in science education.

Data Analysis

The content validity of the instrument was analyzed by using respondents' ratings of the validity of items and comments of understanding the items. The transcripts of

interviews were analyzed by the researcher and other colleagues for triangulation. The further analysis of content validity was verified by feedback from a panel of experts in science education.

Field-Testing of the STI Instrument

The purpose of this field-testing was to explore whether a new instrument could measure reliably and consistently the level of science teacher identity among preservice and practicing science teachers. To estimate the reliability of the instrument, the revised 48-item instrument of STI was field-tested through direct (paper survey) and indirect (online survey) administration to participants who were members of professional associations of science teachers by analyzing internal consistency reliability (Cronbach's alpha). This field-testing was designed as a cross-sectional survey research that was conducted from a cross-sectional sample at a single point in time.

Participants

The participants of this study were representative of the target population: preservice and practicing science teachers. They were members of Midwestern professional organizations or National associations of science teachers. They were typical of preservice teachers intending to become licensed science teachers and practicing teachers with a licensure as science teachers including life science teachers, physical science teachers, and earth science teachers. All participants were adults, over the age of 18. The participants were invited and recruited by verbal request and electronic mail. For a direct administration of the STI instrument, participants who attended a conference held by Midwestern professional organizations of science teachers were randomly recruited with verbal request. For an indirect administration, participants who were a member of

National associations of science teachers were randomly invited and requested to participate in an on-line survey through the electronic mailing list servers. Participants chose voluntary whether they would participate in this survey by responding to a directly administered (paper) survey or to an indirectly administered (on-line) survey. The written consent process was waived by the Institutional Review Board. Of total 476 participants, only 414 participants had completed a questionnaire: 48 of 66 participants for a direction administration and 366 of 410 participants for an indirect administration.

Instruments

For this field test, a 48-item questionnaire was used as a new instrument for measuring STI (Appendix C). The initial instrument of STI was grammatically corrected, rearranged and reformatted through content validation in pilot study. The validity of each item for measuring science teacher identity was rated on a 4-point Likert scale. Through this validation process, 28 items were refined and two items were split into two parts, resulting in a revised questionnaire of 48 items: An item (No. 4) scored under a point 2.0, marked as "somewhat" was revised and six items (No. 3, 5, 16, 20, 29, 30 and 39) scored at margin of or under a point 3.0 marked as "important" were reworded. Additionally, 23 items were refined so that the content of items would be clarified. Among them, two items No. 18 and 37 were split into two parts (Attached in Appendix C). The 48-item questionnaires for the directly administered survey and the on-line survey were equivalent and identical. The instrument was scored on a 5-point Likert scale from "strongly disagree" to "strongly agree." Participants were asked to indicate their opinion about each statement by circling or clicking the appropriate responses in the

questionnaire. Instructions were included in the questionnaire, and participants were advised that there were no correct or incorrect answers; frank opinions were desired.

Data Collection

Data were collected using a cross-sectional sample by conducting a survey of science teachers from a broad range of grade levels concurrently. The revised 48-item questionnaire was directly and indirectly administered: a paper survey and on-line survey. For a direct administration, participants who attended an annual conference held by Midwestern professional associations of science teachers were surveyed immediately following recruitment during three days. For an indirect administration, participants who were members of National professional associations of science teachers were invited to participate in an on-line survey by providing the Internet address through the electronic mailing list servers during a month. The number of completed surveys was 430 of 476 surveys: 64 of 66 direct administered surveys and 366 of 410 on-line surveys, respectively.

Data Analysis

The responses of participants to the instrument were analyzed using the Statistical Package for Social Sciences. Scores on the instrument were characterized using descriptive statistics including means, standard deviations, and variances. The reliability of the instrument was analyzed using Cronbach's alpha for the questionnaire as a whole, and for each subscale of the instrument.

In addition, factor analysis was used to analyze the correlation of factors associated with the conceptual dimensions of the science teacher identity instrument: personal learning experience, having knowledge and skill, community practice, science

teaching practice, degree of success, social respect, belief and value in science teaching, intrinsic satisfaction, and representation. Whole scale and subscale scores of participants were analyzed by multiple statistical analyses (e.g., One-Way Analysis of Variance [ANOVA], *t*-Test, and correlation analysis) to understand group differences based on demographic profiles, e.g., gender, degree, years of teaching and subject areas.

Examination of the STI Model within a Science Teacher Preparation Program

In this section, this study aimed to examine quantitatively and qualitatively the efficacy of the model of science teacher identity among preservice science teachers in constructing their own science teacher identity within a context of graduate level of science teacher preparation programs. In particular, this study focused on how preservice science teachers develop their own science teacher identity and how teacher education programs impact the construction of science teacher identity. First, the level of science teacher identity among preservice science teachers was investigated by quantitative data using a directly administered questionnaire as a pretest and posttest before and after student teaching. Second, the process of the development of science teacher identity was explored by qualitative data using personal interviews, portfolios, reflections on field placement, academic records including biography and course grades and mentors' or supervisors' evaluations of students.

Context

This study was conducted in a graduate level of science teacher preparation program in the Midwestern research university. The teacher education program was begun 100 years ago in this university, and has been highly regarded in the areas of

elementary education, secondary education, school counseling, and educational administration. The institution is strongly committed to reform of teacher education. The science teacher preparation program has offered the Master of Education (M.Ed.) licensure program including the intensive coursework of five quarters from the summer through the following summer, a year-long field experience for student teaching including observation, participation, and internships, and an action research project as the 5th year program. Through this program, preservice science teachers can obtain both a M.Ed. degree and licensure for secondary science education.

Participants

The participants of this study were representative of the target population: preservice science teachers enrolled in a teacher preparation program at the major Midwestern research university (e.g., M. Ed program). They were typical of graduate students intending to become licensed science teachers including life science/biology teachers, chemistry teachers, physics teachers, earth science teachers, environmental science teachers, physical science teachers, or general science teachers. All participants were adults, over the age of 18.

All members of a preservice science teacher cohort were invited and 21 graduate students were randomly recruited through verbal requests. For interviews, six respondents were selected by purposive sampling. All participants were surveyed using the STI instrument. According to scores from the first administration of the questionnaire, all participants were grouped into three levels: weak (lower 33.3 %), moderate (middle 33.3%), and strong levels (upper 33.3%) of science teacher identity, each including seven participants. Then, lists of subgroups were created of individual members for a further

selection. From each subgroup, two respondents were purposively selected as interviewees. All data collected from participants were kept in strictest confidence as each response to the questionnaire and students' work document were assigned a number but only data from six respondents were identified by pseudonyms.

Instruments

For this study, the STI instrument was used as the same as used in field-test (Appendix C). After field-testing, the STI instrument was not revised.

Data Collection

Both quantitative and qualitative research methods were employed to examine the conceptual model of STI among preservice science teachers. It took approximately 20 weeks from the beginning of Winter 2008 through the end of Spring 2008 to conduct this study, including recruitment of participants, consent process, selection of interviewees by purposive sampling, two-time administration of the questionnaire, three-time interviews, and three-time collections of documents.

As a quantitative method, a one-group pretest-posttest was employed to investigate the change in the level of science teacher identity among preservice science teachers before and after student teaching during science teacher preparation program. Following the one-group pretest and posttest design, the questionnaire was administered to preservice science teachers enrolled in the science teacher preparation program at the beginning of winter 2008 and about 20 weeks later at the end of spring 2008.

As qualitative research methods, personal interviews and documents were collected.

The questions of personal interviews were designed as open-ended and structured format. Three-time interviews were conducted to only six participants selected by purposive sampling in order to gather preservice science teachers' beliefs and opinions about the process of development of their own science teacher identity. The interviews were conducted at the beginning, middle, and end of student teaching. A structured interviewing format was followed, with all respondents asked the same series of open-ended questions (Appendix D): Interview I consisted of 11 questions about how participants decided to become a science teacher, how they perceive a science teacher, what they experienced during the first field placement, and what they expected to learn from student teaching in Winter 2008; interview II consisted of seven questions about what they gained from their mentor and experienced during student teaching, how they compared their expectations with their experiences in student teaching, and how they felt about their progress in preparing to be a science teacher; interview III consisted of 27 questions about how they viewed themselves as science teachers, how they viewed science teaching as a profession, how science teachers are characterized, how student teaching experiences impacted the development of their science teacher identity, and how their evaluation of science teacher education programs. Interview responses were recorded with audio tapes by taking notes and then transcribed.

Document analysis was used to identify relevant information of participants for data triangulation. The documents were collected through electronic means (e.g. Carmen is a course management program used in the Internet that allows instructors and students to archive online communication.). Collected document data included primary and secondary sources. Primary sources that participants created directly were portfolios,

reflections, and evaluations of courses, mentors, and supervisors and secondary sources that others created about participants included students', mentors', and supervisors' evaluations of student teaching and academic records including biographies and course grades.

Data Analysis

The collected data were analyzed quantitatively and qualitatively.

In order to investigate the level of changes in STI associated with engagement in a science teacher preparation program, particularly student teaching, statistical techniques including descriptive statistics, *t*-Test and ANOVA were used to analyze both pretest and posttest scores of the instrument.

Personal interview data and documents were analyzed by free-flowing text analysis. Through this process, both inclusive and exclusive elements in relation to the conceptual framework were considered potentially important elements in constructing a model that represents the relationships among them. For ensuring the trustworthiness of qualitative data (e.g., interview and document analysis), member checking from participants and peer debriefing were conducted.

Limitation

The one-group pretest and posttest design employed in this study is categorized as one of pre-experimental research design that extraneous variables are not controlled and results are interpreted without a control group. As a pre-experimental research design, the one-group pretest and posttest design may produce threats to internal validity (e.g. history, maturation, and pretest sensitization) (Ary, Jacobs, & Razavieh, 2002). Despite this weakness, this research design might be appropriate for the purpose of this study that

was not to examine 'the cause and effect' using a standardized instrument but to explore 'change and development' using a diverse resource, such as questionnaire, interview, and document.

In this design, samples were not randomly assigned and an experimental treatment was not provided. Under an existing situation, already existing samples (e.g. M. Ed cohort) was targeted as participants. In addition, extraneous variables provided in science teacher preparation programs (e.g. course works, portfolios, field placement, student teaching, and action research) and relationship between them were not manipulated and explored.

Although the one-group pretest and posttest design may threaten the internal validity of this study (e.g. history, maturation, and pretest sensitization), this study attempted to avoid these effects.

For history effect, there was no specific event that may affect the change of pretest and posttest scores during the period between a pretest and posttest. The pretest and posttest was conducted before and after student teaching (Ary et al., 2002). For maturation, participants might not perform differently due to biological growth in this study because this study was conducted in a short period, 6 months (Ary et al., 2002). For pretest sensitization that the first administration of questionnaire may affect participants' attitude toward an issue studied, an equivalent forms of the questionnaire was used in the posttest rather than same forms of it used in the pretest (Ary et al., 2002).

Chapter 4: Results

This chapter presents the results associated with examining the reliability and validity of the STI instrument and exploring the efficacy of the STI model and STI instrument in examining the levels of science teacher identity among preservice science teachers. In the first section, the results of field-testing the new STI instrument include descriptive statistics, estimates of reliability and validity for the STI instrument, correlation patterns among several variables related to the conceptual model on which the instrument is based, and the outcome of a factor analysis used to examine the predicted dimensions of science teacher identity. The second section presents findings associated with use of the STI model and instrument to examine levels of science teacher identity among preservice science teachers in a science teacher preparation program. A mixed-methods approach included a one-group pretest-posttest design using an STI questionnaire coupled with qualitative methods: document analysis and personal interviews.

Development and Field-Testing of the STI Instrument

A 48-item questionnaire of STI was developed using Likert items to measure nine dimensions of the STI model (e.g., science teachers' personal learning experience, having knowledge and skills, community practice, science teaching practice, degree of success, social respect, belief and value in science teaching, intrinsic satisfaction, and

representation.). The subscale of the instrument was checked for content validity, and the reliabilities of the subscales and total instrument were analyzed. Also, the functional structure of the instrument using factor analysis and examining the pattern of correlations among subscales were examined for evidence of postulated interrelationships.

Content Validity

The content validity of the initial instrument was examined through interviews with nine experienced science teachers and from feedback provided by a panel of experts in science education. The first validation process required participants to rate the validity of each item for measuring science teacher identity on a 4-point scale (not at all, somewhat, important, and critical) and state personal comments on their understanding of what each item meant and thoughts of how they rated each item. As result, the mean score of the validity for a 46-item questionnaire was 3.43 ± 0.4, ranging from 2.00 through 3.88 (Table 4). Table 4 summarizes the revising process of the initial instrument of STI based on comments and feedback with the score of content validity. Through this process, 30 items were refined, resulting in a revised questionnaire of 48 items: One item that scored under a point 2.0 of validity, marked as "somewhat" was revised and six items that scored at a margin of or under a point 3.0 of validity marked as "important" were reworded. Additionally, 21 items were refined so that the content of items would be clarified and two items were split into two parts. Likewise content of items for a new instrument of science teacher identity were verified.

As a result, a 48-item questionnaire was revised by following above process, and then administered to 476 science teachers for further field-testing.

Dimension	Items	Content Validity (M ± SD)	Comments	Revision
Science teachers' personal learning experience	1. I have been interested in science.	3.38± .420	• That's a part of the absolute basic part of being a teacher being interested in science. • These weren't my interest science at all. I wouldn't be doing this job. • It should be reworded. • When?	1. I was interested in science as a student.
	2. I enjoyed learning science.	3.13±.441	• because I know good teacher who didn't enjoy it yet when they were students • When I enjoyed? as students? • Science teachers should enjoy science. • It should be reworded.	2. I enjoyed learning science in schools.
	3. I was good at doing science.	**2.63±.375**	• When I was good at science? • What does "doing science" mean? in the lab? These experiences could happen to college or graduate students... • It should be reworded.	3. I was good at doing science in schools.
	4. I got a higher grade in science than other subjects.	**2.00±.327**	• Problematic: Does high Grades really influence on their decision to be a science teacher? • When do I get a higher grade? • My grades and my knowledge in science made me to be able to enter the college to study science. • -Science teachers are **Not "Scientists."** -Students have **anxiety** about higher grade on science.	4. I got higher grades in science than other subjects.
	5. I liked science teachers who taught me.	**2.88±.350**	• Problematic: Role model or none.. • Because I didn't have a good science teacher • Because a lot of time you used that best experience with a science teacher a kind of model how we teach, they can turn a whole life. • And why they want to teach high school science, some people didn't like science teachers in high schools.	5. I had a science teacher that I want to be alike.

Continued

Table 4. Revision Process of the STI Instrument

Table 4 continued

Dimension	Items	Content Validity (M ± SD)	Comments	Revision
Having knowledge & skill	6. I know and understand the major scientific concepts and processes that I plan to teach.	3.88±.125	• Split to conceptions and processes. I know and understand the major scientific concepts that I plan to teach. I know and understand the major processes that I plan to teach.	6. I know and understand the major science concepts and science processes that I plan to teach.
	7. I integrate scientific knowledge to knowledge of science education, learning, pedagogy and students.	3.88±.125	• It should be reworded. • That was difficult question for me to comprehend what you really want to say. • I integrate scientific knowledge into understanding of science education, learning, pedagogy, and students. • I integrate scientific content knowledge into my teaching science, my pedagogy and science learning	7. When I teach, I am able to integrate my knowledge of science with knowledge of science teaching and learning.
	8. I feel skilled as a science teacher.	3.75±.164	• What does "skilled" mean?	8. I feel skilled as a science teacher.
	9. It is important to me to develop my knowledge and teaching skills.	3.63±.263	• It's confidence.	9. It is important to me to develop my knowledge and teaching skills.
	10. I read journals about science teaching.	3.25±.250	• Problematic: An active teacher is reading journals for their teaching? • Problematic: cultural background in other country, they can get this kind of information from textbooks than journals. • I read journals and articles about science teaching.	10. I use the Internet, journals, and articles to gain information about science teaching.
Community practice	11. I feel part of a community of science teachers.	3.38±.263	• What is the community of science teachers? • I feel like I am a part of community.	11. I feel part of a community of science teachers.
	12. I belong to professional associations or groups of science teachers.	3.25±.250	• In other country, there are few associations that science teachers can participate…	12. I belong to professional associations or groups of science teachers.

Continued

Table 4 continued

Dimension	Items	Content Validity (M ± SD)	Comments	Revision
	13. I frequently talk to colleagues about teaching science.	3.50±.189		13. I frequently talk to colleagues about teaching science.
	14. It is helpful to be able to discuss the progress of students with colleagues.	3.25±.250		14. It is helpful to be able to discuss the progress of students with colleagues.
	15. I enjoy sharing ideas and resources about teaching science.	3.63±.183		15. I enjoy sharing ideas and resources about teaching science.
Science teaching practice	16. I have own my perspective on the nature of science.	**2.88±.350**	• Problematic: What is "nature of science"?/Whether it is acceptable to the scientific community or not? • According to standards, the nature of science is just 6 steps of scientific methods. • I have my own perspective on nature of science • I understand the nature of science or I understand the methods of science. • -"My own perspective" -I have my own perspective on the nature of science. -There are a lot of discussions about the nature of science. -perspective-> belief, understanding -belief about evolution/creation -I have my own understanding of nature of science. -Reverse this item. -I do not understand nature of science.	16. I am not sure how science differs from other disciplines and subject areas.
	17. My understanding of science shapes my teaching philosophy and attitude.	3.63±.263	• This is the same as number 16. And again their philosophy, attitude definitely affect their understanding of science and teaching of science • To be more specific.. it affects my way of teaching? • How do you understand science? what does it means?	17. My understanding of science shapes my philosophy and attitude about teaching.

Continued

Table 4 continued

Dimension	Items	Content Validity (M ± SD)	Comments	Revision
	18. I plan and use an inquiry-based teaching and learning for my students.	3.50±.267	• What kind of inquiry-based teaching& learning? Narrow down it. • It should be reworded. • I plan and use inquiry-based teaching with my students. • Separate "plan" and "use" 1) I plan an inquiry –based teaching and learning for my students. I use an inquiry –based teaching and learning for my students. • I believe inquiry-based teaching is so important for learning science.	18. I plan an inquiry-based science lessons. 19. I use an inquiry approach to teaching.
	19. I employ diverse instructions and activities to teaching science.	3.75±.164	• I employ diverse methods of instructions and activities in teaching science. • I employ diverse teaching strategies and activities in teaching science.	20. I use diverse instructions and activities to teach science.
	20. There is a difficulty to demonstrate my scientific knowledge in teaching science.	**2.43±.429**	• It should be reworded. • It is difficulty to demonstrate scientific knowledge while teaching science. • I find it difficult to demonstrate my scientific knowledge in teaching science. • It's difficulty for me to demonstrate my scientific knowledge in teach knowledge, teaching science. • only negative one • Make a reverse item • That helps a person know what their limits are.. that's part of identity. • In other country, there are some limitation of using a resource for teaching.. it causes teaching difficult • What does "difficulty" mean? • I don't find the difficulty to demonstrate I mean I think that's one I connect. So, I find very easy to demonstrate a lot of skills. • STI needs "parallel questions."	21. I find it difficult to demonstrate my scientific knowledge while teaching science.

Continued

Table 4 continued

Dimension	Items	Content Validity (M ± SD)	Comments	Revision
Degree of success	21. I interact with students to find their needs, interests, and abilities of learning science.	3.75±.164	• I interact with students to identify their needs, interests, and abilities in learning science.	22. I interact with students to find their needs, interests, and abilities of learning science.
	22. I facilitate students more engaged in learning science.	3.38±.183	• It should be reworded. • You help students being more engaged in or for What? • This sentence is not clear.. Where are they engaged? • I facilitate students being more engaged in learning science. • I facilitate students to become engagement in learning science. • I facilitate more like getting students engaged in science. • I facilitate students being more engaged in learning science. • You help students being more engaged in learning science. • Foster an interest I foster students more interest in learning science. • Cultivate an interest: I cultivate students' interests in learning science.	23. I help students become more engaged in learning science.
	23. I create a flexible and supportive learning environment for students.	3.63±.183	• I don't know what the "flexible" is but "supportive	24. I create a flexible and supportive learning environment for students.
	24. I make a positive progress in students' achievement and performance in learning science.	3.63±.183	• I make positive progress in students' grades and performance in learning science. • What is difference between achievement and performance? • Which word is working instead of progress? Difference? Impact? Change? • You may want to say that my students continue to increase in their achievement and performance. • I positively impact student achievement. • I make a positive difference in students' achievement and performance in science. • "Make a difference" I make a difference in students' achievement and performance in science.	25. I positively impact student achievement in science.

