CONCEPTIONS OF AND INTENTIONS FOR THE TEACHING OF REFLECTION BY SCIENCE TEACHER EDUCATORS IN UNIVERSITY-BASED SCIENCE TEACHER EDUCATION PROGRAMS

By

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TABLE OF CONTENTS

APPENDIX

LIST OF TABLES

LIST OF FIGURES

Abstract of Dissertation Presented to the Graduate School
of the University of Florida in Partial Fulfillment of the
Requirements for the Degree of Doctor of Philosophy

CONCEPTIONS OF AND INTENTIONS FOR THE TEACHING OF REFLECTION BY
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While the importance of the development of reflection in science teacher

education programs is widely acknowledged, articulations of the frameworks and

strategies guiding its development in pre-service teachers are less clear. To facilitate

understanding, I developed a heuristic framework to describe and interpret the construct

in two dimensions: orientations to, and components of, reflection. The orientation

dimension considers the increasing complexity of reflective thought through five levels:

technical, reflection-in and on-action, deliberative, personalistic, and critical.

In contrast to these philosophical orientations, the components' dimension

describes how reflective practice is implemented in teacher education programs. Four

components are considered: stimuli, content, process, and outcome. These two

dimensions were organized into a heuristic that contains descriptors for each

combination of components and orientations. This heuristic was then applied as a

conceptual framework to identify and understand the conceptions of and intentions for

the development of reflection of six science educators at teacher education institutions

across the country. Findings highlight the need for science education faculty to have

deliberately constructed personal conceptions of reflection in order for it to be

emphasized in their programs. The impact of external influences on their conceptions

results in their intentions for reflection being modified in the course and program.

CHAPTER 1
THE PROBLEM

Responding to the goal of ensuring that all American students achieve scientific literacy, in 1996 the *National Science Education Standards* called for new emphases in science teaching, including the shift from "teacher as technician" to "teacher as intellectual, reflective practitioner" (National Research Council, 1996, p. 72). Numerous policy documents echoed this appeal, including many focusing on the importance of reflection as an important outcome in the preparation of science teachers (Interstate Teacher and Support Consortium, 2010; National Board for Professional Teaching Standards, 2002; National Council for Accreditation of Teacher Education, 2008; National Science Teachers Association, 2004).

The construct of reflection in relation to the profession of teaching has its roots in the writings of John Dewey, who defined reflective thinking as "active, persistent, and careful consideration of any belief or supposed form of knowledge" (1933, p. 9). Dewey's description of reflection entailed a process of thinking through a problem to its resolution, beginning with the observation of difficulty, and culminating with an experimental test of a solution. Despite Dewey's pervasive influence in progressive education, reflection as an orientation to teacher education did not take hold until the 1980s, with the publication of Donald Schön's *The Reflective Practitioner* (1983).

Schön identified a "crisis of confidence in the professions" (p. 14), noting the inadequacy of contemporary professional knowledge to address the complexity, uncertainty, and value conflicts present in practice. Professional knowledge needed to develop beyond the prevalent model of technical rationality, a mode of "instrumental problem solving made rigorous by the application of scientific theory and technique" (p.

21). The technical approach was characterized in teacher education by programs such as Cruickshank's *Reflective Teaching* (Cruickshank & Applegate, 1981), designed for a step-by-step acquisition of specific pedagogical skills. Schön asserted that progress in the professions, including teaching, required a new approach focusing on the "spontaneous, intuitive performance" (p. 49) that represents skillful professional practice.

While Schön's descriptions of reflective practice did not address teaching in particular, his rejection of the paradigm of technical rationality and his call for the development of professional artistry, appealed to educators on the defensive in response to negative attention from critiques such as *A Nation at Risk* (National Commission on Excellence in Education, 1983) and *Cultural Literacy* (Hirsch, 1988). The notion of reflective teaching was present in education literature prior to this time, but was primarily concerned with the development of thinking processes by students in schools, not with pre-service teacher reflection (Hullfish, 1963; Metcalf, 1962; Trezise, 1964; Zechiel & McCutchen, 1938). Reflection in teacher education appeared in the early 1980s and focused on the role of how field experiences contribute to the development of pre-service teacher thinking about practice (Korthagen, 1985; Zeichner & Liston, 1987). Due to the growth of interest in reflection in teacher education, the notion of "the reflective practitioner" became the standard of excellence to be achieved by members of the teaching profession (Anderson & Mitchener, 1994; Roychoudhury, Roth, & Ebbing, 1993; Watts & Lawson, 2009).