Continued

Table 4 continued

Dimension	Items	Content Validity (M ± SD)	Comments	Revision
	25. I give students an important perspective on science.	3.25±.313	• Problematic: "give" • Science teachers should not give but present multiple perspectives and helps students to form it on... • Problematic: what is "important perspective"?	26. I help students to perceive the unique of nature of science.
	26. I am a role model for students who have interest in science.	3.50±.267	• A role model for scientist? doing science • Add the second one: I am a role model of students who have no interest in science. • I am a role model for students. • I am a role model for students who are interested in science. • I'm a role model for students who have and interested in science.	27. I am a role model who generates interests in science.
Social respect	27. I enjoy the social recognition I get as a science teacher.	3.25±.313	• It depends on how society see them… it could be answered by both ways. • I think that I really interesting but it's true when we meet people, people say that science teachers "Oh wow~~ ."People see that and does it make you feel different.. So, that how I can.. determine number 4 • I would say I'm a science teacher rather than taught physics because if I say I teach physics, then they think the brain then wouldn't... They just thought I'm just too smart… because physics is a hard subject, So, social recognition is not something that I go for.. • That's what I am saying I don't care about this social recognition very much. • Replace "social recognition" with "respect" I enjoy social respect I get as a science teacher.	28. I enjoy the social respect I get as a science teacher.
	28. Students and/or other teachers (faculty) regard me as an effective science teacher.	3.50±.267	• Problematic: "effective" because there are so many meanings of it by who see science teachers... teachers' or students' perspective are so different .	29. Students and teachers regard me as an effective science teacher.

Continued

Table 4 continued

Dimension	Items	Content Validity (M ± SD)	Comments	Revision
	29. It is important that institutions (e.g. colleges or teacher education programs) recognize my teaching in some way.	**2.63±.324**	• Problematic: Why is it important? I didn't understand why we care our colleges recognize my teaching. • Colleges or teacher education programs? • It is important that my teacher education program recognize my teaching in some way. • When I believe myself science teacher and if I wait it for somebody to reward me doing such a good job and it wouldn't happen often. My STI isn't dependent on whether others recognize my good teaching or not. • 'I am recognized as a teacher.' That recognition would give me more confidence maybe. But again that depends on somewhat important because again some recognition may not be important for all teachers. • -Replace institutions with Teacher education programs, supervisors, principals… -Values qualities of my teaching. -It is important that teacher education programs(supervisors or principals) values qualities of my teaching. • It is important that our college programs(teacher education program) educate us for schools.	30. It is important that my good teaching be recognized in some ways.
	30. The school/district rewards my teaching (e.g., monetary rewards, a parking pass, library privileges and financial support for professional development).	**2.75±.366**	• Problematic: It's not applicable for M.Ed to get this stuff for good teaching because of students and interns • Parking passes and library privileges are not used for rewards. There's a certain amount of professional development that everybody entitles too if they want take it. • It wasn't important that I got rewarded from my teaching. • Replace the school/districts with "Teacher education program" - Teacher education program rewards my teaching.	31. I appreciate it when my institutions acknowledge my success as a science teacher.
Belief and value in science teaching	31. It's important to contribute to science education.	3.43±.202	• It's important to contribute to science education knowledge. • It's important for me to contribute to science education. • Who may contribute to science education? Add "for me." • Science education of "students"? or professional community by conducting research? • "Science education" is a broad concept.	32. It's important to me contribute to improvement of science teaching profession.

Continued

Table 4 continued

Dimension	Items	Content Validity (M ± SD)	Comments	Revision
	32. I find it satisfying to think that I am contributing to the profession by teaching.	3.25±.250	• What does "professional teaching" mean? • Which profession? Science careers or teaching? • Do you want to contribute to your profession? Or do you want to increase students' learning and increase? • There is no specific explanation about profession. There is no a way how to do, by teaching, by commitment to teaching job, by devotion to teaching? • I find it satisfying to think that I am contributing to the teaching profession.	33. I find it satisfying to think that I am contributing to the profession by teaching.
	33. I conduct meaningful and interesting learning science to students.	3.38±.263	• It should be reworded. • Learning science? science learning? • Not learning… but teaching • I conduct meaningful and interesting science lessons to students. • I make a learning science meaningful and interesting to students. • I conduct meaningful experience and relevant learning science for students.	34. I make a learning science meaningful and interesting to students.
	34. Good teaching has contributed to my career advancement.	3.25±.313	• If it's for M.Eds, "I would do good job in internship, I maybe find schools that will be popped into any graduates. The other thing, if you get late,, they maybe some districts reward good teaching. some districts reward good OGT scores..." • What is this question looking for? • What does "good teaching" mean? • I believe that good teaching will contribute to my career advancement. • Problematic: Good and my.. Replace "good" with "the quality of my teaching" -What does "career advancement" mean? professional development? positions of careers e.g. principal, supervisor teacher identity development?	

Continued

Table 4 Continued

Dimension	Items	Content Validity (M ± SD)	Comments	Revision
Intrinsic satisfaction	35. I truly enjoy the role of science teacher.	3.88±.125	• "a of role" is not common use. • I truly enjoy being science teachers	36. I truly enjoy being a science teacher.
	36. Working with students has its costs, but it's worth it.	3.75±.164	• Working with students is the most important for STI? • If you have this identity as a science teacher, I think it really critical that you think it worth doing. • I think working with students spend a lot of time.	37. Working with students has its costs, but it's worth it.
	37. I find satisfaction watching my students and/or teaching profession progress.	3.75±.164	• Separate two, for students and for teaching profession • I find satisfaction watching my students' progress. • I find satisfaction watching teaching profession progress. • What does it mean? • Teaching "career" for progress? Do you mean teaching skills? That teaching career is employment, getting new responsibility, getting pay more, teaching skills would be..	38. I find satisfaction in watching my students' progress. 39. I find satisfaction in my own development as a science teacher.
	38. Teaching is a more rewarding job.	3.25±.313	• What does rewarding mean? • More rewarding than what? "more" means a comparing with something. • Teaching is a personally rewarding job • Teaching is a momentary rewarding job • Teaching is a rewarding job. • Teaching is very rewarding job. • Teaching is mostly rewarding job. • More than what? -I hoped more qualified my teaching.	40. Science teaching is very rewarding job.
	39. It is important to me to work in schools.	**2.63±.263**	• Problematic: just in schools? STI works in just schools or everywhere. • I consider myself science teacher always. I may or may not be in science class when I was with students K-12 but I work as a science teacher. • Informal education areas: zoo, natural center, museum, national park than "schools"? • It's true that's important to me to work in schools but, that doesn't make me a feel like a science teacher	41. It is important to me to work in schools.

Continued

Table 4 Continued

Dimension	Items	Content Validity (M ± SD)	Comments	Revision
			• For me, it wasn't important that I work in schools. • "Work in schools" Not necessary. I don't like to find a someone because I'd like to go to the field trip and take kids outside of schools. So, it's not necessary and important for me to work in the school. • Do we need to distinguish Informal teachers vs. formal teachers? Which one is important for STI? Is it important to help students learning? It is important to help students learn in formal schools, traditional schools, formal settings or informal settings. Is it important to be with students? not just in schools?	
	40. Both teaching and science are pleasing to me.	3.75±.164		42. Both teaching and science are enjoyable to me.
Representation	41.I see myself as a science teacher.	3.75±.164	• To be confident in becoming a science teacher. • -Remain blank for teachers to mark directly as " " or give other examples e.g. learning facilitator, professional demonstrator, learner.. I see myself as (blank) OR a science teacher( ) learning facilitator( ) professional demonstrator( ), learner( )	43. I see myself as a science teacher.
	42. I would like to be a more knowledgeable and skillful teacher.	3.75±.164	• Strong STI could be related to intention to improve themselves, e.g. professional development.	44. I would like to be a more knowledgeable and skillful teacher.
	43. I would like to spend more time teaching students.	3.25±.366	• Spent more time doing what? • My 40 or something 20 hours a week is more than enough.. • Some science teachers have a huge teaching responsibility so they might think that they can be better science teachers of fewer students. • Current teaching hour is not enough? or not?	45. I would like to spend more time teaching students.
	44. I would like to be a better science teacher for my students.	3.75±.164	• Do not need to be a better science teacher "for students." Remove this part.	46. I would like to be a better science teacher for my students.

Continued

Table 4 continued

Dimension	Items	Content Validity (M ± SD)	Comments	Revision
	45. I would like to be more involved in a community of science teachers.	3.38±.263	• What does "a community of science teachers" mean?	47. I would like to be more involved in a community of science teachers.
	46. I would like to be more rewarded for my teaching.	3.00±3.78	• Define: personally or monetary rewarding? • That (e.g. money) doesn't change my thinking of myself as a science teacher • It could be answered by two ways: strongly agree for more rewarding for their teaching… strongly disagree for not caring this.. or enough rewarding… • More than what? -I hoped more qualified my teaching.	48. I would like being rewarded for my teaching.

Note. Green sentence represents a feedback of panel expert.

Field-Testing of the STI Instrument

The reliability and validity of the STI instrument was explored using a cross-sectional sampling of science teachers from a broad range of grade levels by conducting direct and indirect administrations of the instrument.

Participants

The total number of participants contributing to the final dataset, then, was 476 preservice and practicing science teachers, including 410 who participated in the on-line survey and 66 who participated in the paper survey. Of these, 87 % (414) of 476 participants completed the survey in its entirety, including 114 males and 300 females. Of 430 participants providing complete demographic information, 28 identified themselves as preservice teachers, while 402 identified themselves as practicing teachers: 93 certificated as elementary school science teachers, 313 certificated as secondary school teachers, and 23 certificated as both elementary and secondary school science teachers. One practicing teacher was not yet certificated. The number of years of teaching for practicing teachers ranged from 0 to 43, with the average number of years being 24 ± 10.55.

As shown in Table 5, 130 participants reported having a bachelor's degree as the highest degree, 280 had a master's degree, and 20 reported having a doctoral degree. In terms of academic majors, 26.4 % of participants reported majoring in life sciences and biology; 7.6% majored in earth sciences; 9.6% majored in chemistry; 3.4 % majored in physics ; 2.8% majored in physical science; 19.7% majored in science education; 11.8% majored in elementary education; and 18.7% majored in other subjects (e.g. music, vocation education, technology, and mathematics). The science subjects taught included

life sciences/biology, physical science, earth/space sciences, chemistry, general science, environmental science, and physics (See Table 6).

	Bachelor	Master	Doctorate	Counts(%)
Majors				
Life sciences/ Biology	194(20.2%)	54(5.6%)	6(.6%)	254(26.4%)
Earth/Space sciences	50(5.2%)	23(2.4%)	0	73(7.6%)
Chemistry	73(7.6%)	16(1.7%)	3(.3%)	92(9.6%)
Physics	26(2.7%)	7(.7%)	0	33(3.4%)
Physical science	23(2.4)	4(.4%)	0	27(2.8%)
Science education	74(7.7%)	108(11.2%)	7(.7%)	189(19.7%)
Elementary education	67(7%)	45(47%)	1(.1%)	113(11.8%)
Other	85(8.8%)	90(9.4%)	5(.5%)	180(18.7%)
Highest Degree Level	130(30%)	280(65%)	20(5%)	
Total counted participants	430			
Total counted responses	961			

Table 5. Majors and Degree of Science Teachers

Note. Degrees and majors were multiple response questions.

Science subjects taught	Response Count	%
Life sciences/Biology	301	18.4%
Earth/Space sciences	220	13.5%
Environmental science	183	11.2%
Chemistry	191	11.7%
Physics	112	6.9%
Physical science	236	14.4%
Integrated science	129	7.9%
General science	190	11.6%
Intervention science	19	1.2%
Other	53	3.2%
Total counted responses	1634	100%

Table 6. Science Subjects Taught

Note. Many participants selected multiple subject areas.

Data Cleaning

Collected data were screened before data analysis. Data were collected from two data sources, a directly administered paper survey and an indirectly administered online survey. The total number of respondents was 476, including 66 using paper surveys and 410 responding to online surveys. The reliabilities of the paper and online surveys are shown in Table 7.

Questionnaire type	Online		Paper	
Reliability	Total (*n*=410)	Complete (*n*=366)	Total (*n*=66)	Complete (*n*=48)
Reliability for the whole scale	.887	.887	.907	.907
Personal experience (PE)	.780	.778	.822	.813
Having a knowledge and skill (KS)	.655	.656	.631	.704
Community practice (CP)	.743	.743	.772	.754
Science teaching practice (TP)	.613	.618	.517	.507
Degree of success (DS)	.847	.852	.863	.864
Social respect (SR)	.619	.610	.687	.654
Belief and value (BV)	.611	.608	.630	.606
Intrinsic satisfaction (IS)	.809	.806	.785	.837
Representation (R)	.647	.645	.717	.693

Table 7. Reliability of Online and Paper Surveys

In screening incomplete data, 38 datasets that included missing data for more than 40% of the items were excluded outright, leaving a total 64 paper surveys and 374 online surveys. The resulting dataset (*n*=438) included eight surveys from eight respondents who neglected to provide the solicited demographic information, leaving 430 surveys available for demographic analysis. Of these remaining datasets, 16 surveys were missing values for one or two items, so they were also excluded. Finally, a complete dataset was

identified, comprising 48 paper surveys and 366 online surveys (*n*=414). The reliability of each dataset was analyzed using Cronbach's alpha in order to assess consistency across datasets (Table 8). As can be seen, the reliabilities for the whole scale and subscales were consistent across subsamples.

	Total (*n*=476)	Incomplete I (*n*=438)	Incomplete II (*n*=430)	Complete (*n*=414)
The whole scale	.889	.889	.889	.889
Personal experience (PE)	.787	.783	.786	.783
Having a knowledge and skill (KS)	.652	.651	.654	.663
Community practice (CP)	.743	.741	.743	.739
Science teaching practice (TP)	.593	.597	.597	.600
Degree of success (DS)	.849	.851	.855	.853
Social respect (SR)	.630	.633	.625	.617
Belief and value (BV)	.613	.613	.610	.609
Intrinsic satisfaction (IS)	.806	.806	.803	.810
Representation (R)	.657	.657	.656	.651

Table 8. Reliability of Datasets

Reliability of STI Instrument

In order to examine the reliability and consistency of the newly developed Science Teacher Identity (STI) instrument, Cronbach's alpha was conducted, with the results recorded in Table 9. The reliabilities of subscales ranged from .60 through .85.

Dimensions	Items	Descriptive Statistics		Cronbach's alpha of a dimension
		Mean	*SD*	
Science teachers' personal learning experience	1. I was interested in science as a student.	4.21	1.12	.78
	2. I enjoyed learning science in schools.	4.14	.98	
	3. I was good at doing science in schools.	4.11	.95	
	4. I generally received lower grades in science than other subjects.	4.20	.93	
	5. I had a science teacher that I want to be alike.	3.42	1.26	
Knowledge & skills	6. I know and understand the major science concepts and science processes that I plan to teach.	4.61	.57	.66
	7. When I teach, I am able to integrate my knowledge of science with knowledge of science teaching and learning.	4.49	.62	
	8. I feel skilled as a science teacher.	4.35	.69	
	9. It is important to me to develop my knowledge and teaching skills.	4.84	.38	
	10. I use the Internet, journals, and articles to gain information about science teaching.	4.65	.60	
Community practice	11. I feel part of a community of science teachers.	3.93	.96	.74
	12. I belong to professional associations or groups of science teachers.	4.54	.68	
	13. I frequently talk to colleagues about teaching science.	4.12	.88	
	14. It is helpful to be able to discuss the progress of students with colleagues.	4.42	.66	
	15. I enjoy sharing ideas and resources about teaching science.	4.65	.55	

Continued

Table 9. Descriptive Statistics and Reliability of STI Instrument

Table 9 continued

Dimensions	Items	Descriptive Statistics		Cronbach's alpha of a dimension
		Mean	*SD*	
Science teaching practice	16. I am not sure how science differs from other disciplines and subject areas.	4.03	.86	.60
	17. My understanding of science shapes my philosophy and attitude about teaching.	4.09	.81	
	18. I plan an inquiry-based science lessons.	4.04	.85	
	19. I use an inquiry approach to teaching.	3.90	.87	
	20. I use diverse instructions and activities to teach science.	4.37	.65	
	21. I find it difficult to demonstrate my scientific knowledge while teaching science.	4.15	.85	
Degree of success	22. I interact with students to find their needs, interests, and abilities of learning science.	4.17	.67	.85
	23. I help students become more engaged in learning science.	4.26	.66	
	24. I create a flexible and supportive learning environment for students.	4.27	.64	
	25. I positively impact student achievement in science.	4.20	.65	
	26. I help students to perceive the unique nature of science.	4.10	.67	
	27. I am a role model who generates interests in science.	4.20	.69	
Social respect	28. I enjoy the social respect I get as a science teacher.	3.59	.95	.62
	29. Students and teachers regard me as an effective science teacher.	4.28	.60	
	30. It is important that my good teaching is recognized in some ways.	4.28	.76	
	31. I appreciate it when my institutions acknowledge my success as a science teacher.	4.00	.88	

Continued

Table 9 continued

Dimensions	Items	Descriptive Statistics		Cronbach's alpha of a dimension
		Mean	*SD*	
Belief and value in science teaching	32. It's important to me contribute to improvement of science teaching profession.	4.34	.71	.61
	33. I find it satisfying to think that I am contributing to the profession by teaching.	3.44	1.15	
	34. I make learning science meaningful and interesting to students.	4.26	.74	
	35. The quality of my teaching contributes to my career advancement.	4.34	.59	
Intrinsic satisfaction	36. I truly enjoy being a science teacher.	4.69	.55	.81
	37. Working with students has its costs, but it's worth it.	4.34	.69	
	38. I find satisfaction in watching my students' progress.	4.25	.73	
	39. I find satisfaction in my own development as a science teacher.	4.80	.41	
	40. Science teaching is very rewarding job.	4.36	.73	
	41. It is important to me to work in schools.	4.71	.47	
	42. Science is enjoyable to me.	4.50	.56	
Representation	43. I see myself as a science teacher.	4.56	.62	.65
	44. I would like to be a more knowledgeable teacher.	4.54	.63	
	45. I would like to spend more time teaching students.	3.91	.94	
	46. I would like to be a better science teacher for my students.	4.51	.59	
	47. I would like to be more involved in a community of science teachers.	4.02	.82	
	48. I would like being rewarded for my teaching.	4.12	.90	
Total		4.26	.74	.89

Factor Analysis of STI Instrument

To validate the factors postulated in the underlying structure of the STI, a common factor analysis of exploratory factor analyses was conducted. The initial 48 items of the STI instrument were subjected to principal-axis factoring with varimax rotation. Thirteen factors emerged having Eignevalues greater than one, accounting for 64 % of the variance in the results (Table 10.). In addition to the nine proposed dimensions the STI instrument, some item clusters were split into two components. For example, the dimension labeled as "science teaching practices" was divided into three factors, "community practice" was divided into two factors, and "having knowledge and skills" was divided into two factors. Consequently, a total of thirteen factors, including nine postulated factors, were extracted. As shown in Table 6, factors 3, 4, 5, 7, 9, 11, 12, and 13 were purely extracted as proposed for the STI instrument. Factors 1, 2, 6, 8, and 10 were mixed with items associated with other dimensions of STI. For example, for factor 1, the items intended to represent "degree of success," items 22-27, loaded on this factor, along with item 35(BV), 29(SR), and 20(TP) that were intended to measure other dimensions. These mixed items were removed for a further factor analysis as shown in Tables 6 and 7. In addition, negative response items 16 and 21 were extracted together, but separately from the items of Factor 5 with which they were presumed to be associated. Item 17 was also removed because it loaded separately with a low loading value (.393). Although item 48 was proposed for the "representation" dimension, this item loaded on factor 6, along with items, 30 and 31 representing "social respect." Because the content of item 48 is similar in meaning as items 30 and 31, this item was recoded and retained for a further factor analysis.

Factor	Extracted items		Representative dimensions	Eigenvalue	Variance %	Cum. Variance %
	Representative Items	Mixed Items				
1	22, 23, 24, 25, 26,27 (DS)	35[a](BV) 29[a](SR) 20[a](TP)	Degree of success	9.962	20.753	20.753
2	36, 37, 38,39 [a], 40,41, 42 [a] (IS)	43[a](R)	Intrinsic satisfaction	3.507	7.307	28.060
3	1, 2, 3, 4, 5 (PE)		Personal experience	3.108	6.475	34.535
4	44, 45, 46, 47 (R)		Representation	2.388	4.976	39.510
5	18, 19(TP)		Science teaching practice	1.964	4.091	43.601
6	30, 31(SR)	48(R)	Social respect	1.749	3.644	47.246
7	11, 12,13(CP)		Community practice	1.607	3.349	50.595
8	14, 15 (CP)	32[a](BV)	Community practice	1.345	2.802	53.397
9	6, 7, 8 (KS)		Having knowledge and skills	1.227	2.557	55.954
10	33, 34 (BV)	28[a](SR)	Belief and value	1.163	2.424	58.378
11	16[a], 21[a] (TP)		Science teaching practice	1.108	2.307	60.685
12	9, 10 (KS)		Having knowledge and skills	1.014	2.113	62.798
13	17[a](TP)		Science teaching practice	1.007	2.097	64.896

Table 10. Initial Factor Analysis Result for 48 Items of STI

Note. [a] items were removed from further analysis.

In an attempt to refine the STI instrument and improve its structural dimensions, 11 items (16, 17, 20, 21, 28, 29, 32, 35, 39, 42, and 43) were excluded from further factor analysis because their factor loading scores were low (Hair et al., 2009) or ambiguous in representing a specific factor. The remaining 37 items were subjected to a second round of confirmatory analysis using principle axis factoring with varimax rotation. As a result, eleven factors were loaded having Eignevalues greater than one, accounting for 67% of the variance reported in Table 11. The associated screen plot is shown in Figure 5, with an arrow indicating the point of inflexion on the curve to identify the optimum number of factors extracted for this analysis.

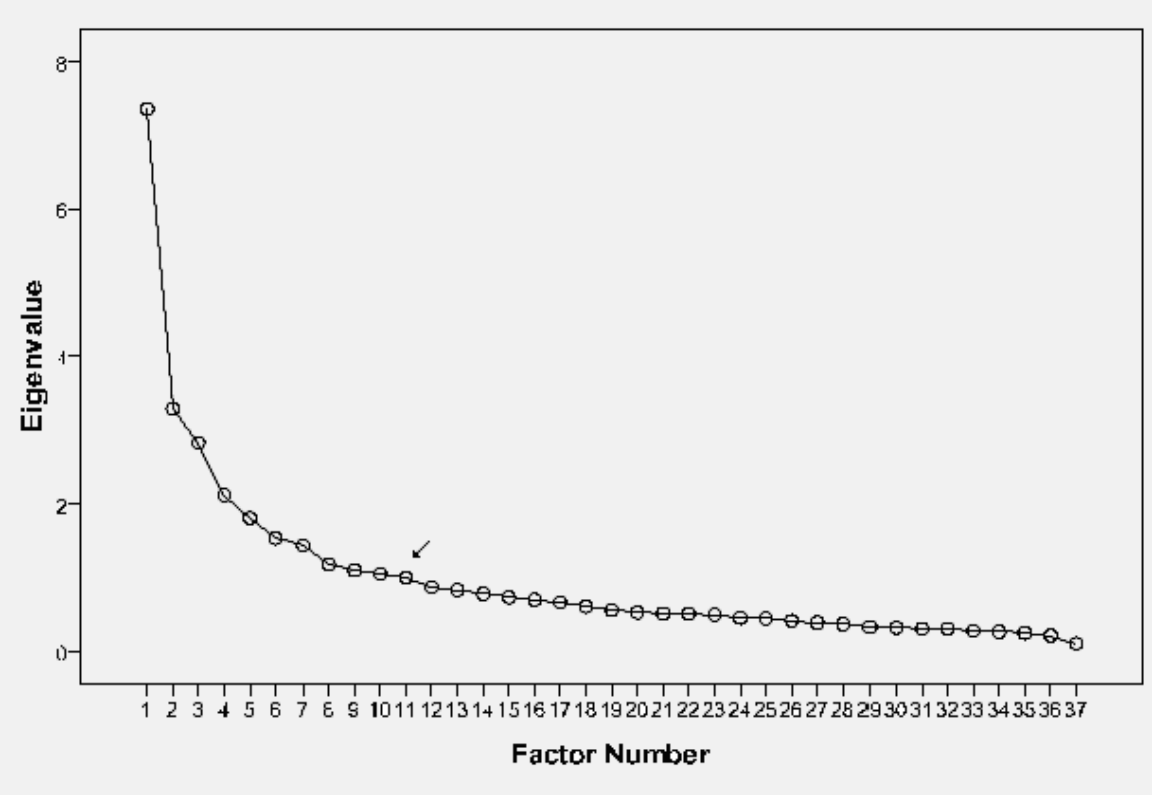


Figure 5. Scree Plot for Factor Analysis of 37 Items of STI

As proposed in the STI instrument, nine factors were extracted, with two dimensions, "having knowledge and skills" and "community practice," being divided into two sub-components. That is, for dimension, "having knowledge and skills," two factors, 8 and 10 were extracted. Though the dimension is split into two factors, the items of the two dimensions focus on the same dimension, and the two sets of items are each internally consistent in how the dimension is represented. That is, items 6 through 8 represent the "having knowledge and skills" dimension in terms of the present time (present-oriented), while items 9 and 10 refer to the importance of "increasing" knowledge and skills (future-oriented). For the dimension, "community practice," two factors 5 and 9 were extracted, as in the previous example pertaining to "having knowledge and skills." Items 11 through 13 represent more factual statements (e.g. what they do for community practice), while items 14 and 15 represent value statements (e.g. "helpful" used item 14 and "enjoy" used in the item 15.).

Rotated factor loading scores for each item are presented in Table 7. The factor loading scores range from .351 to .864 since the minimal level of factor loading scores should be above .3 for an exploratory factor analysis (Hair et al., 2009). The factor loading scores of 37 items are deemed acceptable according to the guideline for identifying significant factor loadings based on sample size on a .05 significance level that factor loadings of .30 and above are significant in a sample of 350 respondents (Hair et al., 2009). Additionally, items with factor loading scores of .7 or higher can be considered as representative items for an extracted factor (Hair et al., 2009). For example, items 25, 27, and 23 for factor 1, "degree of success;" items 3, 2, and 1 for factor 2, "personal experience; items 40, 38, and 36 for factor 3, "intrinsic satisfaction;" items 46

and 44 for factor 4, “representation;” item11 for factor 5, “community practice;” items 18 and 19 for factor 6, “teaching practice;” items 31 and 48 for factor 7, “social respect;” item 7 for factor 8 and item 9 for factor 10, “having knowledge and skills;” item 33 for factor 11, “belief and value” have factor loading scores above .7. These 19 items can be used to further refine the revised STI instrument. Also, the factor loading scores being above .6 can be interpreted to confirm factors as expected in models or instruments (Hair et al., 2009), so items 26, 24, 37, 47, 13, 6, 15, and 14 that are above .6 of factor loading scores can be used to further refine the instrument, as well.

Dimension	Extracted items	Factor										
		1	2	3	4	5	6	7	8	9	10	11
Degree of Success	25	.757										
	27	.741										
	23	.714										
	26	.641										
	24	.560										
	22	.441										
Personal Experience	3		.864									
	2		.836									
	1		.774									
	4		.532									
	5		.351									
Intrinsic Satisfaction	40			.737								
	38			.693								
	36			.681								
	37			.629								
	41			.504								

Continued

Table 11. Second Factor Analysis Result for 37 Items of STI

Note. Items 16, 17, 20, 21, 28, 29, 32, 35, 39, 42, and 43 were removed in this analysis.

Table 11 continued

Dimension	Extracted items	Factor										
		1	2	3	4	5	6	7	8	9	10	11
Representation	46				.780							
	44				.689							
	47				.608							
	45				.475							
Community Practice	11					.829						
	13					.610						
	12					.436						
Teaching Practice	18						.872					
	19						.816					
Social respect	31							.812				
	48							.721				
	30							.437				
Having knowledge and skills	7								.725			
	6								.618			
	8								.531			
Community Practice	15									.568		
	14									.567		
Having knowledge and skills	9										.687	
	10										.398	
Belief and Value	33											.709
	34											.434
Eigen value		7.361	3.300	2.840	2.125	1.811	1.537	1.441	1.185	1.101	1.053	1.001
Variance(%)		19.895	8.920	7.676	5.742	4.895	4.154	3.896	3.203	2.977	2.847	2.706
Cum. Variance(%)		19.895	28.815	36.491	42.243	47.129	51.284	55.179	58.382	61.359	64.205	66.912

Statistical Significance of Mean Differences between Demographic Characteristics and STI Dimensions

Differences in performance on the STI instrument enables construction of science teacher identity profiles based on the comparisons of STI scores and subscale scores with

demographic characteristics. As seen in Table 12, the statistical significances of the differences between the STI full scale score and individual subscale scores and several demographic characteristics (e.g., gender, highest degree level, preservice and practicing science teachers, elementary and secondary science teachers, science majors) provides evidence of relationships based on a significance level of .05.

Dimension of STI Demographic information	PE	KS	CP	TP	DS	SR	BV	IS	R	AVG
Gender	✓									
Highest educational levels		✓								
Preservice vs. practicing teachers			✓	✓						
Elementary and secondary teachers	✓			✓	✓			✓		
Major							✓			

Table 12. Summary for Significant Mean Difference between STI Dimensions and Demographic Information

Gender Differences and the Personal Learning Experiences Associated STI.

In the survey dataset for 430 participants who provided demographic information, male science teachers constituted 28% (n=118) of the sample, and female science teachers constituted 72% (n=311) of the sample. (Note. One participant neglected to provide gender information.). Between "gender" and a dimension of STI, "personal experience," there is a significant difference (p=0.000, d= .43) indicated by an independent t-Test. The mean score for male science teachers (4.23) is significantly higher than the mean score for female science teachers (3.92) teachers in the dimension, "personal experience" as shown in Table 13. This result suggests that male science

teachers might typically have more positive learning experiences for science than do female science teachers.

Groups	*N*	*M*	*SD*	*t*-Test	*df*	*p*	*d*
Male	117	4.23	.598	4.260	284.136	.000	.43
Female	307	3.92	.815				

Table 13. Male and Female Science Teachers' Difference on the Dimension "Personal Experience"

Note. The *t* and *df* were adjusted because variances were not equal (Levene's Test for equality of variances (p=.000) was <.05).

Highest Educational Levels and Differences in the STI Dimension, "Having Knowledge and Skills"

Among the 430 surveyed who included demographic information among science teachers, the highest educational levels were reported to be: 20 (5%) science teachers who have a doctorate, 280 (65%) science teachers who have a master's degree, 130 (30%) science teachers who have a bachelor's degree. For this dimension of STI, "having knowledge and skills," a statistically significant difference was found between highest education levels and the STI score, F (2, 426) = 4.901, p=.008 as results of a One-Way Analysis of Variance (See Table 14).

	Df	*SS*	*MS*	*F*	*p*
Between Groups	2	1.363	.681	4.901	.008
Within Groups	426	59.216	.139		
Total	428	60.578			

Table 14. One-Way Analysis of Variance of Highest Education Levels on the Dimension, "Having Knowledge and Skills"

As shown in Table 15, the mean score for a dimension of STI "having knowledge and skills" is 4.50 for science teachers who have bachelor's degree, 4.62 for science teachers who have a master's degree, and 4.68 for science teachers who have doctorate as the highest education level. Of these groups, significant differences were compared using the Post hoc Tukey HSD (Honestly significant differences) tests. The result indicates that the bachelor's degree group and master's degree group differed significantly in their scores on the dimension, "having knowledge and skills" (p=.011, d=.31). From these results, it could be concluded that science teachers who are more educated and prepared will likely be more knowledgeable and skillful in teaching science. Also, the impact of graduate level science teacher preparation programs on STI development may be greater than undergraduate programs if increased knowledge and skills are emphasized.

Highest education levels	*n*	*M*	*SD*
Bachelor	130	4.50	.384
Master	279	4.62	.366
Doctorate	20	4.68	.391
Total	429	4.59	.376

Table 15. Means and Standard Deviations for Three Groups of Highest Education Levels on the STI Dimension "Having Knowledge and Skills"

Differences between Preservice vs. Practicing teachers in Levels of "Community Practice" and "Science Teaching Practice" as Measured by the STI Instrument

An independent samples *t*-Test was conducted to compare differences in STI mean scores among preservice and practicing science teachers. For the STI dimension, "community practice," the mean score for preservice science teachers (4.10) is

significantly lower that the mean score of practicing science teachers (4.34) (p=.032, d=.48) (See Table 16).

Groups	*N*	*M*	*SD*	*t*-Test	*df*	*p*	*d*
Preservice science teachers	22	4.10	.508	-2.151	412	.032	.48
Practicing science teachers	392	4.34	.530				

Table 16. Preservice and Practicing Science Teachers' Difference on the Dimension "Community Practice"

For the STI dimension, "science teaching practice," the mean score for preservice science teachers (3.89) is significantly lower than the mean score of practicing science teachers (4.11) (p=.021, d=.44) (See Table 17).

Groups	*n*	*M*	*SD*	*t*-Test	*df*	*p*	*D*
Preservice science teachers	22 (27)[a]	3.89	.511	-2.082	412 (424)[a]	.038 (.021)[a]	.44
Practicing science teachers	392 (399)[a]	4.11	.467				

Table 17. Differences in Preservice and Practicing Science Teachers' Mean Scores on the Dimension "Science Teaching Practice"

Note. ( )[a] shows statistics from an incomplete data set(n=430).

These results predict that preservice science teachers might have a lack of membership or participation as a science teacher and experience to teach science than practicing science teachers.

Differences among Elementary and Secondary Science Teachers' Mean Scores on Four Dimensions of STI

The initial licensure or certificate identified by participating science teachers were varied and many participants indicated having multiple licensures or certifications. Initial licensure or certification for grade levels P-3, K-3, 1-3, K-4, K-6, K-8, 1-6, 1-8, and 4-6 were categorized into an elementary science teacher group. Grade levels 4-9, 5-8, 5-9, 6-9, 7-9, 5-12, 6-12, 7-12, 8-12, and 9-12 were categorized into a secondary science teacher group. Science teachers who have licensures or certificates in both categories were classified into an elementary and secondary science teacher group. Also, science teachers who marked 'K-12' in the grade level were classified into an elementary and secondary science teacher group. Among 430 participants, 93, 313, and 23 respectively were grouped into the following groups: elementary, secondary and elementary and secondary science teachers. One participant marked "not yet certificated" for grade level.

Three different groups of grade levels—elementary science teachers, secondary science teachers, and elementary and secondary science teachers—exhibited statistically different mean scores for four STI dimensions: "personal experience," F (2, 420)=27.355, p=.000, "science teaching practice," F (2, 422)=7.554, p=.001, "degree of success," F (2, 424)=6.102, p=.002 and "intrinsic satisfaction," F (2, 425)=5.668, p=.004 (See Table 18).

Dimensions		*Df*	*SS*	*MS*	*F*	*p*
Personal experience	Between groups	2	29.137	14.569	27.359	.000
	Within groups	420	223.644	.532		
	Total	422	252.781			
Science teaching practice	Between groups	2	3.270	1.635	7.554	.001
	Within groups	422	91.326	.216		
	Total	424	94.596			
Degree of success	Between Groups	2	3.056	1.528	6.102	.002
	Within Groups	424	106.185	.250		
	Total	426	109.241			
Intrinsic Satisfaction	Between Groups	2	1.855	.928	5.668	.004
	Within Groups	425	69.559	.164		
	Total	427	71.414			

Table 18. One-Way Analysis of Variance for mean scores of Elementary and Secondary Science Teachers on Four STI Dimensions

Means and standard deviations for each group's scores on four STI dimensions are presented in Table 19. The mean scores were analyzed by the Post hoc tests using Tukey HSD and Games-Howell because the results for two dimensions, "science teaching practice" and "degree of success" can be assumed to exhibit about equal variances between groups, but the equal variances cannot be assumed for the mean scores

in the other two dimensions, “personal experiences” and “intrinsic satisfaction.” By the Post hoc Tukey HSD (Honestly significant differences) tests, significant mean differences between elementary science teachers and secondary science teachers groups in dimensions “science teaching practice” and “degree of success” were .195 (p=.000, d=.40) and .17127(p=0.011, d= .34) respectively. As shown in Table 19, elementary science teachers’ mean scores in two dimensions, “science teaching practice” and “degree of success” (TP= 4.23, DS= 4.32) are significantly higher than those of secondary science teachers(TP= 4.04, DS= 4.15). From these findings, it can be suggested that elementary science teachers might believe that they are more successful in teaching science than do secondary science teachers.

According to the Games-Howell Post hoc test, the mean score of secondary science teachers (4.16) is significantly different from the mean score of elementary science teachers (3.52) in the dimension “personal learning experience” (p=.000, d=.81). This result suggests that secondary science teachers have more positive experiences in learning science than do elementary science teachers. In the dimension, “intrinsic satisfaction,” there were significant mean differences between elementary science teachers and elementary and secondary science teachers (p=.005, d=.69) and between secondary science teachers and elementary and secondary science teachers (p=.000, d=.76). The mean score of elementary and secondary science teachers (4.77) is significantly higher than both elementary science teachers (4.55) and secondary science teachers (4.49). Science teachers licensed or certificated for both elementary and secondary science teachers may experience more intrinsic satisfaction as science teachers

than science teachers licensed or certificated for either elementary or secondary science teachers.

Groups		PE		TP		DS		IS	
	n	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Elementary Science Teachers	93	3.52	.902	4.23	.466	4.32	.453	4.55	.348
Secondary Science Teachers	313	4.16	.675	4.04	.462	4.15	.513	4.49	.428
Elementary and Secondary Science Teachers	23	3.91	.671	4.25	.500	4.40	.504	4.77	.258
Total	429	4.00	.774	4.09	.472	4.20	.506	4.52	.409

Table 19. Means and Standard Deviations for Elementary and Secondary Science Teachers on Four STI Dimensions

Differences in Three STI Dimensions in Relation to Years of Teaching

The number of teaching years were divided into seven groups: A group1 (0 years: preservice teachers), group2 (0< years≤ 1: first year teachers), group3 (1< years ≤ 5), group 4 (5< years ≤ 10), group5 (10< years ≤ 20), group6 (20< years ≤ 30), group7 (30< years). Among the seven groups of teaching years, significant differences were shown in three STI dimensions, "having knowledge and skills," F (6, 422) = 6.534, p=.000, "science teaching practice," F (6, 419) = 4.486, p=.000, and "degree of success," F (6, 421) = 4.289, p=.010 in Table 20.

Dimensions		*df*	*SS*	*MS*	*F*	*p*
Having Knowledge and Skills	Between groups	6	5.150	.858	6.534	.000
	Within groups	422	55.429	.131		
	Total	428	60.578			
Science Teaching Practice	Between groups	6	5.713	.952	4.486	.000
	Within groups	419	88.941	.212		
	Total	425	94.654			
Degree of Success	Between groups	6	4.289	.715	2.867	.010
	Within groups	421	104.970	.249		
	Total	427	109.259			

Table 20. One-Way Analysis of Variance of Seven Groups for Teaching Years on Three STI Dimensions

As displayed in Table 21, the mean scores for the first-year science teachers are the lowest among mean scores for preservice or practicing science teachers in each dimension. The significant differences in mean scores among groups were identified by the Post hoc Tukey HSD test at the level .05. In the dimension, "having knowledge and skills," the mean score for the first-year science teachers (4.22) is significantly lower than others ($p < .05$, p value ranged from .000 through 0.042; d value ranged from .78 through 1.51). In particular, it can be noted that first year science teachers may have more difficulty in demonstrating the knowledge and skills they learned in classrooms, even though preservice teachers perceive that they do demonstrate knowledge and skills. In the

dimension, “science teaching practice,” the difference in the mean score for the first-year science teachers is also significantly lower than three groups of science teachers who have taught over 10 years ($p< .05$, p value ranged from .004 through .016; d value ranged from .81 through .87). From this result, science teaching could be stable over 10 years. In the dimension, “degree of success,” the mean score for first-year science teachers is significantly different from preservice science teachers ($p=.044$, $d=.71$) and science teachers who have taught for 11- 20 years ($p=.012$, $d=.70$) and over 30 years ($p=.021$, $d=.90$). It can show that first-year teachers might not be sure about success for their profession. From these results, it might indicate that first-year science teachers are troubled in developing their own science teacher identity with practical difficulties.