Early studies of reflection in science education applied Schön's framework to field experiences (MacKinnon, 1987) and methods courses (Rosenthal, 1991), but did not

emphasize specific aspects of science teaching and learning. More recent studies have focused on the role of reflection in the development of pre-service teachers' views of science teaching and learning (Abell, George, & Martini, 2002; Barnett, 2008; Parsons & Summer, 2004), science inquiry (Blanchard, Southerland, & Granger, 2009; Dietz & Davis, 2005; Eick & Reid, 2002; Wang & Lin, 2008), and the nature of science (Akerson, Abd-El-Khalick, & Lederman, 2000; Scharmann, Smith, & James, 2005).

In this chapter, the issues and concepts relevant to the construct of reflection will be introduced, focusing on different orientations to reflection and different components of reflection as implemented in teacher education. A heuristic for the examination of reflection with respect to these two dimensions will be presented, leading to the problem statement of the study, followed by research questions. The chapter concludes with a discussion of the significance of the study and its limitations.

Two Dimensions of Reflection

Reflection is a problematic construct in teacher education programs due to the differences in terms of how it is defined, how it is implemented, and how growth in reflection is measured (Calderhead, 1989; Hatton & Smith, 1994; Makinster, Barab, Harwood, & Andersen, 2006; Sparks-Langer & Colton, 1991). Tension exists between the need for some explicitness in the teaching of reflection (Korthagen & Kessels, 1999; Loughran & Gunstone, 1997; Russell, 2005) and the preservation of its complexity (Jay & Johnson, 2002; Markham, 1999). Some researchers emphasize the solitary aspects of reflection (Larrivee, 2000), while others suggest it functions best as a communal activity (Loughran, 1996; Lyons, 1998; Rodgers, 2002). Nearly all studies of reflection contain a distinct perspective on one or more of these aspects.

One strategy for addressing this complexity is through a system for classifying different characteristics of reflection. Zeichner and Liston (1996) suggested five "traditions" of reflective teaching (academic, social efficiency, developmentalist, social reconstructionist, and generic), based on the content of reflection, which considers the experiences, ideas, or issues being reflected upon. Van Manen (1977) proposed that reflective thought occurs on three developmental levels (technical, practical, and critical), as revealed by teachers' thinking within the content of reflection. Other schemes describe the construct in terms of types of reflection (Valli, 1997); orientations to reflective practice (Wellington & Austin, 1996); forms and functions of teacher reflection (Danielowich, 2007): and sources, modes, and purposes of reflection (Grimmett, Erickson, MacKinnon, & Riecken, 1990). To show how reflection is conceptualized and implemented in science teacher education programs, a heuristic was developed that characterizes the construct in terms of two dimensions: orientations to reflection and components of reflection.

Dimension 1: Orientations to Reflection

The orientation dimension considers the increasing complexity of reflective thought. Van Manen (1977) described three levels of reflection and self-evaluation (technical, practical or deliberative, and critical). When the teacher recognizes the constraints of the present level, such as the rationale of efficiency embedded in the technical level, there is a need for a higher level of reflection. These levels function as developmental stages in van Manen's approach to teacher reflection.

Researchers have utilized van Manen's taxonomy to describe the growth of pre-service teachers' reflective thinking (Jay & Johnson, 2002; Larrivee, 2010; Pultorak, 1993). Valli (1997) added Schön 's reflection-in and on-action and a personalistic mode

to this hierarchy, proposing that effective teacher education programs should help pre-service teachers develop each of these five orientations: technical, reflection-in and on-action, deliberative, personalistic, and critical.