Teaching years		KS		TP		DS	
	n	*M*	*SD*	*M*	*SD*	*M*	*SD*
G1: Years=0	28	4.54	.365	3.89	.506	4.31	.482
G2: 0< years≤ 1	21	4.22	.368	3.79	.525	3.87	.630
G3: 1< years ≤ 5	104	4.51	.350	4.04	.419	4.14	.480
G4: 5< years ≤ 10	85	4.58	.371	4.06	.495	4.17	.476
G5: 10< years ≤ 20	105	4.66	.395	4.20	.490	4.28	.544
G6: 20< years ≤ 30	51	4.67	.332	4.20	.388	4.20	.483
G7: 30< years	35	4.73	.307	4.21	.426	4.32	.413
Total	429	4.58	.376	4.09	.472	4.20	.506

Table 21. Means and Standard Deviations for Seven Groups of Teaching Years on Three STI Dimensions

Differences in Mean Score for the Dimension, "Belief and Value" According to Science Major

From the dataset for secondary science teachers (*n*=336), the number of science teachers who majored in a single field of sciences was 159. Of these, 89 majored in life science/biology, 18 majored in earth/space science, 14 majored in chemistry, 4 majored in physics, 1 majored in physical science, and 33 majored in science education. To compensate for the disparity in numbers of participants across groups, four groups classified as chemistry, physics, and physical science were combined into a single group. There was a significant mean difference of between major groups and the STI dimension, "belief and value," F (3, 155) =3.677 p=.014 (See Table 22 and 23). The Post hoc test using Tukey (HSD) test revealed that the mean score for the combined group of chemistry, physics and physical science is lower than mean scores of all other groups, in particular, statistically lower than the mean score of science education groups (p= .009, d= 1.0.).

	df	*SS*	*MS*	*F*	*p*
Between Groups	3	3.496	1.165	3.677	.014
Within Groups	155	49.118	.317		
Total	158	52.614			

Table 22. One-Way Analysis of Variance among Science Major Groups on the Dimension, "Belief and Value"

Science Majors	*n*	*M*	*SD*
Life/Biology	89	4.05	.578
Earth/Space Science	18	4.01	.597
Chemistry, Physics & Physical Science	19	3.79	.488
Science Education	33	4.31	.541
Total	159	4.07	.577

Table 23. Means and Standard Deviations for Four Groups of Science Majors on the Dimension, "Belief and Value"

Correlations between Demographic Data and STI Dimensions

The correlation matrix of demographic variables and total and subscale STI scores is presented in Table 24. Between gender and the dimension, "personal learning experience," there is a statistically positive association analyzed by Pearson's correlation coefficient. Because gender was recorded as a dichotomy, male=1 and female=0, this positive correlation is associated with "male." Male science teachers seemingly have more positive personal learning experiences than do female teachers. Highest education levels of science teachers are more positively associated with three dimensions, "having knowledge and skills," "community practice," and "teaching practice" by Spearman's rho coefficient. Science teachers who have higher educational degrees are more likely to feel that they are more knowledgeable and skillful, are more active in participating in the community of science teachers, and have more confidence in teaching science. Also, between preservice versus practicing science teachers, the dimension "teaching practice" is significantly correlated by Pearson's correlation coefficient. Like gender variables, preservice science teachers were coded as "0" and practicing science teacher were coded

as “1” in a dichotomy so that this correlation pattern is associated with practicing science teachers. Practicing science teachers sense that they are more professional in teaching science. Elementary and secondary science teachers showed a statistically significant correlation with two dimensions, “personal learning experience” and “science teaching practice” analyzed by Spearman’s rho coefficient as reported in mean differences. Teaching year groups have a positive correlation with four dimensions, “having knowledge and skills,” “community practice,” “science teaching practice,” and “degree of success” by Pearson’s correlation coefficient. It reveals that science teachers develop their profession and strengthen their science teacher identity as they progress through career experiences year by year. As there is a negative correlation between “teacher year groups” and the STI dimension, “representation,” science teachers exhibit a tendency to decline or regress in terms of visions and images for the future as their professional status becomes stable.

	AVG	PE	KS	CP	TP	DS	SR	BV	IS	R
Gender	-.022	.178**	.010	-.090	-.059	-.043	-.071	-.039	-.084	.000
Highest Degree Level	.093	-.020	.158**	.104*	.113*	.072	.058	.029	.039	-.064
Pre vs. Practicing teachers	-.007	.043	.034	.064	.112*	-.057	-.063	-.043	-.053	-.053
Elementary and secondary teachers	.061	.237**	.080	.064	-.132**	-.066	.016	-.053	.038	-.007
Teaching years	.079	-.061	.235**	.112*	.221**	.098*	.025	.018	.005	-.099*

Table 24. Correlation between Demographic Information and Dimensions of STI Instrument

Note. n=430 ** p< 0.01 (2-tailed), * p<0.05 (2-tailed)

Inter-Correlations of STI Dimensions

The inter-correlation pattern of whole and sub dimensions of STI is displayed in Table 25. Significant correlation coefficient r between a total score and subscale score of STI instrument is ranged from .36 through .75 so that effect size is medium through large according to Cohen's guide (1998). In particular, one dimension, "degree of success" is most strongly correlated with science teacher identity so that dimension, "degree of success" is positively associated with construction of science teacher identity. Meanwhile, one dimension, "personal experience", seems least associated with science teacher identity, since its correlation coefficient is the smallest.

	AVG	PE	KS	CP	TP	DS	SR	BV	IS	R
AVG		.358**	.645**	.634**	.671**	.754**	.667**	.695**	.648**	.501**
PE			.167**	.129**	.011	.057	.162**	.003	.068	.002
KS				.413**	.479**	.536**	.339**	.352**	.311**	.169**
CP					.395**	.403**	.337**	.435**	.320**	.156**
TP						.625**	.367**	.433**	.343**	.148**
DS							.502**	.513**	.391**	.229**
SR								.523**	.301**	.317**
BV									.424**	.367**
IS										.431**
R										

Table 25. Inter-correlation of STI Instrument

Note. n=430 ** p< 0.01 (2-tailed), * p<0.05 (2-tailed)

Development of Science Teacher Identity among Preservice Science Teachers

The efficacy of the model of science teacher identity was explored with 17 preservice science teachers in a graduate-level science teacher preparation program using both quantitative data and qualitative data. The level of science teacher identity among the 17 preservice science teachers was measured using a directly administered

questionnaire as a pretest and posttest before and after student teaching. The growth of science teacher identity among six of the preservice science teachers was examined through personal interviews, review of portfolios, reflections on program experiences, and study of other secondary documents and resources.

Changes in the Level of STI among Preservice Science Teachers

The new STI instrument was used to examine the effects of professional development experiences on science teacher identity. The 17 preservice science teachers participating in the study exhibited significant changes in science teacher identity based on scores of the STI instrument before and after student teaching and on data gathered through interviews and document analyses.

Participants

Of the 28 students enrolled as a cohort in a science teacher preparation program during an academic year 2007-2008, only 21 students participated in the pretest, but four of those students declined to participate in the posttest. All of the students were graduate students and ranged in age from the mid 20s to mid 30s.

Of these preservice teachers, ten were female and seven were male. Eight of the preservice science teachers had majored in life science/ biology as content areas of licensures (five females and three males); four in chemistry (three females and one male); four in physics (two females and two males); and one in earth science (1 male). Preservice teachers who majored in either chemistry or earth science pursed a double licensure with life science as a content area. About 90% had no teaching experiences prior to student teaching.

The Level of Change among Preservice Science Teachers

On the basis of results from administering the STI instrument as a pretest and posttest, the level of science teacher identity significantly increased during student teaching. Particularly, increases in scores on five dimensions of STI were statistically significant ($p < .05$): "having knowledge and skills" $t(16)= -2.416$, $p=.028$, $d=.58$; "science teaching practice," $t(16)= -3.257$, $p=.005$, $d=.79$; "degree of success," $t(16)= -3.574$, $p=.003$, $d=.84$; "intrinsic satisfaction," $t(16)= -2.506$, $p=.023$, $d=.64$ and "representation" $t(16)= -2.308$, $p=.035$, $d=.50$ (See Table 26).

For further analysis of the changes in STI scores, participants were sorted into three levels of science teacher identity: weak (lower 33.3%), moderate (middle 33.3 %), and strong groups (upper 33.3%), based on scores during the first administration of the STI instrument. Changes in the level of science teacher identity before and after student teaching are presented in Table 27. The STI scores of participants exhibiting a weak science teacher identify were found to change significantly from before ($M=3.48$ $SD=.16$) to after student teaching ($M=3.80$, $SD=.35$), $t(5)= -3.279$, $p=.022$, $d=1.15$ because $p < .05$.

STI Dimensions	Mean		*t*-Test	P
	Before	After		
Personal Experience	4.39	4.31	1.040	.314
	(.42)	(.57)		
Having knowledge and skills	4.01	4.25	-2.416	.028
	(.43)	(.37)		
Community practice	3.92	4.04	-.979	.342
	(.52)	(.52)		
Science teaching practice	3.72	4.10	-3.257	.005
	(.47)	(.49)		
Degree of success	3.65	4.07	-3.574	.003
	(.44)	(.55)		
Social Respect	3.43	3.58	-.840	.413
	(.47)	(.74)		
Belief and value	3.96	4.01	-.416	.683
	(.52)	(.68)		
Intrinsic Satisfaction	4.03	4.43	-2.506	.023
	(.70)	(.52)		
Representation	3.86	4.16	-2.308	.035
	(.62)	(.56)		
AVG	3.92	4.13	-2.308	.035
	(.43)	(.43)		

Table 26. The Level of Change among Preservice Science Teachers for Nine Dimensions and Score of Science Teacher Identity

Note. ( ) presents standard deviation.

Groups	Mean		*t*-Test	*P*
	Before	After		
Weak (*n*=6)	3.48	3.80	-3.279	.022
	(.16)	(.35)		
Moderate (*n*=5)	3.87	4.15	-1.200	.296
	(.09)	(.48)		
Strong (*n*=6)	4.40	4.44	-.781	.470
	(.20)	(.18)		

Table 27. The Change of Three Levels of Science Teacher Identity Groups among Preservice Science Teachers

Note. The number of participants before student teaching was 21 but three participants missed a posttest and one participant left a school for private reasons after student teaching.

As can be seen in Table 28, two participants rose from a weak STI level to a moderate STI level. In the moderate STI group, two participants' levels of STI score exhibited change: The STI score of one participant dropped to a weak STI level, while another participant's STI score rose to a strong STI level (Table 28). In the strong STI score group, only one participant's level of STI dropped to moderate STI level. As presented in both Table 27 and 28, participants in the strong STI level groups exhibited more stable and consistent STI status than participants in other groups.

Groups	Mean	
	Before	After
Weak	3.21	3.50
(*n*=6)	3.40	3.38
	3.52	3.67
	3.53	3.88
	3.59	4.10 (M)
	3.66	4.29 (M)
Moderate	3.77	4.71 (S)
(*n*=5)	3.82	4.29
	3.88	3.40 (W)
	3.88	4.30
	4.00	4.06
Strong	4.20	4.23 (M)
(*n*=6)	4.23	4.35
	4.26	4.31
	4.43	4.67
	4.63	4.44
	4.65	4.67

Table 28. The Change within Three Levels of Science Teacher Identity Groups among Preservice Science Teachers

Note. ( ) represents the changed STI level.

STI Development of Six Participants

To further examine how individual preservice science teachers construct their science teacher identity, qualitative data were collected through interviews and documents. Personal interviews were conducted with six participants who were grouped into three levels of science teacher identity: weak, moderate, and strong STI. Emma and Chad were in the weak STI group, Rachel and Mike in the Moderate group, and Nancy and Joe in the strong STI group (Six participants were identified by pseudonyms). Although Emma and Nancy did not complete the interviews for personal reasons, their other documents were used for data analysis. For document analysis, the four sources

provided information about participants' science teacher identity and teaching profession development. The first source was the participant's reflections on program experiences such as student teaching experiences, lesson plans and DVD critiques (Emma: 53 entries; Chad: 44; Rachel: 61; Mike: 47; Nancy: 50; Joe: 48). The second source was their portfolio, including resumes. The third source was course assignments such as reflection on reading assignments, students' pretest/posttest results, and the report of students' evaluations of preservice teachers. The forth source was reference documents such as course grades, preservice teachers' evaluation of mentor teachers, and supervisors' evaluation of mentor teachers. Through these interviews and document analysis, participants' profile, their decisions to become a science teacher, and their development of science teacher identity and teaching profession were investigated.

Emma (Weak STI, Incomplete Interview)

Background: She was in her mid-20s and a recent graduate with a B.S. degree in biochemistry. Her target licensure was a secondary science teacher in life science and chemistry. She had no teaching experience but assisted in research of biochemistry for three years. She did not complete interviews but she did a posttest questionnaire. She accepted a job offer as a chemistry teacher for 7^{th} -12^{th} grade before graduation.

Decision: She introduced herself as one of those who planned to enter a graduate school or medical school. She had thought she would be a scientist or medical doctor. However, during three years of research associate experience, she realized that she really liked helping younger people to learn science more than doing an experiment or research.

Thus she decided to become a science teacher in her senior year of college. Her parents and sister were supportive of her decision because they are teachers.

Science is her most favorite subject. She stated in her portfolio that "science fascinates me," and that she loved science, especially chemistry. She thinks that chemistry is valuable enough to solve problems in our world. She felt that teaching is also gratifying to herself. These factors affected her career decision to become a science teacher.

Development: She had a weak science teacher identity in the beginning of student teaching. Her score on the pretest was ranked as the lowest. For item 43, "I see myself as a science teacher," her answer was "disagree." She did not perceive herself as a science teacher although she desired to become one. Her science teacher identity was very unstable during student teaching. In the middle of student teaching, she asked herself "Am I being their teacher and not their friend?" and she answered with a resounding "yes." She knew that she should behave like a teacher but she experienced tension about how to represent herself to students as such. This dilemma of preservice teachers was also found in Volkmann and Anderson's study (1998). However, science teacher programs and student teaching experiences had affected a change of view about herself. She finally reflected that she grew as a teacher and improved all aspects of her teaching at the end of the program. As a result, her posttest score was highly increased over her pretest score (Figure 6.). In her reflections from autumn quarter through spring quarter, she changed her narration style, from the informative observations of a student to the sophisticated reflections of a teacher. Her reflections revealed a journey that she was

becoming a science teacher. She mentioned that the most important change was that she came to have a confidence to teach science.

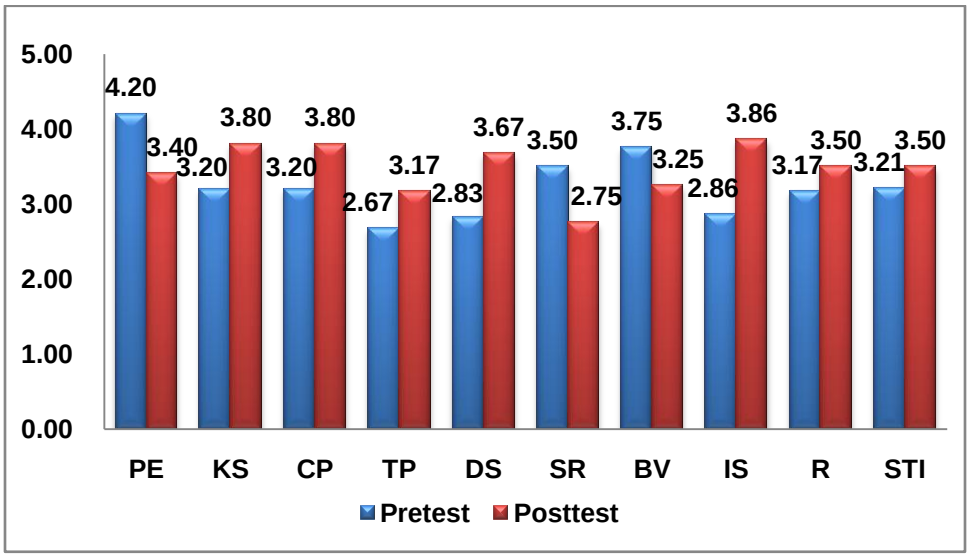


Figure 6. Emma's Science Teacher Identity Changes

The primary goals of the autumn student teaching placement were to engage students in each lesson; to gain classroom management skills; and to prepare adequately for lessons. Through observation, she found how teaching strategies worked to engage students in learning and what was effective to manage students in classroom in several cases. However, she was concerned that she was not comfortable teaching in front of students and in demonstrating an experiment in lab. She confessed that she had always been nervous about being in front of a group of people. She could not concentrate on teaching and follow her lesson plan. She felt that her teaching was not perfect all the time because she did not complete what she prepared.

Additionally, she felt a lack of confidence in teaching. This was the most serious problem for Emma to become a teacher. In winter quarter, she noticed this problem as a big hindrance to becoming an effective teacher, so that she set this as a goal. She tried several methods to make herself comfortable, such as building rapport with students and reviewing her lesson plan before class. Through these, she came to know that her confidence came from her preparation, rapport with students, and management. In particular, when she felt she had prepared well, she could have confidence in teaching. At the end of quarter, she reflected that her confidence got 100% better than in the beginning of quarter through her preparation before class. She showed progress, getting better and becoming confident in teaching science throughout winter quarter. In addition, she tried to learn more classroom management skills because she encountered a new environment, the "urban school," in winter student teaching placement. As can be seen in her reflection, "there is no right way to handle anything…but that my classroom management style has to reflect me," she struggled in several ways to find her own strategies. This was also listed as a goal of the last student teaching.

For her instruction style, she set goals: To incorporate formative assessments and to use diverse resources. She was advised about useful formative assessments from a mentor and other teachers. She tried to find and integrate good resources in her lesson plan. However, she was not satisfied with her lesson plans. In the last student teaching placement, more detailed goals to become a better science teacher were listed, particularly further improvement on lessons and instructions. As she taught chemistry in high school for five weekdays during last field experience, she still had trouble making and enforcing rules in classroom management. However, she showed tremendous growth

in her teaching abilities. For example, she used various resources to make her lesson interesting and gained students' positive reaction to her teaching. Her teaching improved overall. She reflected deeply on herself and her teaching: What she observed in students' learning, what needs to be improved as a science teacher, and what problems she had in teaching science. She started to view herself as a science teacher in the end of the last student teaching as she reflected that "As a first year teacher, I hope to continue to grow."

Chad (Weak STI, Complete Interview)

Background: He is in his mid-20s, with a B.S. degree in human resource management. After college, he followed his wife who was earning a Ph.D. of politics science and he pursued a licensure in life science and earth science. He got a teaching position after graduation.

Decision: His only formal teaching experience was working as a counselor at debate camp in his junior and senior years of college. He heard that he was good at teaching students from other colleagues, and started to think about a teaching job. He researched the teaching job market and found that it was more open in science and mathematics. Although he did not major in science as an undergraduate, science was one of his favorite subjects. For this reason, he came to decide to be a science teacher. He liked earth science, though didn't like life science as much even though his licensure was in both subjects. His family background was not related to the teaching profession or teachers. Also, his previous science teachers were not role models for him as a science teacher.

Development: His science teacher identity was categorized in the weak STI group. In the beginning of the program, his initial science teacher identity was ambiguous as he responded "moderate" to the question, "I see myself as a science teacher." In his cover letter, he appealed not as a science teacher but as a debating counselor. His confusion of his science teacher identity came from a lack of knowledge about science. He had to take science content classes related to his area, earth science, during preparation programs. Other students already took those before enrolling in the preparation program. In spite of a lack of academic background, he easily passed the PRAXIS exam of content areas. He recalled that it was hardest for him to take the exam in the winter quarter because he was busy handling all of his other duties such as coursework, examinations, and student teaching. However, he finally got a licensure and job as a science teacher. The ambiguity of his science teacher identity was reformed by student teaching experiences. He reported a progress as a science teacher as 50% by the end of winter quarter and 75% of by the end of spring quarter. As a result, his posttest score was slightly increased from his pretest score (Figure 7.). Since he thought that 100 % of science teacher identity means to be "a good science teacher," he didn't view himself as a good teacher yet even though he had already become a science teacher.