Other researchers reject the idea of applying a hierarchy to teacher reflection. "If teachers' writing is evaluated according to hierarchical levels of reflectivity, then that evaluation has as much of a disciplinary or socializing effect as generative or innovative effects" (Fendler, 2003, p. 20). Pultorak (1993) used categories as a descriptor rather than levels to deliberately avoid an externally imposed hierarchy. "Pre-service students should be encouraged to choose issues of importance related to the context of their classrooms and reflect within all categories." (p. 294). Danielowich (2007) agreed with this view, suggesting teachers should position reflective thinking and learning across different orientations rather than aiming toward the most complex one as a final goal.

Lyons (1998) viewed the development of reflection not as a simple progression from one mode to another, but as a process of integrating increasing complexity into examination of one's practice. Jay and Johnson (2002) also promoted the integration of the different orientations: "These dimensions of reflection are not mutually exclusive. In fact, they become intimately intertwined to compose a composite concept" (p. 80).

Valli (1997) noted a purpose in the ordering of the five types of reflection (technical, reflection-in and on-action, deliberative, personalistic, and critical), suggesting "certain types of reflection might be prerequisite to others. For example, a basic grasp of technical knowledge and skill might be needed for deliberative reflection. This ordering also suggests that certain educational issues or questions might be more important than others" (p. 74). The cumulative nature of the different orientations to

18

reflection is represented in Figure 1-1, which represents Valli's five types of reflection, beginning with technical in the innermost circle, and progressing through the other four orientations. This graphic uses Jay and Johnson's (2002) notion of a "widening of the lens, from the situation at hand to multiple perspectives on a situation to an appreciation of the bigger picture of implications surrounding the problem at hand" (p. 79). Descriptive phrases from Valli's (1997) typology identify each orientation, and the dashed boundaries between the orientations portray the integrative aspect of the dimension. In the present study, Valli's perspective is adopted, recognizing the need for pre-service teachers to develop reflective thinking through each of the different orientations.

Technical reflection

The development of teaching techniques is the essence of technical reflection. Rules and structures of the teacher's work are determined externally. Within this orientation, pedagogy typically has a behaviorist approach. The "arena of the problematic" (Tom, 1985, p. 37) is narrowly defined, often focusing on the efficiency and precision of a teacher's own performance of an established method (Wellington & Austin, 1996).

Reflection-in and on-action

Schön's (1983, 1987) approach to reflection focuses on the two distinct facets of reflection-in-action and reflection-on-action. Reflection-on-action refers to retrospective or anticipatory thinking about an experience. Problems of practice are considered through a cycle of problem setting, reframing, and resolving, resulting in new points-of-view and employment of new expertise. Reflection-in-action builds a repertoire of professional practice by recognizing the tacit knowledge manifested in an act of

teaching. Schön asserts the development of reflection-in and on-action can be facilitated through a reflective practicum, a situation that simulates professional practice, but with reduced complexity, such as a student teaching internship. Experiences in the reflective practicum provide opportunities for dialogue between pre-service teachers and their supervisors, who are often cast in the role of coaches (Schön, 1987; Valli, 1997).

Deliberative reflection

In deliberative reflection, teachers consider multiple perspectives and sources of knowledge in their decision-making. While the sources of knowledge and organizational structures are often externally authorized, teachers' decisions are based on internal considerations, focused on student meaning-making. Teachers' interactions with any or all of Schwab's (1973) commonplaces of teaching (subject matter, teachers, student, milieu) can serve as the sources of reflective thinking in the deliberative mode (Valli, 1997; Wellington & Austin, 1996).

Personalistic reflection

The personalistic orientation is focused on personal development and liberation. Teachers' reflections connect the personal and professional aspects of their lives, using autobiography to examine attitudes, emotions, hopes, and concerns. Personalistic reflection attends to these aspects of students' lives as well, often from a perspective of trust and care (Noddings, 1984). Reflection in this mode is typically introspective and personal (Valli, 1997; Wellington & Austin, 1996).

Critical reflection

The critical orientation positions reflection as instrumental in improving the quality of life for the disadvantaged in society. Schools and schooling are portrayed as political

constructs that function in hegemonic ways to reproduce the dominant culture. The

moral and ethical considerations in critical reflection extend more broadly into society

than in personalistic reflection (Valli, 1997; Wellington & Austin, 1996).

Summarizing the orientations

This first dimension of reflection considers the intellectual complexity of each

orientation. Recognizing the consistency of one's own performance with externally

established standards in the technical orientation is less complex than making a

decision based on multiple viewpoints considered by deliberative orientation. Valli

(1997) recognized advantages and shortcomings in each orientation and advised that

the different types should be used in combination to balance these inequalities. Some

orientations have rigid externally imposed guidelines and some have personally

determined guidelines. Valli concludes, "each type of reflection is uniquely suited to

addressing different questions" (p. 81).

Dimension 2: Components of Reflection

The formation of the different orientations into tasks within a teacher education

program comprises the second dimension for classifying reflection, its components. One

effort to characterize these components comes from Grimmett, MacKinnon, Erickson,

and Riecken (1990), who identified three questions essential for understanding and

framing reflective tasks or practice: "(1) What is being reflected upon?,(2) How is the

reflective process engaged?, and (3) What is the purpose of reflection?" (p. 35). In a

similar way, Calderhead (1989) categorized the variance in concepts of reflective

teaching in terms of process, content, preconditions (context), and product. The need

for detail in the explicit teaching of reflection was asserted by Jay and Johnson (2002):

"We need to look closely at the processes that comprise reflective thought. . . a holistic

view of reflection is difficult to teach" (p. 75). For the purpose of describing reflection as it is implemented in teacher education programs, Grimmett et al.**'s** essential questions and Calderhead's concepts were formulated into four components of reflection: stimulus, content, process, and outcome. This scheme provides a second dimension for examining the construct, as shown in Figure 1-2.

Stimulus: What is causing you to reflect?

The first component of reflection, stimulus, refers to the context of the initial problem that triggers an act of reflection. Dewey (1933) asserted "Demand for the solution of a perplexity is the steadying and guiding factor in the entire process of reflection" (p. 122). Schön (1987) referred to this element of experience as *surprise,* an unforeseen event that is inconsistent with our tacit professional knowledge and thus leads to reflection. Since such reflection occurs in response to this puzzling situation, the context of that situation needs to be carefully considered. While some pre-service teachers may possess an inherent reflective manner, without an explicit recognition and examination of the forces that stimulate reflection, the effort "may be unintentional as well as unfocused and unsystematic" (Wildman, Niles, Magliaro, & McLaughlin, 1990, p. 139). Various stimuli for reflection in science education have included field experiences (Posner, 2000), research experiences (Blanchard, Southerland, & Granger, 2009), and video editing (Yerrick, Ross, & Molebash, 2005).

Content: On what are you reflecting?

The content component refers to the subject of the teacher's thinking in the act of reflection. While the initial response might suggest that teachers reflect on what they are doing, researchers have characterized the content of reflection in many ways. Different orientations towards reflection specify different content (Danielowich, 2007). One

organization of the content of reflection occurs with Zeichner and Liston (1996) who list five "traditions" of reflective practice in teacher education. These traditions include the academic, social efficiency, developmentalist, social reconstructionist, and generic. While these varieties of reflective practice vary in their purposes for reflection, they also emphasize different topics as the content of reflection, such as representations of subject matter (academic), research-based teaching practices (social efficiency), student interests and patterns of development (developmentalist), and issues of inequality and injustice (social reconstructionist). Content provides the text that is typically coded and classified in research studies to determine some measure of development of reflection in pre–service teachers (Hatton & Smith, 1995; Sparks-Langer, Simmons, Pasch, Colton, & Starko, 1990).

Process: How are you reflecting?

The process component is the system of thoughtful actions engaged in by pre-service teachers when analyzing the problem being considered. Dewey conceived of reflection as a meaning-making process, in which a learner moves from one experience to another with deeper understanding of relationships and connections. Central to this process are attitudes of open-mindedness, responsibility, and whole-heartedness, (Dewey, 1933). Schön also described a cycle of problem setting, reframing, and experimenting, where "the practitioner's effort to solve the reframed problem yields new discoveries which call for new reflection-in-action" (1983, p. 132). In teacher education programs, Dewey and Schön's approaches do not specify a methodology for engaging in reflection. The effect of particular structures designed to facilitate pre-service teacher reflection is influential on the nature and quality of those reflections (LaBoskey, 1994).