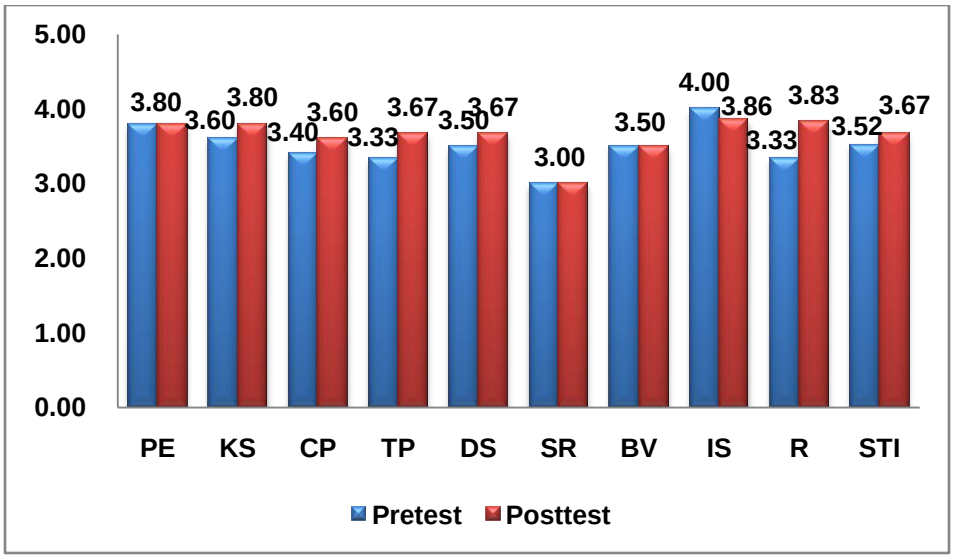


Figure 7. Chad's Science Teacher Identity Change

For his first student teaching, he tried to achieve three aspects of his teaching: developing a proper opening and closing, provoking "why" questions, and using "feedback" card on his lessons. Through teaching three classes with his own lesson plans, he had explored how these goals worked for his classes. For instance, he reflected about his opening and closing as "I will continue to work on this by being sure to emphasize 'big ideas' at the beginning of class and then reinforcing at the end with review questions." His supervisor said, "The lesson activities are good, but that there is not a strong introduction (hook or engagement) or a good closure for the lessons." He had struggled with this through the next student teaching placement. He finally found his own style for opening and closing using review/preview slides in the winter quarter student teaching, which improved students' awareness of the lessons and their participation in learning. He received positive feedback about his "why" questions from some students; they appreciated the opportunity to think critically. Also, he referenced specific students'

comments for reflecting on his lesson outcomes, modifying his teaching styles, and understanding students' awareness. Additionally, he added two goals for winter quarter student teaching besides providing a proper opening and closing: improvement of time management skills and use of formative assessments.

Time management was a big challenge for him. Because a couple of his lessons came up short last quarter, he wanted to avoid this happening. As he prepared several extension activities for each lesson, he came to have a sense of when his planned lesson would be done. He used flash assessment at the end of the lesson so that he could diagnose whether his explanation was clear. For the last student teaching placement, he focused more on his instruction styles: student-centered teaching and classroom management. Specifically, he intended to address more behavioral/discipline issues. His class had often been disturbed by students' misbehaving. He observed that his classes ran smoother than before due to the heightened discipline in the last placement. In this aspect, he believed that classroom management may be beneficial in establishing a student-center teaching. He further observed that a student-centered teaching may lead to fewer discipline issues. Based on his improved classroom management and lessons, his mentor seemed pleased with the students' responses to his new lesson plans. He was sure that he was doing a good job and his class was going well. From the middle of spring quarter, he began to feel that he had become a science teacher. At the end of the quarter, he finally believed that he would perform well as a science teacher.

Rachel (Moderate STI, Complete Interview)

Background: She was in her mid-20s and a graduate with a B.S. degree in life science. She worked as a nanny for 8-year-old twins. She prepared a teaching licensure for life science and chemistry for 7^{th}-12^{th} grade. She got a job as a physical science and chemistry teacher before she left the program.

Decision: She did not seriously consider being a teacher until her junior year of college. Before graduation, she felt that she could not give up her favorite thing, "science." She had really loved biology and chemistry since high school. She tried to think how to keep these favorite things in her life. As she recalled how she learned science at high school, she found herself teaching her friends in AP science classes. She remembered that she enjoyed teaching at that time, and believed that teaching could be a way to incorporate science into her life. She mentioned, "All I've known in my life is a teacher so it's a really good fit for me." Many of her family members are teachers and supportive of her decision to become a science teacher. Also, her high school science teacher helped and guided her preparation. She decided to enroll in a science teacher education program, and to become a physical science and biology teacher.

Development: She belonged to the moderate STI group in both the pretest and posttest of the questionnaire (Figure 9). Her posttest score was higher than her pretest score. She assessed her preparation to be a science teacher as 50% at the end of autumn quarter, 65% at the end of winter quarter, and 90% at the end of spring quarter. She would fill the remaining 10 % of her preparation throughout first-year teaching. In the final interview, she said, "I don't view myself as a student teacher any more. But I'm still a graduate student. I'm not a teacher yet. I think I will be a teacher on the first day of school." In her final reflection, she said: "There are times that made me down but never

doubted to become a teacher. I remembered why I liked to teaching. I thought about all the good things that I was able to do and strengths…" Even though she was afraid to be called a science teacher until she could confirm being a science teacher, she was ready to be a science teacher.

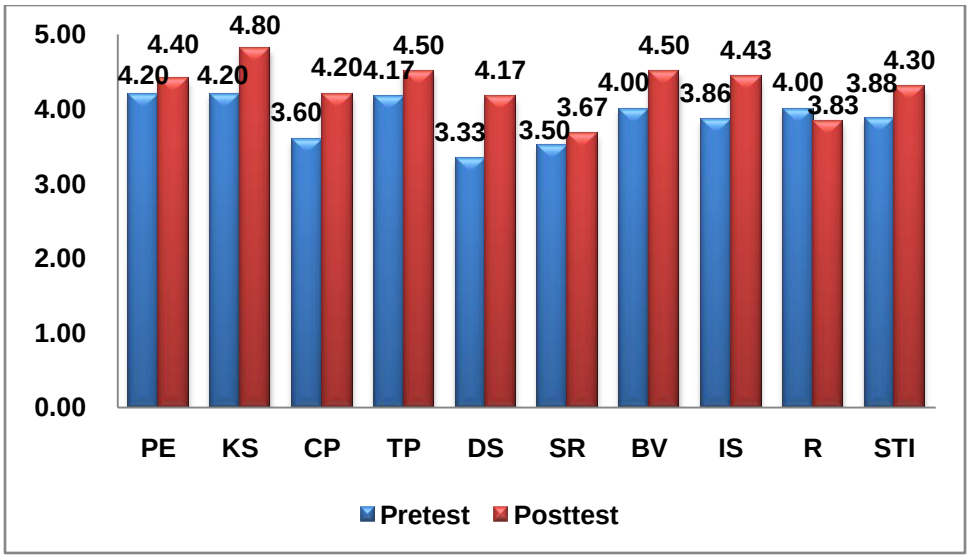


Figure 8. Rachel's Science Teacher Identity Change

She wanted to achieve three goals for autumn quarter student teaching: Learning many strategies to maintain order and disciplined classrooms, finding several ways of integrating chemistry with other subject areas, and having a better understanding for what comprises a cohesive unit. First, she made progress in classroom management. As she realized that discipline is an integral part to gain the students' respect, she tried to improve her attitude toward classes as well as her students' behaviors. Her attempt to integrate other subject matter into her lessons was successful. Also, she applied what she learned in science teacher preparation programs to creating her assessment. However, she

had problems making a lesson plan. She was not sure how many concepts should be included in her lessons and how a cohesive lesson was organized according to standards and curriculums. This part was a significant challenge to her. She tried to solve it through three consecutive student teaching placements. Her mentor teacher helped to solve this problem, as he had reviewed and given her feedback about her lesson plans before classes. She improved gradually in lesson planning.

For winter quarter student teaching, she had tried to improve the quality of her lessons to be more student-centered, to employ diverse teaching strategies and learning activities, to develop more effective and varied assessments, and to establish a more confident classroom presence. She tried many different teaching techniques and resources to promote students' participation such as group discussions, age appropriate journal articles, videos and simulations, using students' own vocabulary, and concept folders. She attempted to use several types of assessment (e.g., pair and share, exit slips, group discussions, brainstorming sessions, a reading check, and various questions with each activity) and examined the effectiveness of each. At the end of winter quarter, her lesson plans and assessments were positively evaluated by her mentor and supervisor, and she felt that she definitely gained confidence through this student teaching experience.

In the spring quarter, she added new goals about instructional skills: questioning techniques to facilitate group and class discussion and including a clear introduction and closing to connect what students learned with how the next lessons were related. She also developed her discussion strategies: to give the students more wait time, ask more concise questions, and provide examples to the students if they are struggling to answer a question. She could successfully lead great discussions in her physical science and life

science classes. For transition skills, she also tried to connect previous concepts to current ones. At the closing of each period, she reviewed the current activity and the next topic. Her mentor commented that her connections between lessons were becoming much stronger. Also her introductions had been attention grabbing and had really engaged students in learning. In addition, many of the students had commented that they had really enjoyed the last several weeks of class because of her and showed improved test scores. Thus she was more confident that her instruction was successful, and she showed huge improvement in planning and implementing her lessons by the end of the last student teaching placement.

Mike (Moderate STI, Complete Interview)

Background: He was his mid-30s and graduated with a B.S. degree in biology and a minor in human anthropology. He noted that he had been everything from a microbiologist, bouncer, artistic welder, professional aquarium maintenance guy, sub-teacher, and a bartender, among a few other things. He had followed his wife through medical school and residency, and had a six-month-old baby son. He accepted a biology teaching position before he left the program.

Decision: He had a love for science, particularly biology. When he worked as a microbiologist, he questioned whether he would continue to pursue his career as a scientist. Soon he realized that his passion was in sharing his knowledge about science, and decided to become a science teacher. His high school science teacher, Mr. Horton, also supported his decision.

Development: His science teacher identity was ranked in the moderate STI group (Figure 9). He knew that becoming a science teacher would be a long journey. He thought that it was impossible for him to be a science teacher through "a short field experience." He believed that he would be a real science teacher within 5-10 years if he survived his first-year teaching. He was ready to become a science teacher but he considered himself as a teacher "intern," not a regular teacher. Although he felt that his preparation to be a science teacher was 40-50% in the end of winter quarter, he did not view himself as a teacher intern anymore at the end of the final interview. He introduced himself as a novice teacher. He said that it would take 30 years for him to be a professional science teacher.

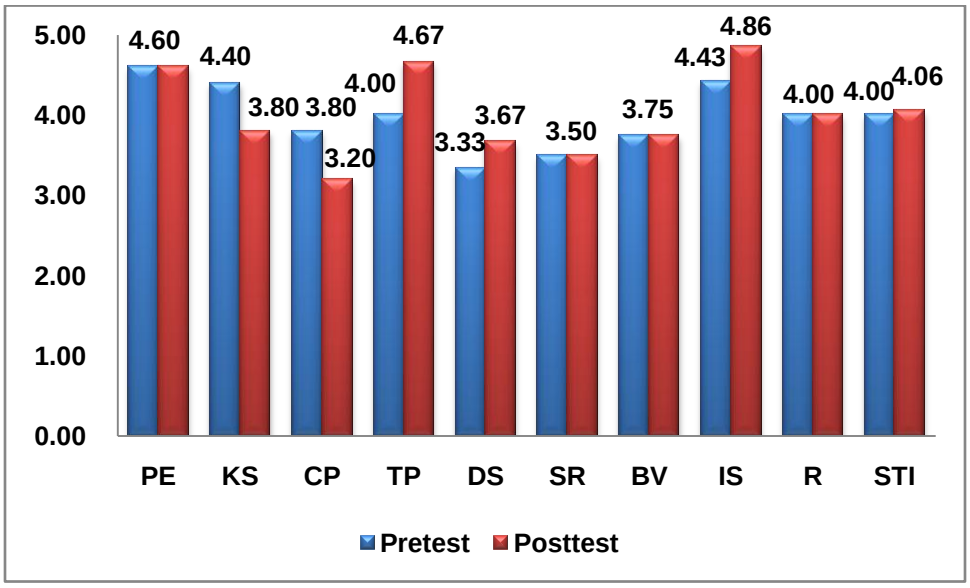


Figure 9. Mike's Science Teacher Identity Change

For his first student teaching, he set several goals: learning classroom management skills, learning the names of students, helping the more troubled kids,

experiencing lesson flow, making several lesson plans, and time management. Compared to other preservice teachers, he felt comfortable with a school environment sooner. Within a couple of weeks, he developed his own strategies on classroom management with the help of his mentor teacher. One of his ways to engage with his students was to memorize their names. Also, he personally contacted some of the problematic students, which changed their attitudes toward him and toward science. These students, who had been disruptive in his classes, became more engaged and became interested in learning science. Among them, a few students got higher grades in science than before. The administration guide told him that a student who had a disability was doing better in his class. Also, some of his lesson plans showed a great success for meeting students' and schools' needs. He could confirm that the students gained knowledge and got many of the questions correct.

For winter quarter, he set four goals: to gain mastery knowledge of environmental science, to engage the students in academic dialog, to incorporate technology and assessment, and to explore non-academic opportunities such as student clubs. The biggest challenge was to teach an AP class in the winter quarter of student teaching. He tried to study environmental science topics and content to cover some deep concepts. His efforts polished his knowledge and teaching. Also, he took outline notes about his speaking and connecting between concepts and issues, which was helpful to keep his teaching flowing well. He researched how to hook students' interest and encourage their participation in class discussions. As his mentor teacher positively evaluated on his classes, he felt that "Lecture went remarkable well…Some recent classes have afforded

me the opportunity to practice in a more realistic manner and gain a sense of my strengths and weaknesses."

Sometimes, he faced disobedient behaviors in lab; for instance, a student refused to put on goggles. Discipline and classroom management were listed again as a top priority in the last student teaching placement. In order to incorporate technology into his lesson, he used a smart board for his flash assessment, as he had learned about it through professional development training. Although assessment is the weakest area for him, he tried to use dialog and inquiry to assess what students know or think they know regarding the lesson. His mentor teacher also offered good advice on reinforcing his questioning skills.

Mike wanted to create a club outside of the biology classroom. He had discussed about his idea with other teachers, administrative staff, and coaches, so that he could lead this club during the next student teaching. However, he had many struggles with a different environment and different students in the last student teaching placement. Since his school was located in the inner city, his plans were not practical. According to his reflection, "Everything taught in class sounded great theoretically… but doesn't work… Since ultimately we are guests and interns… and the students know it… It's not my class, not my students… things will change when it is… Verbal talking and one on ones isn't working… Next week I will have to start calling home, and writing up citations, or discipline plans… It's working…but again… The reality is very frustrating." He continued to make efforts; for example, he attended after school activities such as dance classes to understand his students, and prepared different lesson plans for the worst period classes. Finally he had achieved a few goals: to gain more mastery assessment

strategies, to engage student with multiple intelligence projects, and to become better at time management. Significantly, he had developed his own assessment strategies and time management skills. His multiple intelligence theory projects made students motivated to learn. He had received essays, poems, and pictures from students. In spite of many difficulties, he reflected that although his teaching did not change that much, the mechanics of how he teaches had clearly changed.

Nancy (Strong STI, Incomplete Interview)

Background: She was in her mid-20s and graduated with a B.S. degree in life science in June 2006. She was working as a science instructor for after school programs and workshops for children ages 4-13. She could not find a position until graduating but she settled down as a biology science teacher for 10th grade. She did not complete interviews but she did a posttest in the questionnaire.

Decision: Nancy had never dreamed of being a teacher: she just wanted to be a medical doctor, like her husband, because she likes life science. She had been more interested in science than other subjects in middle and high school. Science is really enjoyable to her and it has always been her favorite subject, so she enjoyed taking content classes and reading books related to life science. She knew that she had a tendency to help friends to learn science, chemistry in particular, and she was good at tutoring it. While she worked as a science instructor after graduation, her colleague asked her, "Have you considered being a teacher?" This question was a turning point to her life to decide to become a teacher. Through this question, she had a long conversation with her colleague,

and she discussed her future with her family. Her parents, who were teachers, supported her decision.

Development: Her science teacher identity was positioned in the strong STI group. Her science teacher identity was stable according to the result of both the pretest and posttest of the survey (Figure 10.). She evaluated that she progressed 60-65% in becoming a science teacher by the end of winter quarter. She felt that she would have many areas needing growth as a science teacher. She said that her student teaching experiences were mostly helpful in improving herself and her teaching abilities.

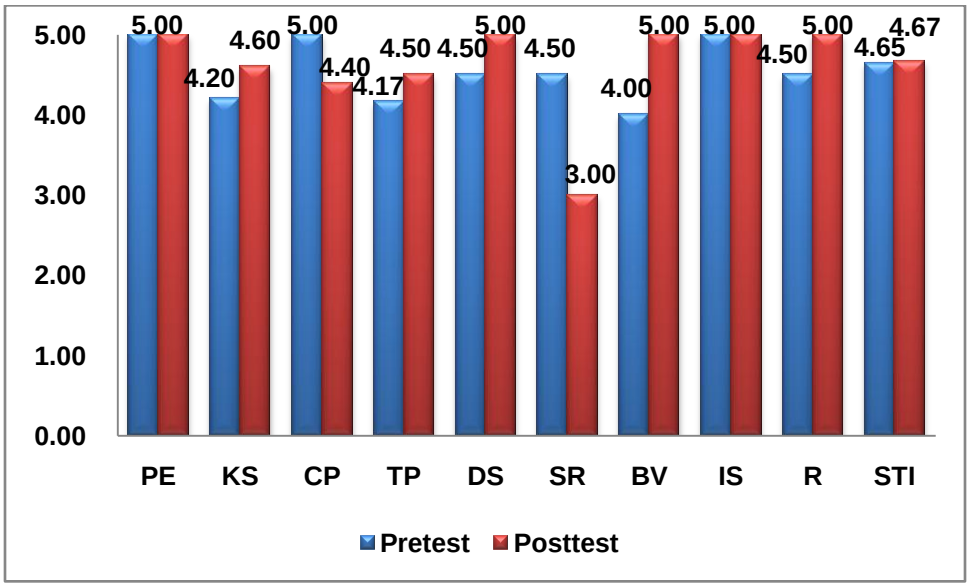


Figure 10. Nancy's Science Teacher Identity Change

For the first student teaching, she set goals for students' participation in classes. She observed how her mentor teacher had been teaching 10th grade life science classes. Her mentor teacher could not facilitate class discussion, activities, and a lab because students were not willing to participate in classes. She concluded that involving students

in class would be a key to succeed in her teaching career. However, she faced yet more trouble. She had planned too many things to teach, and rushed to cover too much information in a short time. She mentioned that these problems came from her passion: "I want the kids to learn everything that I know." With time management, she also found that she had difficulty in figuring out what content should be taught and what activities to choose. These challenges were listed in her learning goals for the next quarter student teaching placement.

Additionally, she had struggled to make her own lesson plans, identifying what constituted a good lesson and how to teach it. Another struggle was to force her to teach not her own lesson but her mentor's lesson. This made her so frustrated. She had few opportunities to implement her own lessons in student teaching. At the end of the second student teaching placement, she still observed that she did not yet have control over the content and what goes into the lessons. However, she positively evaluated some goals that she had reached fully: Giving clear directions, providing adequate wait time, and including all students in the lessons and activities. For the last quarter, she had improved in time management and lesson planning. She observed herself and noted that she had created her own lessons and had a personal teaching style. However, she left the goal of implementing technology into her lessons for first-year teaching, since she had not become technology- savvy in using tools such as a smart board or maintaining a webpage to post grades and homework. She had been successful in achieving other goals: setting fair and consistent classroom management and making a smooth transition between content and materials in closing. Eventually, she reflected that "My teaching has changed dramatically over the last 6 weeks" at the end of student teaching. She recalled in this

period that she was trying to establish herself as a teacher. She felt that she became an independent science teacher to teach her own lesson in her own classroom.

Joe (Strong STI, Complete Interview)

Background: He was in his mid-20s and graduated with double B.S. degrees in physics and astronomy, with a minor in Spanish. He had worked as a mathematics teaching associate for last two years. Before he graduated this program, he became a physical science teacher for 8^{th} grade.

Decision: While teaching mathematics at the college, he was excited at every class, and realized that teaching was the most rewarding career that he had experienced. Thus he decided to be a physics teacher as he majored in it. His senior physics teacher was influential in his decision to study physics and to become a science teacher.

Development: He showed strong science teacher identity in both the pretest and posttest of the STI instrument, although his posttest score decreased slightly (Figure 11). He had developed his science identity through integrating his creative ideas into lessons and exploring students' needs during student teaching. When interviewing with him, he shared a lot of stories about how he succeeded or failed and what his students was doing well or badly in his classes. Every single moment of student teaching made him think how to improve himself. For example, to remember students' names and develop rapport with them, he spent time with two or three students during his break time and met with problem students before classes. He shared and discussed extra learning materials with some students who had interests in science. Also, he tried to integrate good resources such as a smart board, flash assessment, and video tapes into his lessons, as he learned

from preparation programs. He examined his lesson plans to meet diverse needs of learners, e.g., disabled students. After every class, he reflected critically about his lessons in terms of his goals. As a result, he made rapid progress in his teaching. However, he felt that he was not yet a perfect science teacher. He estimated his progress in preparing to become a science teacher as being 50% at the end of winter quarter. Even though he felt he had enough content knowledge compared with other practicing science teachers whom he met in placements, he had less experience on how to manage, interact with, and help students than others. He believed that he could become a 100% science teacher within 10-20 years.

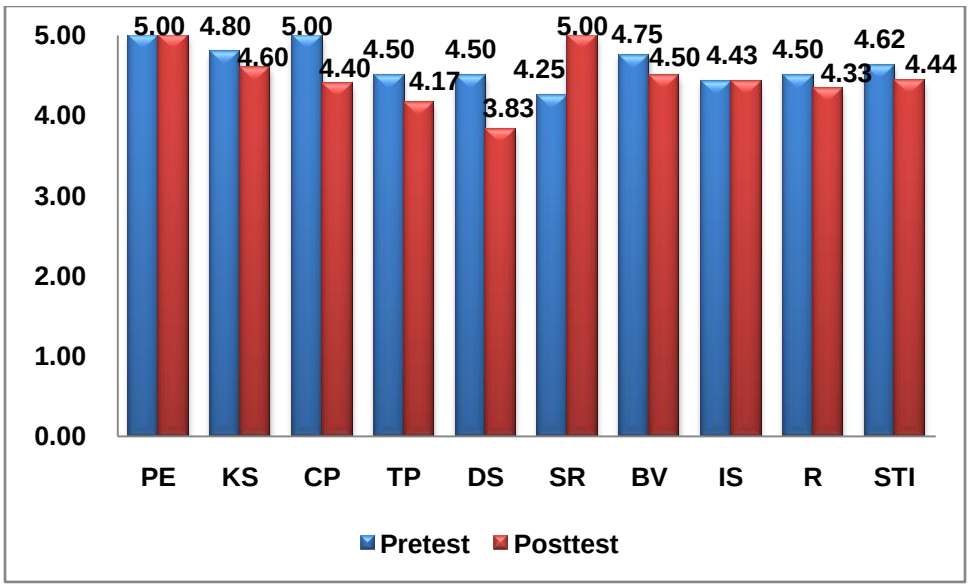


Figure 11. Joe's Science Teacher Identity Change

During the first student teaching, he exhibited many struggles with his previous teaching experiences as a mathematics TA. There was a difference between college-level teaching and high-school teaching. He needed to change his familiar teaching styles. For

example, he did not feel the need to discipline his students in college classrooms but he understood the importance of discipline for high school students. He tried to make rules for his classroom management. He realized that there are different learning needs between college students and high school students. College students need to cover all planned content regardless of their understanding, while high school students need teachers to work with students until they understand. He tried to slow down his pace by waiting for the students' response. Also he adjusted himself into a new environment: instead of a chalkboard which he could easily use to write and erase, he needed to learn how to handle projectors and use transparencies effectively.

In the second student teaching placement, he focused on how to make a good lesson plan. Pursuing each goal was very detailed: Time management of running lesson plans, integrating technology into lesson plans, developing multiple representations of lesson contents, and creating performance-based assessment. Of these four goals, he successfully reached three, but had trouble with time management. He had tried to be more realistic in creating lessons in the given time of 50 minutes. When he planned the first lesson, he was concerned that he would not have to waste time or leave excessive time. However, he couldn't completely run his lessons because he prepared too much content and too many activities per lesson. He kept in mind that "less is more" in creating lessons, and remembered to "watch students" in guessing how long one lesson would take.

For the last student teaching placement, he set four practical goals which are necessary to teach science: Meeting the needs of diverse learners, using Predict-Observe-Explain (POE) teaching methods, minimizing the use of classroom time to do classroom

management, and asking predominantly specific questions rather than general questions. For his action research project, he used POE teaching methods to measure how effective it is at increasing student engagement during class and their ability to recall the content. Through action research, he appreciated that he could broaden his insight as a science teacher to view his students and his lessons. He came to make his own way to teach science according to what worked for his students and classes. Therefore, he showed strong confidence in teaching science at the end of quarter.

The Impact of Science Teacher Education Programs on STI

All interviewees agreed that the science teacher preparation program helped them to become a science teacher. They said that they were not science teachers before they enrolled in science teacher education programs, but by the end of the program, three interviewees believed that they had become science teachers even though they did not get a position as a science teacher. For example, one interviewee said, "Now, I am a science teacher and I feel that I'm a science teacher. I argue and talk that. I proved that. I give an example. It's me!" They appreciated that they learned more about how to teach science and what to teach than what they had expected through the science teacher preparation programs. One of interviewees enjoyed exploring and planning how to teach what he had newly learned in the teacher education program. He felt he could develop his own action research project during student teaching. Among the various aspects of the science teacher preparation program (e.g., coursework, student teaching, portfolio, reflection seminars, action research, and mock interviews), student teaching experiences were

considered the most influential in promoting their professional growth and helping them prepare as a science teacher.

Student Teaching Experiences

According to interviewees' testimony, "Overall, the placement experience has really opened my eyes." "Student teaching definitely impacted me 90% in becoming a science teacher." Some interviewees emphasized that student teaching was so important that it made them be into a real teacher. When they first felt themselves to be a science teacher was when they taught science in classrooms during student teaching. Through the interviews, three crucial aspects of student teaching on the development of science teacher identity were identified. First, student teaching provides an opportunity for preservice teachers to experience the practical aspects of teaching science. The interviewees suggested that they could apply the knowledge and skills that they had learned and been learning throughout the teacher education program. Second, it involves them as a science teacher in the school community and in the science teacher professional community. Through student teaching, preservice teachers develop a variety of relationships with diverse members of the educational community: faculty, mentors, supervisors, students, and other science teachers. Interviewees found the basis for their satisfaction and commitment in teaching science through developing a rapport with students. Third, student teaching promotes increased confidence in teaching science through experiencing a degree of success. Either failure or success in implementing lesson plans or activities in classrooms were valuable in helping them to come to learn about their weakness and strengths in teaching science and managing classrooms.

Overall, student teaching experiences was felt to have a more valuable impact on the development of science teacher identity than other aspect of the program.

Development of the Teaching Profession

Progress in professional preparation was reported as being in varying stages of development during the middle of the program, but almost at the same level of 90-100% complete for all interviewees by the end of the program. Preservice teachers felt that they were already science teachers or ready to be science teachers by the end of the program. Some interviewees did express concerns regarding their first-year of teaching, but they believed that they would be perfectly fine science teachers after the first-year of teaching. These concerns were represented as a critical crisis of first-year teachers for development in the science teaching profession, as presented in comparison to mean differences with teaching years groups. Interviewees identified themselves as being more professional as science teachers than they were at the beginning of the program. They mentioned their lesson plans as a good example to show their professional development and growth because the plans had been changed and improved over the course of student teaching.

The Dimensions of the STI Model with Professional Development Experiences

The construct validity of the science teacher identity model was explored through qualitative data. Two themes were identified and explored: the decision to become a science teacher and the characteristics of effective science teachers and science teaching. These themes presented the dimensions of STI as following:

- Decision to become a science teacher: Positive science learning experience (PE) and social respect (SR)

- Characteristics of effective science teachers and science teaching: being knowledgeable (KS), preparing and planning lessons (TP), instructing diverse teaching strategies (e.g., inquiry-based, project-based, hands-on activities, problems-solving, student-centered, and standard-based teaching and learning) (TP), managing and organizing classrooms (DS), establish a rapport with students (DS), collaborating with others (CP), having a passion and enthusiasm (IS), having a goal and vision (R), and reflection.

Decision to Become a Science Teacher

Several reasons for becoming a science teacher were identified (e.g., personal background, preference for a subject, "science," academic success in science, science teachers, and family support). The most important aspect in the decision to become a science teacher was "science" as a subject area. Interviewees had positive experiences related to science. For example, all interviewees mentioned that science was more interesting than other subjects, regardless of their grades in science. Most interviewees showed a strong enthusiasm in science.

Some participants also listed their past science teachers as being very influential in their decision. Participants also mentioned wanting to be like them because their favorite science teachers were their role models. Also, during the first interview, they had strong confidence in their ability to teach in the subject area. They were likely to help others learn science as much as they like science. They believed that teaching science is a way of doing science and a contribution to the science education community. Likewise, both enthusiasm in science and interest in teaching may lead one to decide to be a science teacher.

Before entering the science teacher preparation program, the initial perceptions and images that preservice science teachers held of science teachers varied. There were both positive and negative perception and images. For example: “Science teachers are always smarter than other teachers.” “Too scary; too intelligent.” “Being a science teacher is so boring.” “Not making much money.” They indicated that social respect influenced their career decisions slightly.

Characteristics of an Effective Science Teacher and Science Teaching

Interviewees pointed out several characteristics of effective science teachers and science teaching: being knowledgeable, preparing and planning lessons, using diverse teaching strategies (e.g., inquiry-based, project-based, hands-on activities, problem-solving, student-centered, and standard-based teaching and learning), managing and organizing classrooms, establishing a rapport with students, collaborating with others, having passion and enthusiasm, and having a goal and vision. These characteristics are related to several dimensions of the STI model: having knowledge and skill (KS), science teaching practice (TP), degree of success (DS), community practice (CP), intrinsic satisfaction (IS), representation (R) and reflection.

All participants listed ‘having knowledge and skill’ as a primary characteristic of effective science teachers. As Volkmann and Anderson (1998) asserted, teaching science is different from liking or knowing about science or teaching, which means that science teachers should have the necessary knowledge and skill in teaching science. In fact, preservice science teachers had challenges or concerns related to content knowledge, pedagogical content knowledge, and pedagogical knowledge. Although some participants had a bachelor’s degree in science majors, they felt a lack of pedagogical content

knowledge to teach science to students. One participant who had a lack of content knowledge in a licensure area showed an ambiguity of his science teacher identity.

Preparing and planning lessons and using diverse teaching strategies (e.g., inquiry-based, project-based, hands-on activities, problem-solving, student-centered, and standard-based teaching and learning) are categorized as "science teaching practice." Because science teaching practice reflects how science teachers perform in teaching science, it is a crucial part of becoming a science teacher. Interview data revealed that science teaching practice is important in interviewees' evaluating themselves as science teachers. According to the questionnaires of 'students' evaluation of teacher interns' that participants created, there were many relevant items to science teaching practice. For instance, "The teacher was prepared for class." "Materials for class were organized and available." "The teacher presented scientific ideas in a way that makes me easier to understand." "The teacher explained things clearly." "The teacher created exciting and helpful lessons." "The teacher made class interesting." Moreover, the impact of science teaching practice on student learning is emphasized because what students learn is determined by how science teachers teach (NRC, 1996). In other words, the science teacher's view of and attitude toward science directly reflect on their science teaching. Several studies have supported the importance of science teaching practice (Helms, 1998; Lederman, 1992, 1996; Lunn, 2002; Solomon, Scott, & Duveen, 1996).

The domain of the degree of success that focuses on relationship with students includes "managing and organizing classrooms and establishing a rapport with students." As discussed above, many preservice teachers had struggled with classroom management. When they had no rapport with students, they experienced a failure of their teaching and

classroom management in the beginning of student teaching placement. They came to know that the key to success in implementing their lessons was learning how to interact with students. Establishing a rapport with students might help preservice science teachers to become successful and confident science teachers.

Science teachers' relationship with others was conceptualized as the domain of "community practice." One of the interviewees mentioned that unless he could have a network of colleagues, mentor teachers, and supervisors, he did not accomplish his placement. When another interviewee felt lost in student teaching, her colleagues encouraged her to recover her confidence in teaching. Another participant stated that the most important need for his student teaching was "collaboration."

For the domain of intrinsic satisfaction, participants stressed science teachers' enthusiasm, passion, and enjoyment about science and teaching science. Volkmann and Anderson (1998) suggested that having an interest in science or enjoying science is fundamental in teaching it. Also, watching students' learning progress was the most satisfying and enjoyable aspect of teaching science to science teachers. This makes the teaching profession different from other professions. Participants set up several goals for every student teaching placement. Most of them struggled to achieve those goals but this process was essential for them to represent themselves as a science teacher and improve the science teaching profession.

Finally, all participants commented on the significance of reflection in becoming a science teacher. In the final reflection, one participant said, "Being reflective and being unsatisfied are keys to growth and improvement." The other participant said, "I can see by looking at my reflections that I have progressed." Without a deep reflection, they

could not find their strength and weakness, or success and failure. Through reflection, they reconstructed their knowledge and experiences in representing the self as a science teacher as well as in constructing their science teacher identity.

Chapter 5: Discussion

Efforts to improve student performance in science are hampered by shortages of qualified science teachers. Science teacher shortages result from the combined effects of an insufficient supply of new, well-qualified science teachers, and a high turnover of science teachers during the early years of their professional experiences. This infrastructural issue of recruiting and retaining highly motivated and qualified science teachers is thought to be deeply related to a teacher attribute, science teacher identity. Given the possible relationships among professional identity, teacher supply, teacher retention, and student performance, science teacher identity is receiving increased attention as an important construct in the science teacher education community. In response to this issue, this study was conducted to seek answers to the following questions:

1. How can the dimensions of the science teacher identity construct be conceptualized and represented?
2. Can the level of science teacher identity be validly and reliably measured?
3. What evidence supports the efficacy of the proposed model of science teacher identity?

The research strategy of this study comprised four phases. In the first phase, the construct of science teacher identity was conceptualized. Based on conceptualization of science teacher identity, a conceptual model of science teacher identity was proposed.

And a new instrument of science teacher identity was developed and field-tested. In phase four, the efficacy of the STI model as measured by the STI instrument was examined. The validity and reliability of the STI instrument were examined during field-tests, and the efficacy of the STI model was quantitatively and qualitatively explored. Both quantitative and qualitative research methods were employed to begin the construct validation process for the dimensions of STI and the structural formation of the STI model.

As a result, this study involved the construction of a conceptual model of science teacher identity and development of a new instrument to measure the level of science teacher identity. Further, this study provided evidence supporting the efficacy of the model of science teacher identity in explicating the self-construction of science teacher identity among preservice science teachers within the context of a graduate level science teacher preparation program.

This chapter interprets findings to the context of the guiding research questions presented in Chapter 1. Following a summary of findings, conclusions relating to the research questions are highlighted, as well as implications of the findings. Lastly, limitations of this study are discussed and recommendations for further research are suggested.

Summary of Key Findings

Question 1. How can the dimensions of the science teacher identity construct be conceptualized and represented?

As a result of the procedures used to construct a conceptual model of science teacher identity (STI model), 11 proposed construct dimensions emerged from a review of findings on identity and professional identity in fields within and outside of education, and from previous qualitative studies focusing on science teacher identity. In order to establish a rigorous conceptual foundation, each construct dimension of related models was compared with the initial formulation of the conceptual framework of this study: The ten principles of teacher identity proposed by Danielwicz (2001), the four dimensions of identity in a model suggested by Helms (1998) and the seven elements of physician teacher identity identified by Starr et al. (2006).

Of the various dimensions proposed, one construct dimension is a procedural component. The other construct dimensions are structural components of the STI model. Among structural components, seven components are categorized into a self-knowledge dimension—including personal self-knowledge and collective self-knowledge—and three components are categorized into a self-reflection dimension. The resulting 11 construct dimensions and key terms of the proposed model are defined as follows:

- Structural component: A schematic component used in constructing science teacher identity, like building blocks are used to build a structure
  - Self-knowledge dimension: An informative domain of self: Knowledge relevant to self, which is gathered from self or outside of self and interpersonally or intrapersonally assembled to inform self-concept.
    - Personal self-knowledge: Individual and subjective self-knowledge of a knower-self (I-self), which is obtained and accumulated by a self.

- Personal Learning Experience (PE): Personal self-knowledge obtained from life history and learning experiences, academic success, memory relation to classroom and school, and role model.
- Having knowledge and skill (KS): Personal self-knowledge obtained from relevant knowledge and skill in teaching science e.g., professional knowledge, pedagogical knowledge, content knowledge, and pedagogical content knowledge.
- Qualification (Q): Personal self-knowledge affirmed by licensure and certification of science teachers

• Collective self knowledge: Public and objective self knowledge for a known-self (Me-self), which is established through relationships with others, as participation in a group, community, society, culture, or subject matter specialization.

- Community practice (CP): Collective self-knowledge from community practice through collaboration with colleagues.
- Science Teaching practice (TP): Collective self-knowledge from science teaching practice driven by the nature of the subject matter (science).
- Degree of success (DS): Collective self-knowledge as a result of interactions with students.

- Social respect (SR): Collective self-knowledge from recognition for science teachers by institutions, parents, and the general public.

▪ Self-reflection dimension: An intrapersonal response domain to self, which leads to cognitive and affective responses to a sense of self as a science teacher: An individual's intrapersonal reflection on the individual's sense of self as a science teacher in relation to specific context, such as science teaching, which is a positive or negative attribute of self. Through self-reflection, self-knowledge may be reconstructed and then presented through self as a science teacher.

- Belief and value in science teaching (BV): Cognitive reflection on belief and value in science teaching.
- Intrinsic satisfaction (IS): Affective reflection on enjoyment of science teaching.
- Representation (R): Conscious and unconscious reflection on a future-self as a science teacher, e.g., positive images, ambitions, visions, goals and attitudes related to science teacher identity.

◆ Procedural component: A component playing a role in making linkages to connect cognitively and psychologically among components. e.g., Reflexivity, reconstruction, and reflection.

- Reflection and Reconstruction: A cognitive and affective self-process to reorganize and represent self-knowledge for a self in reaction to a self and others.

In this new model, science teacher identity is based on a construction of self-knowledge, including personal and collective self-knowledge; reconstructed by self-reflection dimensions; and then, reflected on self to form an individual science teacher identity. Since the STI model is intended as a way of representing the teacher identity attribute in the specific context of science teaching, the subject matter "science" is crucial in construction of science teacher identity.

Question 2. Can the level of science teacher identity be validly and reliably measured?

A new instrument of science teacher identity (STI instrument) was developed as a 48-item questionnaire using a Likert format to measure the nine postulated dimensions of the proposed STI model including self-knowledge and self-reflection dimensions: science teachers' personal learning experience, having knowledge and skills, community practice, science teaching practice, degree of success, social respect, belief and value in science teaching, intrinsic satisfaction, and representation. The quality of the STI instrument was evaluated by two empirical criteria: Validity and reliability.

Validity is defined as the degree to which evidence and theory represent the interpretation of test scores entailed by the proposed uses of a test (American Educational Research Association [AERA], 1999; Ary et al., 2002; Furr & Bacharach, 2008; Hair et al., 2009). Evidence of validity include: the validated content of the instrument for measuring science teacher identity, the outcome of a factor analysis used to examine the predicted dimensions of science teacher identity, correlation patterns among several variables purportedly related to the conceptual model on which the instrument is based, and comparisons of STI scores among various groups of science teachers.

Reliability is defined as the degree to which the observed variables or scores measure consistently the true value and error free as reflecting psychological construct proposed uses of a test (Ary et al., 2002; Borsboom, 2005; Furr & Bacharach, 2008; Hair et al., 2009). In order to examine the internal consistency of the STI instrument, Cronbach's alpha was calculated for all participant groupings. To check for sampling bias that could result from excluding data contributed by participants who did not respond to all items of the questionnaire, the results were consistent across groups. The reliability of the total STI score was .89 and reliabilities of subscales ranged from .60 through .85. Some subscales including small numbers of items (4 through 5) exhibited lower coefficients than those of other subscales. This is likely explained by the dependence of reliability on the length of a scale, with scales having more items producing the greater reliabilities (Ary et al., 2002; Borsboom, 2005; Furr & Bacharach, 2008). According to Ary et al.'s guideline (2002), a coefficient of .80 for a scale would be evaluated as 'excellent' (p.262). This level of reliability is particularly noteworthy for scales of personality variables, since such scales tend to have typically moderate reliability (.60 to .70) due to the nature of the variables being measured (Ary et al., 2002). For an instrument to be used for making decisions about groups and other research purposes, a moderate coefficient in the range of .50 to .60 may be acceptable (Ary et al., 2002). Within the context of these criteria, the results of this study show that the reliability of the STI instrument is robust for measuring the nine dimensions of the STI model (Ary et al., 2002; Hair et al., 2009). Based on this evidence, the level of science teacher identity can be validly and reliably measured with the newly developed STI instrument.

Question 3. What evidence supports the efficacy of the proposed model of science teacher identity?