Loughran (2002) acknowledges the need for explicit attention to the ability of pre-service teachers to learn how to reflect, warning "simply being encouraged to reflect is likely to be as meaningful as a lecture on cooperative group work" (p. 33). Issues relevant to the process component consider the time frame in which reflection occurs (Hatton & Smith, 1995), reflection which occurs as a solitary or collaborative activity (Zeichner & Liston, 1996), and the types of activities that promote reflection such as reflective writing or supervisory conferences (Ross, 1990).

Outcome: Why are you reflecting?

The final component concerns how the different orientations characterize the larger purpose or outcome of the reflective process. Like the other components, the outcomes of reflection are varied. In one framework, reflection serves the goal of moral development (Valli, 1990). Many researchers propose a critical lens, deliberating on the relationships between schooling and the attainment of equity and justice for the disadvantaged in society (Dinkelman, 2000). LaBoskey (1994) asserts the transformation of pre-service teachers' beliefs, knowledge, attitudes and emotions is the ultimate goal of reflection.

An example of the implemented components in a science methods course

Careful distinctions need to be made between the stimulus, content, process, and outcome components in this conceptual framework. The example of pre-service teachers in a science methods course with a personalistic orientation reflection (Abell, Bryan, & Anderson, 1998) illustrates these distinctions:

1. Stimulus: pre-service teachers reflect after viewing a video of an elementary science case of teaching science for conceptual change.

2. Content: pre-service teachers reflect on their own ideas and personal theories about science teaching and learning.

3. Process: pre-service teachers respond in writing to tasks in which they uncover and examine their personal science histories and visions of science teaching.

4. Outcome: pre-service teachers' recognition of the authority of experience in thinking clearly about science teaching and learning.

A Heuristic for Describing Reflection

The heuristic presented in Table 1-1 highlights the different levels of complexity in the orientations to reflection as originally described by Valli (1997), and aligns the different components adapted from Calderhead (1989) and Grimmett et al. (1990) with those orientations.

Seminal writing representative of each orientation was carefully examined in order to identify key phrases that related to each component. For example, in *Educating the Reflective Practitioner,* Schön (1987) deliberately describes the nature of the reflective practicum as a process for learning reflection: "these practicums are reflective in that they aim at helping students learn to become proficient at a kind of reflection-in-action. . . . they depend for their effectiveness on a reciprocally reflective dialogue of coach and student" (p. 40). In this orientation, the activity of reciprocally reflective dialogue is central in learning how to reflect, and is identified as key to the process component in the heuristic. In their description of reflective practice in teacher education, Wellington and Austin (1996) identified specific examples of each orientation in the literature, from which relevant descriptors were obtained for use in the heuristic.

This conceptual alignment can be used to identify different orientations related to reflection and also to interpret how these orientations are implemented in teacher education programs. Genor (2005) recognized the utility of this type of structure in providing guidance to the pre-service teachers' development of reflection. "A framework for reflection can be helpful in this process, but only when it provides an explicit

rationale that both articulates its definition and outlines what reflection might 'look like' in practice" (p. 49).

Problem Statement

In the past three decades, reflection has become widely espoused as an essential part of university-based teacher education (Danielowich, 2007; Larrivee, 2010; Smith, Yendol-Hoppey, & Milam, 2010). Yet, the lack of empirical evidence regarding how reflection is conceived and implemented is a prevailing concern (Larrivee, 2010; Smith, Yendol-Hoppey, & Milam, 2010). Science education research has used the reflections of pre-service teachers to examine issues such as co-teaching (Eick, Ware, & Jones, 2004), use of probeware (Gado, Ferguson, & van 't Hooft, 2006), and the dilemmas of practical work (Yoon & Kim, 2010). Despite the apparent popularity of this construct, Russell and Martin observed, "There is little public evidence that reflection is actually being taught" (2007, p. 1175).