Both quantitative and qualitative evidence has been found for the efficacy of the STI model. In particular, the efficacy of the STI model was examined within the specific context of a science teacher preparation program. The degree of change in levels of STI associated with participation in a science teacher preparation program was investigated by a one-group pretest-posttest design using the STI instrument, interviews, and document analysis. The results confirmed the prediction that the level of STI would increase as preservice teachers progressed through a science teacher preparation program. Among three different levels of STI groups, the STI scores of the weak STI level groups showed the most significant change, while the STI scores of the strong STI level groups exhibited the most stable and consistent STI status. This finding could explain that preservice science teachers have experienced for professional development and construction for their science teacher identity. Qualitative data gathered from the purposely selected six interviewees also supported the consistent findings that preservice teachers had improved in having knowledge and skills to teach science; became more comfortable and confident in teaching science and classroom management; were intrinsically satisfied about their profession; and represented themselves positively as science teachers. In particular, the student teaching experience was identified as the most influential aspect of the teacher preparation program on development of science teacher identity and the science teaching profession. Moreover, each construct dimension of STI model was explicated by two themes of qualitative data: the decision to become a science teacher and the characteristics of an effective science teacher and science teaching.

Additional Findings Related to STI

From field-testing of the STI instrument and examination of the STI model, additional findings related to the construct dimensions of science teacher identity were found. These findings would be worthy of further study to examine important relationships of science teacher identity with various science teacher groups.

- Male science teachers might have more positive learning experiences in science than do female science teachers.
- Science teachers who have advanced degrees might be more knowledgeable and skillful in teaching science. Also, they are likely to be more professionally active in the community of science teachers and have more confidence in teaching science.
- Preservice science teachers may have a less well developed sense of membership or participation in the science teaching community than practicing science teachers
- First-year science teachers might be challenged in developing their own science teacher identity due to the practical difficulties associated with a new profession.
- Practicing science teachers might feel more professional in teaching science. It is suggested that science teachers develop their profession skills and strengthen their science teacher identity as they progress through career experiences year by year. On the other hand, science teachers might have a tendency to regress in terms of vision and self-image for the future as their professional status becomes stable.

- Though secondary science teachers have more positive learning experiences and attitudes toward science than do elementary science teachers, they might have lower in confidence in their science teaching practices and degree of success than do elementary science teachers.
- Science teachers licensed or certificated for both elementary and secondary science teaching may experience more intrinsic satisfaction as science teachers than do science teachers licensed or certified as either elementary or secondary science teachers.
- Science teachers who major in chemistry, physics, and physical science might value science teaching less than those who major in science education.
- The impact of graduate level science teacher preparation programs on STI development may be greater than undergraduate programs if increased knowledge and skills are emphasized. Through science teacher preparation programs, several dimensions of STI, such as having knowledge and skills, science teaching practice, degree of success, intrinsic satisfaction, and representation could be increased.

Conclusions

The interpretation of the results presented here is that science teacher identity is an attribute that can be indirectly measured using the STI instrument. The instrument structure reflects a conceptual model of science teacher identity that has been constructed on the basis of the available research, both within education and in related professional areas. The pattern of correlations and comparisons presented also provides initial

evidence of construct validity, but there is clearly much work to be done to test the functional utility of both the STI model and the associated STI instrument.

Construct Validation of STI Model and STI Instrument

As discussed above, results were found to support the construct validity of the STI model, and analyses of response patterns to the STI instrument explicate the structural dimensions of the STI model. According to recommendations of the "Standards for Educational and Psychological Testing" (AERA, 1999), the scientific evidence of construct validity and structural formation is assessed by examining the content of scale content, the internal structure of the scales, the psychological process based on scale responses, the consequence of the scale use, and the associations among scale scores and other variables.

First, the content validity was established through a pilot study. The content of the STI instrument was validated at point 3.43 ± 0.4 above the designated level (3.0) for measuring science teacher identity. Based on participants' comments regarding their understanding of the meaning of each item and their responses to each item, a panel of experts provided support for the content validity of the STI instrument. As a result of the feedback during the pilot study, the initial instrument was revised as a 48-item questionnaire.

Second, the psychological processes associated with scale responses were assessed by examining interviewees' comments on their understanding of what each item means and their thoughts of how they rated each item in a pilot study. This process provided information about what and how the STI construct is being measured (See Table 4) (Ary et al., 2002; Furr & Bacharach, 2008). Based on this information, revision

of the STI instrument was guided by assessing whether the meaning of each item was interpreted the same among interviewees, and by determining which items were construct-irrelevant. After modifying the STI instrument on the basis of these assessments, scores obtained by using the STI instrument had been interpreted as valid measures of science teacher identity.

Third, evidence of validity was sought by assessing the correspondence of the internal structure of the instrument subscales with the construct structure (dimension of STI model), further indicating that the STI instrument measures what it is intended to measure (Ary et al., 2002; Furr & Bacharach, 2008). During field-testing, the internal structure of the STI instrument was examined through factor analysis and inter-correlations among the subscales. Factor analysis has been a useful statistical technique to identify and define the underlying structure or dimensions among the items in a scale (Hair et al., 2009). As Furr and Bacharach explained (2008), the aims of factor analysis are to clarify the number of factors within a set of items and to reveal the associations among the factors within a scale. There are two representative techniques: component factor analysis and common factor analysis. The objectives of the two techniques are different. Component factor analysis is used to find the minimum number of factors for representing the construct, while common factor analysis aims to identify the latent dimensions or construct represented in the original test set. Thus this study used a principal-axis factoring with varimax rotation as a common factor analysis in order to validate the factors postulated in the underlying structure of the STI instrument. As a result of two consecutive factor analyses, a total of 11 factors were extracted with significant loading scores that accounted for 64% of the variance and retained with a

cutoff value of 1.0 for the eigenvalue (Hair et al, 2009). Seven factors were purely extracted and four factors were interpreted as representing two complementary aspects of two factors. In addition, as a result of inter-correlation analysis, all subscales are significantly correlated as predicted, with the exception of some correlations on one subscale, personal learning experience. Through these findings, it is confirmed that the nine subscales of the STI instrument conform to the postulated dimensions of the STI model.

The consequences of testing the STI instrument also support construct validity. As reported, field-testing provided an expected pattern of relationships between STI scores and a variety of external demographic variables. There were anticipated consequences that indicate the differences in STI subscale scores between groups, for example, gender (female and male), highest degree levels (e.g., doctoral degree, master degree, and bachelor degree), preservice and practicing science teachers, grade levels (elementary science teachers, secondary science teachers, and elementary and secondary science teachers), teaching years, and science majors. In addition, the expected changes in STI levels were quantitatively observed among preservice science teachers as they progressed through a teacher preparation program, and the noted changes were qualitatively explained by data extracted from interviews and documents. The validity of the STI construct dimensions was exhibited in qualitative data.

However, evidence of associations among scale scores and other variables was not evaluated in this study, since there was no instrument for measuring the level of science teacher identity prior to this study.

In conclusion, four preliminary forms of evidence provide an empirical basis for the construct validity of the STI model and STI instrument developed in this study.

For the STI Model:

- The underlying structure of the STI model is identified (See Figure 4), and an array of predicted correlations are presented. Factor analysis provides evidence that the scale developed to measure science teacher identity does comprise nine subscales representing nine dimensions of the STI model. All subscales are significantly correlated as predicted (In particular, the dimension, 'Degree of Success' was most strongly associated with STI score), with the exception of some correlations on the dimension 'Personal Experience.'
- It is demonstrated that the proposed dimensions of science teacher identity can be reliably and validly measured with a newly constructed instrument. Total STI score exhibited a reliability coefficient of .89 and subscale reliabilities ranged from .60 to .85. Evidence of content validity was provided in a pilot study, and evidence of construct validity was initiated with this study. Preliminary evidence is provided by confirmation of model structure through factor analysis; robustness of reliability coefficients across groups studied (Ary et al, 2002; Hair et al. 2009) the pattern of positive correlations among STI instrument subscales, the pattern of relationships noted between STI scores and a variety of external demographic variables, and confirmation of an increase in STI levels as teacher interns progress through a teacher preparation program.

For the STI Instrument:

- The new STI instrument can be used to examine the effects of professional development experiences on science teacher identity. In this study, STI scale scores were found to increase as preservice teachers progressed through the component, ‘student teaching placement’ of their teacher preparation program.
- The STI instrument can provide science teacher identity profiles of whole or sub-dimensions of groups based on demographic information. As one would predict if the STI model is valid, STI scale score was found to be positively associated with increased teaching experience, knowledge and skills, level of education, and other variables associated with personal and professional growth.

Implications

The implications of this study are discussed as theoretical and practical contributions in the field. This study is the first known attempt to propose, validate, and examine a new conceptual model of science teacher identity within the science education discourse community. This procedure may provide educational researchers with a two-faceted scientific approach in building a conceptual model. Through an inductive reasoning process, the concept of science teacher identity and the construct dimensions of the STI model have been conceptualized and drawn from previous findings of empirical research. On the other hand, the validation and examination of STI model have been tested through a deductive process. Through this scientific approach, the procedures and results of this study may provide the foundational basis for formulating a new conceptual and theoretical framework of STI, together with an instrument for measuring STI.

Informed through several lines of evidence for the efficacy of the STI construct and model, this study showed that STI is a multi-faceted concept including 11 components. Specifically, nine dimensions of the STI model postulated in the STI instrument have exhibited a nomological network of the concept of science teacher identity through factor analysis, correlation analysis, and statistical difference among external variables representing science teacher demographic information. The conceptual model of STI may be not only a composite framework for this individual study but also a predictive framework serving purposes of research interests in relation to science teacher identity as well as broader interest in relation to professional identity within education research communities. This study may facilitate greater research interest among science teacher educators and researchers studying teacher attributes, professional identity, teacher education, and professional development.

Beyond increasing awareness of the psychological construct of science teacher identity as an emerging variable of interest in the science education discourse community, the availability of an instrument to measure science teacher identity provides a powerful new tool for examining longstanding issues and concerns in the field. In particular, this new instrument can be used to broaden research on: a) the effects of science teacher preparation programs and professional development experiences; b) factors related to recruitment, retention, and turnover among science teachers; and c) the influence of professional practices and expectations on professional identity.

Among science teacher educators, the outcomes of this study identify science teacher identity as an important variable to consider when gauging the impact of teacher preparation programs and improve the structure and function of teacher preparation

programs. On a more individual level, for science teachers, findings from use of this new model and instrument may provide guidelines for career decisions, professional success, and professional development pathways.

Limitation and Further Study

The recommendations for further study are based on various aspects of this study, including a limitation, theoretical justification, and research context. As previously discussed, the preliminary findings reported here associated with the conceptualization of the science teacher identity construct and development of the STI instrument cannot be broadly generalized to science teacher populations. Though both the field-testing of this study conducted with a broad range of target populations and the investigation of the change in level of STI at one location within one type population has provided acceptable evidence of construct validity and efficacy of measurement, the results might not generalize to different types of populations or to different contexts (Furr & Bacharach, 2008). Therefore, the examination of the STI model and the STI instrument should be replicated with other populations in other contexts.

Another limitation for this study is embedded in the data source type. For measuring the level of science teacher identity, the STI instrument has been designed as a self-report scale. In investigating changes in the level of STI, the main sources of data depends on self-reported data (e.g., STI instrument, reflection, and interviews) in spite of various types of methods used. As Furr and Bacharach (2008) pointed out, although self-report scales are common, easy, inexpensive, and informative (p.219), there is a drawback in assessing the validity of measurements. For example, a correlation analyses

based on self-report questionnaires are potentially inflated due to shared method variance. When correlation analyses are based on different methods, the coefficients tend to be smaller than those based on self-report data. To enhance the credibility of data, further study could include data reported from multiple methods (self-report, acquaintance ratings, and interviewer ratings).

For construct validation, the relation to other measurements is critical in establishing convergent validity and discriminant validity of the instrument (Ary et al., 2002; Furr & Bacharach, 2008, Hair et al., 2009). The convergent validity is the degree to which two measurements of the same constructs are correlated, while discriminant validity is the degree to which a measurement is uncorrelated with another of unrelated constructs (Ary et al., 2002; Furr & Bacharach, 2008, Hair et al., 2009). To further validate the STI model and STI instrument, a few measurements intended to measure teacher identity (Song & Wei, 2007 and Cheng, 2008) and other attributes of teachers such as burnout (Byrane, 1994), efficacy (Tschannen-Moran & Hoy, 2001), and satisfaction (Lester, 1984) may be used for further analysis.

To justify the STI model, additional confirmatory steps are needed in addition to the previous factor analysis (Hair et al., 2009). Commonly, confirmatory factor analysis through structural equation modeling is used to validate directly the underlying structure of a model. In confirmatory factor analysis, a pretest of a new measurement should be used to purify the scales. In this manner, this study has provided the results of a pretest. To further refine the STI instrument, there are two ways: selecting the item with highest factor loading as a surrogate representative for a particular factor dimension or replacing and recreating the original set of items with an entirely new, smaller set of variables (Hair

et al., 2009). Based on factor analysis, the STI instrument would be revised and administered with a new population and in a new context for further study.

In the beginning of this study, research problems were inspired by several issues surrounding science education discourse community (e.g., poor students' performance of learning science and quality and quantity of science teachers). Specifically, the most significant construct in relation with these issues was identified as a science teacher's sense of a self, science teacher identity. This study has sought the conceptual and theoretical foundation of the research construct, science teacher identity. As a result, a new conceptual model of science teacher identity along with an instrument of science teacher identity were developed and examined. Through these findings, this study may provide a foundation to initiate and explore the practical relationships between science teacher identity and issues of professional development. The further study can be conducted with practicing science teachers and professional development.

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Appendix A: Initial STI Instrument

Instruments to Measure Science Teacher Identity

Date: _____/_____/_____/
Month / Day / Year

	Strongly disagree	Disagree	Moderate	Agree	Strongly agree
1. I have been interested in science.	1	2	3	4	5
2. I enjoyed learning science.	1	2	3	4	5
3. I was good at doing science.	1	2	3	4	5
4. I got a higher grade in science than other subjects.	1	2	3	4	5
5. I liked science teachers who taught me.	1	2	3	4	5
6. I know and understand the major scientific concepts and processes that I plan to teach.	1	2	3	4	5
7. I integrate scientific knowledge to knowledge of science education, learning, pedagogy and students.	1	2	3	4	5
8. I feel skilled as a science teacher.	1	2	3	4	5
9. It is important to me to develop my knowledge and teaching skills.	1	2	3	4	5
10. I read journals about science teaching.	1	2	3	4	5
11. I feel a part of a community of science teachers.	1	2	3	4	5
12. I belong to professional associations or groups of science teachers.	1	2	3	4	5
13. I frequently talk to colleagues about teaching science.	1	2	3	4	5
14. It is helpful to be able to discuss the progress of students with colleagues.	1	2	3	4	5
15. I enjoy sharing ideas and resources about teaching science.	1	2	3	4	5
16. I have own my perspective on the nature of science.	1	2	3	4	5
17. My understanding of science shapes my teaching philosophy and attitude.	1	2	3	4	5
18. I plan and use an inquiry-based teaching and learning for my students.	1	2	3	4	5
19. I employ diverse instructions and activities to teaching science.	1	2	3	4	5
20. There is a difficulty to demonstrate my scientific knowledge in teaching science.	1	2	3	4	5
21. I interact with students to find their needs, interests, and abilities of learning science.	1	2	3	4	5
22. I facilitate students more engaged in learning science.	1	2	3	4	5
23. I create a flexible and supportive learning environment for students.	1	2	3	4	5
24. I make a positive progress in students' achievement and performance in learning science.	1	2	3	4	5
25. I give students an important perspective on science.	1	2	3	4	5
26. I am a role model for students who have interest in science.	1	2	3	4	5
27. I enjoy the social recognition I get as a science teacher.	1	2	3	4	5
28. Students and/or other teachers (faculty) regard me as an effective science teacher.	1	2	3	4	5
29. It is important that institutions (e.g. colleges or teacher education programs) recognize my teaching in some way.	1	2	3	4	5

30. The school/district rewards my teaching (e.g., monetary rewards, a parking pass, library privileges and financial support for professional development).	1	2	3	4	5
31. It's important to contribute to science education.	1	2	3	4	5
32. I find it satisfying to think that I am contributing to the profession by teaching.	1	2	3	4	5
33. I conduct meaningful and interesting learning science to students.	1	2	3	4	5
34. Good teaching has contributed to my career advancement.	1	2	3	4	5
35. I truly enjoy the role of science teacher.	1	2	3	4	5
36. Working with students has its costs, but it's worth it.	1	2	3	4	5
37. I find satisfaction watching my students and/or teaching profession progress.	1	2	3	4	5
38. Teaching is a more rewarding job.	1	2	3	4	5
39. It is important to me to work in schools.	1	2	3	4	5
40. Both teaching and science are pleasing to me.	1	2	3	4	5
41.I see myself as a science teacher.	1	2	3	4	5
42. I would like to be a more knowledgeable and skillful teacher.	1	2	3	4	5
43. I would like to spend more time teaching students.	1	2	3	4	5
44. I would like to be a better science teacher for my students.	1	2	3	4	5
45. I would like to be more involved in a community of science teachers.	1	2	3	4	5
46. I would like to be more rewarded for my teaching.	1	2	3	4	5

Biography

- Teacher Gender: Male ( ) Female ( )
- Teaching years:
- Please indicate the subjects for each of your degrees (or the subject that you prepare to teach)

	Bachelors	Masters	Doctorate
a. Life science/Biology			
b. Earth/Space science			
c. Chemistry			
d. Physics/Physical science			
e. Engineering/Technology			
f. Science education			
g. Elementary education			
h. Other subject areas, please specify (e.g. mathematics, mathematics education, or special education.)			

Appendix B: Content Validity Questionnaire of STI Instrument

Content Validity of STI Instruments

Date: _____/_____/_____
Month / Day / Year

How valid is the item for measuring science teacher identity on a 4-point scale (not at all, somewhat, important and critical)?

	Not at all	Somewhat	Important	Critical
1. I have been interested in science.	1	2	3	4
2. I enjoyed learning science.	1	2	3	4
3. I was good at doing science.	1	2	3	4
4. I got a higher grade in science than other subjects.	1	2	3	4
5. I liked science teachers who taught me.	1	2	3	4
6. I know and understand the major scientific concepts and processes that I plan to teach.	1	2	3	4
7. I integrate scientific knowledge to knowledge of science education, learning, pedagogy and students.	1	2	3	4
8. I feel skilled as a science teacher.	1	2	3	4
9. It is important to me to develop my knowledge and teaching skills.	1	2	3	4
10. I read journals about science teaching.	1	2	3	4
11. I feel a part of a community of science teachers.	1	2	3	4
12. I belong to professional associations or groups of science teachers.	1	2	3	4
13. I frequently talk to colleagues about teaching science.	1	2	3	4
14. It is helpful to be able to discuss the progress of students with colleagues.	1	2	3	4
15. I enjoy sharing ideas and resources about teaching science.	1	2	3	4
16. I have own my perspective on the nature of science.	1	2	3	4
17. My understanding of science shapes my teaching philosophy and attitude.	1	2	3	4
18. I plan and use an inquiry-based teaching and learning for my students.	1	2	3	4
19. I employ diverse instructions and activities to teaching science.	1	2	3	4
20. There is a difficulty to demonstrate my scientific knowledge in teaching science.	1	2	3	4
21. I interact with students to find their needs, interests, and abilities of learning science.	1	2	3	4
22. I facilitate students more engaged in learning science.	1	2	3	4

23. I create a flexible and supportive learning environment for students.	1	2	3	4
24. I make a positive progress in students' achievement and performance in learning science.	1	2	3	4
25. I give students an important perspective on science.	1	2	3	4
26. I am a role model for students who have interest in science.	1	2	3	4
27. I enjoy the social recognition I get as a science teacher.	1	2	3	4
28. Students and/or other teachers (faculty) regard me as an effective science teacher.	1	2	3	4
9. It is important that institutions (e.g. colleges or teacher education programs) recognize my teaching in some way.	1	2	3	4
30. The school/district rewards my teaching (e.g., monetary rewards, a parking pass, library privileges and financial support for professional development).	1	2	3	4
31. It's important to contribute to science education.	1	2	3	4
32. I find it satisfying to think that I am contributing to the profession by teaching.	1	2	3	4
33. I conduct meaningful and interesting learning science to students.	1	2	3	4
34. Good teaching has contributed to my career advancement.	1	2	3	4
35. I truly enjoy the role of science teacher.	1	2	3	4
36. Working with students has its costs, but it's worth it.	1	2	3	4
37. I find satisfaction watching my students and/or teaching profession progress.	1	2	3	4
38. Teaching is a more rewarding job.	1	2	3	4
39. It is important to me to work in schools.	1	2	3	4
40. Both teaching and science are pleasing to me.	1	2	3	4
41.I see myself as a science teacher.	1	2	3	4
42. I would like to be a more knowledgeable and skillful teacher.	1	2	3	4
43. I would like to spend more time teaching students.	1	2	3	4
44. I would like to be a better science teacher for my students.	1	2	3	4
45. I would like to be more involved in a community of science teachers.	1	2	3	4
46. I would like to be more rewarded for my teaching.	1	2	3	4

Appendix C: STI Instrument

Survey

Date: _____/_____/_____/
Month / Day / Year

Instructions: Please indicate your opinion about each statement by circling the appropriate responses at the right of the statement. There are no correct or incorrect answers. Your responses are confidential.

	Strongly disagree	Disagree	Moderate	Agree	Strongly agree
1. I was interested in science as a student.	1	2	3	4	5
2. I enjoyed learning science in schools.	1	2	3	4	5
3. I was good at doing science in schools.	1	2	3	4	5
4. I generally receive lower grades in science than other subjects.	1	2	3	4	5
5. I had a science teacher that I want to be alike.	1	2	3	4	5
6. I know and understand the major science concepts and science processes that I plan to teach.	1	2	3	4	5
7. When I teach, I am able to integrate my knowledge of science with knowledge of science teaching and learning.	1	2	3	4	5
8. I feel skilled as a science teacher.	1	2	3	4	5
9. It is important to me to develop my knowledge and teaching skills.	1	2	3	4	5
10. I use the Internet, journals, and articles to gain information about science teaching.	1	2	3	4	5
11. I feel part of a community of science teachers.	1	2	3	4	5
12. I belong to professional associations or groups of science teachers.	1	2	3	4	5
13. I frequently talk to colleagues about teaching science.	1	2	3	4	5
14. It is helpful to be able to discuss the progress of students with colleagues.	1	2	3	4	5
15. I enjoy sharing ideas and resources about teaching science.	1	2	3	4	5
16. I am not sure how science differs from other disciplines and subject areas.	1	2	3	4	5
17. My understanding of science shapes my philosophy and attitude about teaching.	1	2	3	4	5
18. I plan an inquiry-based science lessons.	1	2	3	4	5
19. I use an inquiry approach to teaching.	1	2	3	4	5
20. I use diverse instructions and activities to teach science.	1	2	3	4	5
21. I find it difficult to demonstrate my scientific knowledge while teaching science.	1	2	3	4	5
22. I interact with students to find their needs, interests, and abilities of learning science.	1	2	3	4	5
23. I help students become more engaged in learning science.	1	2	3	4	5
24. I create a flexible and supportive learning environment for students.	1	2	3	4	5
25. I positively impact student achievement in science.	1	2	3	4	5
26. I help students to perceive the unique of nature of science.	1	2	3	4	5
27. I am a role model who generates interests in science.	1	2	3	4	5
28. I enjoy the social respect I get as a science teacher.	1	2	3	4	5
29. Students and teachers regard me as an effective science teacher.	1	2	3	4	5
30. I appreciate it when my institutions acknowledge my success as a science teacher.	1	2	3	4	5
31. It is important that my good teaching be recognized in some ways.	1	2	3	4	5

32. It's important to me contribute to improvement of science teaching profession.	1	2	3	4	5
33. The quality of my teaching contributes to my career advancement.	1	2	3	4	5
34. I find it satisfying to think that I am contributing to the profession by teaching.	1	2	3	4	5
35. I make learning science meaningful and interesting to students.	1	2	3	4	5
36. I truly enjoy being a science teacher.	1	2	3	4	5
37. Working with students has its costs, but it's worth it.	1	2	3	4	5
38. It is important to me to work in schools.	1	2	3	4	5
39. Science is enjoyable to me.	1	2	3	4	5
40. Science teaching is very rewarding job.	1	2	3	4	5
41. I find satisfaction in watching my students' progress.	1	2	3	4	5
42. I find satisfaction in my own development as a science teacher.	1	2	3	4	5
43. I see myself as a science teacher.	1	2	3	4	5
44. I would like to be a more knowledgeable teacher.	1	2	3	4	5
45. I would like to spend more time teaching students.	1	2	3	4	5
46. I would like to be a better science teacher for my students.	1	2	3	4	5
47. I would like to be more involved in a community of science teachers.	1	2	3	4	5
48. I would like being rewarded for my teaching.	1	2	3	4	5

Biography

- **Gender: Male ( ) Female ( )**
- **The number of years as a classroom teacher:**

- **Science subjects taught during your career:**

Life science/ Biology	Earth/space science	Environmental science	Chemistry	Physics	Physical science	Integrated science	General science	Intervention science	Others

- **Grade level of Initial certification/Licensure:**

PreK-3	K-3	K-8	1-8	4-6	4-9	7-8	7-12	9-12

- **Please indicate the subjects for each of your degrees**

	Bachelor	Master	Doctorate
a. Life science/Biology			
b. Earth/Space science			
c. Chemistry			
d. Physics			
e. Physical science			
f. Science education			
g. Elementary education			
h. Other subject areas, please specify (e.g., mathematics, technology or special education.)			

Appendix D: Interview Questions

Interview I (3rd week in WI 2008)

About decision to become a science teacher and student teaching experience

1. What first led you to consider becoming a science teacher?

2. Why did you decide to become a science teacher?

3. What past experiences, personal family histories or aspects of your academic background do you think led you to science teaching?

   1) Did you have more interest in science than other subjects?

   2) Did you get higher grades in science? When?

   3) Did you like your science teachers? Why?

   4) If yes, what grade or subject did they teach? Did any of these teachers influence your decision to become a science teacher? Did any of these teachers become a role model for being a science teacher?

4. We have all been students, so we all have initial perceptions about what it is like to be a science teacher. What were some of your initial perceptions about science teaching? How did these perceptions influence your decision to become a science teacher?

5. How do you think science teachers might be described by someone from outside the profession? Did this social recognition have a positive or negative impact on your becoming a science teacher?

6. Do you have any concerns or issues about your decisions to become a science teacher? If yes, what are they?

7. How would you describe yourself as a science teacher? What characteristics would you want others to notice about you as a science teacher? What image would you like to have as a science teacher?
8. What is your primary goal or vision as a science teacher?
9. In what ways do you pursue your goal or vision as a science teacher?
10. What did you learn from field experience in past autumn quarter?
11. What do you expect to learn and hope to gain through student teaching during this quarter?

Interview II (9th week in WI 2008)

About student teaching experience and preparation for their teaching profession

1. What were your expectations for student teaching this quarter? How do these compare with what you have experienced in student teaching this winter quarter?
2. What did you gain from your mentor teacher this winter quarter? Was his/her mentoring helpful to your development as a science teacher?
3. How would you compare what you learned and experienced through student teaching during winter quarter with autumn quarter?
4. Is there anything in your writings (e.g. journals, reflections, or teaching philosophy) that you would like to share with me or anything that would help me to understand your development as a science teacher?
5. How do you feel about your progress in preparing to become a science teacher? How far along do you think you are (on a scale of 0 to 100%) in preparing to become a science teacher?

6. What more do you think you need in order to be prepared as a science teacher?
7. What do you expect to learn and hope to gain through student teaching during next spring quarter?

Interview III (9th week in SP 2008)

About their science teacher identity and teaching profession

1. How do you view yourself now? Are you still a student? Or an intern (student-teacher)?
2. At what point did you begin to define yourself as a science teacher rather than a student or an intern?
3. How would you describe yourself as a science teacher?
4. What are your strengths as a science teacher? What are your limitation or challenge as a science teacher?
5. What about your goals or vision as a science teacher? Have these changed or remained the same? If they have changed, how have they changed?
6. Do you think that there are particular beliefs, attitudes or practices you might need to modify to become a more effective science teacher?
7. What is the most important reason for your commitment to science teaching as a profession? If this reason is important to you, what challenges or difficulties would cause to reconsider your decision to continue pursuing science teaching as a profession?
8. How do you think your role as a science teacher contributes to broader science education discourse community?

About student teaching experience

9. What were your expectations for student teaching this quarter? How do these compare with what you have experienced in student teaching this spring quarter?
10. What did you gain from your mentor teacher this winter quarter? Was his/her mentoring helpful to your development as a science teacher?
11. How do you think your science teaching experiences have helped your development or growth as a science teacher?
12. What have you learned about becoming a science teacher through your student teaching experience?
13. What experiences have impacted you the most?
14. Is there anything in your writings (e.g. journals, reflections, or teaching philosophy) that you would like to share with me? (Anything that would help me to understand your development as a science teacher)

About having knowledge and skills and science teaching practice

15. What is the most important part of science teaching for you?
16. In your view, what are the characteristics of good science teaching?
17. What is the hardest part of science teaching for you? When you experienced difficulties in teaching science, did you reconsider whether you wanted to become a science teacher? How did you overcome your difficulties?
18. What is the easiest part of science teaching for you?
19. What is the most enjoyable aspect of teaching science?

20. What aspects of science teaching are most satisfying to you as a science teacher?

About social respect and support

21. What kinds of responses from others help you most as a science teacher?
22. What could have been done at any level (family, coworkers, students, parents, administrators, yourself) to help this year be more successful in preparing to be a science teacher?

About teacher preparation program

23. What were your expectations of the science teacher preparation program? How do these compare with what you have experienced in the program?
24. What specific experiences helped you most during the course of this program?
25. What aspects of the science teacher preparation program (e.g. coursework, student teaching, portfolio, reflection seminar, action research and mock interview) helped you to develop professionally and create your science teacher identity?
26. What did you think about student teaching (internship)? What changes would you make to the program if you could?
27. How much do you feel the science teacher preparation program impacted the development of your science teacher identity?

Appendix E: Consent Forms

The Ohio State University Consent to Participate in Research

Study Title:	Development of the instrument to measure the level of Science Teacher Identity
Researcher:	Dr. David L. Haury
Sponsor:	N/A

This is a consent form for research participation. It contains important information about this study and what to expect if you decide to participate.

Your participation is voluntary.

Please consider the information carefully. Feel free to ask questions before making your decision whether or not to participate. If you decide to participate, you will be asked to sign this form and will receive a copy of the form.

Purpose: The purpose of this study is to examine a new instrument to measure Science Teacher Identity (STI). The participants will include about twenty through thirty students enrolled in or graduated from the graduate programs of science education at The Ohio State University. We are asking you to participate in this study because you are qualified for this study as indicated above. For this study, a new instrument was developed to measure the level of science teacher identity of pre-service and in-service science teachers. Through this pilot study, we will explore whether this new instrument consistently measures science teacher identity and validate the contents of science teacher identity construct.

Procedures/Tasks: If you decided to participate in this study, a 46-item questionnaire will be administered to you at two different times (The second questionnaire will be administered approximately one month after the first.). After the first administration, 10 respondents randomly selected will be interviewed to rate the validity of each item on a 4-point scale and state personal comments on their understanding of what each item means and thoughts of how they rated each item. The interview will be recorded on audio tape and transcribed by researchers.

Duration: It will take approximately five weeks to conduct this study, including two administration of a questionnaire and an interview. The second administration of the questionnaire will be about four weeks after the first administering of the questionnaire. It will take 5 -10 minutes to answer the 46-item questionnaire. The interview will take 30 minutes.

You may leave the study at any time. If you decide to stop participating in the study, there will be no penalty to you, and you will not lose any benefits to which you are otherwise

entitled. You will have no consequence on course grades or program standing. Your decision will not affect your future relationship with The Ohio State University.

Risks and Benefits:
No risks are anticipated.
You will not benefit directly from participating in the study. However, this study will likely help us to have a greater awareness to develop a reliable and valid instrument to measure science teacher identity and to guide improvements in science teacher preparation programs.

Confidentiality:
Response to the questionnaire will be anonymous; no identifying information will be collected.

Interview data will be confidential with no identifying information associated with the recorded data. The recorded data will be transcribed and the audiotapes will be maintained for a period of at least 3 years. The audiotapes will be locked in a secure location (a private storage) where there is limited access to individuals other than me.

Incentives:
You will not be paid to participate in the study.

Participant Rights:

You may refuse to participate in this study without penalty or loss of benefits to which you are otherwise entitled. If you are a student or employee at Ohio State, your decision will not affect your grades or employment status.

If you choose to participate in the study, you may discontinue participation at any time without penalty or loss of benefits. By signing this form, you do not give up any personal legal rights you may have as a participant in this study.

An Institutional Review Board responsible for human subjects research at The Ohio State University reviewed this research project and found it to be acceptable, according to applicable state and federal regulations and University policies designed to protect the rights and welfare of participants in research.

Contacts and Questions:
For questions, concerns, or complaints about the study you may contact
Principle investigator: _Dr. David L. Haury (Arps 254, 614-292-2526/ haury.2@osu.edu)
Co-investigator: Ms. Hyun Jung Chi (Arps 249D, 614-218-3241/ chi.40@osu.edu)

For questions about your rights as a participant in this study or to discuss other study-related concerns or complaints with someone who is not part of the research team, you may contact Ms. Sandra Meadows in the Office of Responsible Research Practices at 1-800-678-6251.

If you are injured as a result of participating in this study or for questions about a study-related injury, you may contact Dr. David L. Haury or Ms. Hyun Jung Chi.

Signing the consent form

I have read (or someone has read to me) this form and I am aware that I am being asked to participate in a research study. I have had the opportunity to ask questions and have had them answered to my satisfaction. I voluntarily agree to participate in this study.

I am not giving up any legal rights by signing this form. I will be given a copy of this form.

Printed name of subject	Signature of subject
	AM/PM Date and time
Printed name of person authorized to consent for subject (when applicable)	Signature of person authorized to consent for subject (when applicable)
Relationship to the subject	AM/PM Date and time

Investigator/Research Staff

I have explained the research to the participant or his/her representative before requesting the signature(s) above. There are no blanks in this document. A copy of this form has been given to the participant or his/her representative.

Printed name of person obtaining consent	Signature of person obtaining consent
	AM/PM Date and time

The Ohio State University Consent to Participate in Research

Study Title:	Impact of teacher preparation programs on Science Teacher Identity(STI) among pre-service science teachers
Researcher:	Dr. David L. Haury
Sponsor:	N/A

This is a consent form for research participation. It contains important information about this study and what to expect if you decide to participate.

Your participation is voluntary.

Please consider the information carefully. Feel free to ask questions before making your decision whether or not to participate. If you decide to participate, you will be asked to sign this form and will receive a copy of the form.

Purpose: The purpose of this study is to explore the impact of teacher preparation program on constructing science teacher identity among pre-service science teachers. This study will focus on how science teacher education programs and student-teaching, in particular, impact constructing science teacher identity among pre-service science teachers enrolled in the M.Ed graduate program of science teacher preparation program by analyzing data from surveys, interviews, and students' academic works including portfolios, reflections on filed placement, journal entries, evaluations on classes, academic records including biography and transcripts and mentors' or supervisors' evaluations. The participants will include for about twenty through thirty enrolled in graduate programs of science education at The Ohio State University. We are asking you to participate in this study because you are qualified for this study as written above.

Procedures/Tasks: If you decided to participate in this study, a 48-item questionnaire will be administered to you at two times. Each questionnaire will be administered once per quarter, at the beginning of winter quarter and the end of spring quarter. After the first administration, only 6 respondents selected by purposive sampling will be interviewed three different times. The interviews will be recorded on audiotape and transcribed by researchers. In addition, your consent will allow us to access Carmen and to use your portfolios, reflections on filed placement, journal entries, evaluations on classes, records including biography and grades and mentors' or supervisors' evaluations for data analysis in this study.

Duration: This study will be conducted during winter and spring quarter 2008 including two-time administering of a questionnaire, three interviews and data collection of students' academic works. The questionnaire will be administered at the beginning of winter quarter

and the end of spring quarter. It will take 10-20 minutes to answer the 48-item questionnaire. Also, interviews will be conducted at three times, at the beginning and end of winter quarter and the end of spring quarter, and will take approximately 30 minutes.

You may leave the study at any time. If you decide to stop participating in the study, there will be no penalty to you, and you will not lose any benefits to which you are otherwise entitled. You will have no consequence on course grades or program standing. Your decision will not affect your future relationship with The Ohio State University.

Risks and Benefits:
No risks physically, socially, and legally are anticipated.
You may not benefit directly from participating in the study. However, this study will likely help us to gain useful information for pre-service science teachers to prepare for the teaching profession and for science teacher educators to improve science teacher preparation programs.

Confidentiality:
All data collected from you will be kept in strictest confidence as each response to the questionnaire and your academic works (e.g. portfolios, reflections on filed placement, journal entries, evaluations on classes, records including biography and grades and mentors' or supervisors' evaluation on students) will be assigned a number but only data from six respondents purposively sampled will be identified by pseudonyms.
Interview data will be confidential with no identifying information associated with the recorded data. The recorded data will be transcribed and maintained for a period of at least 3 years. The audiotapes will be locked in a secure location where there is limited access to individuals other than me.
All data will be destroyed upon 3 years after completion of this study.

Incentives:
You will not be paid to participate in the study.

Participant Rights:
You may refuse to participate in this study without penalty or loss of benefits to which you are otherwise entitled. If you are a student or employee at Ohio State, your decision will not affect your grades or employment status.

If you choose to participate in the study, you may discontinue participation at any time without penalty or loss of benefits. By signing this form, you do not give up any personal legal rights you may have as a participant in this study.

An Institutional Review Board responsible for human subjects research at The Ohio State University reviewed this research project and found it to be acceptable, according to applicable state and federal regulations and University policies designed to protect the rights and welfare of participants in research.

Contacts and Questions:
For questions, concerns, or complaints about the study you may contact
Principle investigator: Dr. David L. Haury (Arps 254, 614-292-2526/ haury.2@osu.edu)
Co-investigator: Ms. Hyun Jung Chi (Arps 249D, 614-218-3241/ chi.40@osu.edu)

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If you are injured as a result of participating in this study or for questions about a study-related injury, you may contact Dr. David L. Haury or Ms. Hyun Jung Chi.

Signing the consent form

I have read (or someone has read to me) this form and I am aware that I am being asked to participate in a research study. I have had the opportunity to ask questions and have had them answered to my satisfaction. I voluntarily agree to participate in this study.

I am not giving up any legal rights by signing this form. I will be given a copy of this form.

Printed name of subject	Signature of subject
	Date and time AM/PM
Printed name of person authorized to consent for subject (when applicable)	Signature of person authorized to consent for subject (when applicable)
Relationship to the subject	Date and time AM/PM

Investigator/Research Staff

I have explained the research to the participant or his/her representative before requesting the signature(s) above. There are no blanks in this document. A copy of this form has been given to the participant or his/her representative.

Printed name of person obtaining consent	Signature of person obtaining consent
	Date and time AM/PM

College of Education & Human Ecology

School of Teaching and Learning
333 Arps Hall
1945 N High Street
Columbus, OH 43210-1172

Dear Science Teachers,

My name is Hyun Jung and I am currently working on a doctorate in Science Education at the Ohio State University. I am developing a survey instrument to science teacher identity.

The purpose of this survey is to examine whether a new instrument could perform reliably and consistently what I expect to measure. For this, I need science teachers' active participation.

I am asking you to participate in the field test of a newly developed survey (IRB Protocol No.2008E0101).
If you want to participate, you will take an on-line survey from this website:
http://www.surveymonkey.com/s.aspx?sm=MLe68BqiFQnGzJB02605ag_3d_3d

The survey will take about 20 minutes. All response will be anonymous. All information that you provide will be kept in the strictest confidence and maintained for three years after completion of this study. There are no risks physically, socially, or legally in conducting the study. Also, your participation will not be paid because your participation is voluntary. Your participation will not influence your social status, financial standing, employability or reputation. Although you may not directly benefit from this study, your participation will likely contribute to improved science education and increased understanding within the science education community.

I would also appreciate any additional comments you may have regarding additional assistance you would like us to provide. If you have any questions or comments, please contact Ms. Hyun Jung Chi at 614-292-4372 , e-mail: chi.40@osu.edu , address: Arps Hall 249D, 1945 North High Street, Columbus, OH 43210.
I greatly thank you for your assistance in helping my research.

Thanks,

Dr. David L. Haury, Principal Investigator
Hyun Jung Chi, Co-investiagtor
The Ohio State University.

If you want to participate, please follow the below link to complete the on-line survey:
http://www.surveymonkey.com/s.aspx?sm=MLe68BqiFQnGzJB02605ag_3d_3d