This degree of uncertainty, along with the issues of varying definitions and approaches, points to its unclear status, particularly with respect to the frameworks science teacher educators employ to teach their pre-service science teachers to reflect. Since researchers have posited that reflection is of vital importance to the development of accomplished science teachers, it is useful to characterize how science teacher educators conceive this construct, and how they translate those conceptions into intentions for the development of reflection by pre-service teachers in teacher education programs.

The purpose of this study is to examine science teacher educators' conceptions of and intentions for the teaching of reflection in university-based secondary science teacher education programs. More specifically, the ideas of those teacher educators

who articulate some emphasis on reflection are scrutinized to address four research questions.

Research Questions

1. What orientations to reflection do science teacher educators hold?

2. What influences have contributed to the development of these orientations?

3. How are the orientations of science teacher educators towards reflection manifested through the components of reflection provided in their intended curriculum?

4. What constraints and limitations do science teacher educators perceive on the enactment of their intentions for the teaching of reflection?

Discussion of Research Questions

Research Question 1: Science Teacher Educators' Orientations to Reflection

The first research question prescribes an examination of how science teacher educators conceive the construct of reflection as an orientation. An orientation is an indication of the specific ways an individual views the world: beliefs of epistemology, axiology, and ontology. Van Manen characterizes an orientation as "a device for making visible how each subject matter or knowledge area constitutes a way of making sense of the world" (1977, p. 212). As science teacher educators articulate their orientations, they "make visible" their notions of the truth, value, and reality of reflection in teacher education. While some teacher educators' orientations may align to those described in the heuristic, other characterizations are not excluded. The most valuable component in addressing this research question is whether the meaning and purpose of reflection is explicitly considered and clearly articulated by science teacher educators.

Research Question 2: Influences on Orientations

The second research question examines the origins of science teacher educators' orientations to reflection. Uncovering the influence of factors such as teachers, family

members, or professional experiences provides insights into how teacher educators come to value reflection. The development of and engagement in their own reflective practice by science teacher educators contributes to an understanding of how their intentions for reflection may be realized for pre-service teachers (Russell, 2007; Russell & Martin, 2007).

Research Question 3: Manifestation of Orientations in Programs

The third research question examines how science teacher educators intend to put their orientations into practice in teacher education programs. Specific components, such as assignments and activities that are designed to function as stimuli for reflection, topics considered as the content of reflection, and methods of learning a process of reflection are important lenses into science teacher educators' conceptions of the construct. The intentions of these faculty members are manifested in the kinds of opportunities they implement for pre-service science teachers learning how to reflect (Houston & Clift, 1990).

Research Question 4: Constraints and Limitations

The fourth research question addresses the difficulties perceived by science teacher educators regarding their intentions for the teaching of reflection. Barriers to the achievement of reflective practice could include definitions of the construct, preconceptions about the profession of teaching, and structural and ideological features of programs (Hatton & Smith, 1994). Insight into particular difficulties may be gained by considering them through the heuristic as corresponding to particular components. This examination provides another relevant perspective on science teacher educators' orientations to reflection, particularly with respect to how reflection is valued and reified. Addressing this question contributes to what Tom (1985) describes as the development

of "a set of dimensions that clarifies the range of options" (p. 36) for the implementation of reflection in teacher education.

Boundaries of the Study

While some science teacher education programs have taken an explicit approach to reflection in the science methods course, (Abell & Bryan, 1997; Rosenthal, 1991), more often the focus is on the experience of the student teaching internship (Eick & Dias, 2005; MacKinnon & Erickson, 1983; Roychoudhury, Roth, & Ebbing, 1993; Yoon & Kim, 2010). Similarly, a large portion of the research examines the development of reflection in elementary pre-service science teachers (Abell & Bryan, 1997; Britner & Finson, 2005; Rosenthal, 1991; Roychoudhury, Roth, & Ebbing, 1993; Van Zee & Roberts, 2001; Yoon & Kim, 2010). It is therefore worthwhile in this study to examine how science teacher educators in secondary programs conceive reflection and intend it to develop in their pre-service teachers. Acknowledging the call for opportunities and encouragement to reflect earlier rather than later, this inquiry examines conceptions and intentions throughout the teacher preparation sequence, including methods courses, early field experience, and the student teaching internship (Northfield & Gunstone, 1997; Roychoudhury, Roth, & Ebbing, 1993).

It is the intent of the inquiry to examine the ideas of those science teacher educators who emphasize reflection explicitly and intensely. It is therefore critical that those faculty members contacted are highly familiar with the secondary science teacher education programs at their institutions, and that those programs manifest the vision of the faculty involved. Science teacher educators need to have a significant degree of influence over the curriculum in these programs. Smaller programs often demonstrate this type of unified mission (Yost, Sentner, & Forlenza-Bailey, 2000). This study is

confined to secondary science teacher education programs at regional institutions, specifically those colleges and universities who are accredited by the National Council for Accreditation of Teacher Education (NCATE) and members of the Teacher Education Consortium of State Colleges and Universities (TECSCU). The NCATE standards call specifically for the development of reflection in teacher education candidates. TECSCU institutions typically have smaller programs with one or two science teacher education faculty, but graduate a large proportion of the teachers in their states (L. G. Daniels, personal communication, December 8, 2010). It is likely that the science teacher education faculty at these institutions would have familiarity with the secondary science teacher education program and awareness of deliberate efforts toward the development of reflection.

Significance of the Study

This study's exploration of reflection in teacher education is analogous to Tom's (1985) approach to examining inquiry-oriented teacher education:

> Such dimensions have at least two uses to a teacher educator. First, these dimensions can help a teacher educator see the range of inquiry-oriented alternatives. Second, the measuring of a particular approach to inquiry can help identify the strengths and weaknesses of an approach. . . Thus the dimensions are simultaneously used as descriptive and evaluative devices (p. 35).

While it is not the explicit purpose of this study to make evaluative claims as to the soundness of individual programs, relationships between the orientations and components articulated by science teacher educators may reveal innovative approaches, specific emphases, or areas of exclusion particular to science education.

This exploration of reflection contributes to an important area in need of research, as Zeichner (2005) identified:

Very little work has documented the nature and quality of the teacher
education curriculum, the variety of requirements, the content of preparation
programs at different levels and in different subject areas, and academic
rigor of the preparation as assessed by such means as analysis of syllabi
and assignments (p. 748).

The aims of this study are highly consistent with Zeichner's concerns. The study will
look specifically at science teacher education at the secondary level, consider the
science methods course and other program components, and examine program and
course documents for evidence of alignment.

The heuristic used in this study also has practicality in other studies of reflection,
such as a self-study of the development of reflection by a teacher educator, or an
exploration of reflective practices of teachers engaged in National Board Certification.
Utilizing these two dimensions of orientations to and components of reflection can
provide a detailed view on the intentional alignment of these dimensions in practice.

Limitations of the Study

The present study will collect data from science education faculty engaged in
university-based science teacher education programs. The study is confined to
programs for initial certification of secondary science teachers, and does not consider
the orientations to and components of reflective practice that may be explored in
elementary certification, advanced professional degrees, or professional development
programs. While many science teacher educators may be involved in both elementary
and secondary levels, their influence on program design and curriculum choices will
typically be greater in secondary programs. Additionally, it is not the purpose of this
inquiry to portray how reflection is conceived by a representative sample of science
teacher educators across the field. Rather, the study focuses only on those educators
who convey an intense emphasis on the development of reflection by pre-service

secondary science teachers in their programs. Since faculty members are the principal

sources for data on programs, any conclusions about the implementation of reflection

will represent an intended curriculum, not necessarily an enacted one.

Critical Reflection:
improving the quality of life of the
disadvantaged; commitment to inquiry,
self-criticism, and social action

Personalistic Reflection:
personal growth and relational issues

Deliberative Reflection:
effective decision making
by considering a variety of sources

**Reflection-in
and on-action:**
practical knowledge from
one's own unique experience

**Technical
Reflection:**
efficient teaching
techniques derived
from research

Figure 1-1. Orientations to reflection. This figure illustrates the five orientations to
reflection in teacher education.
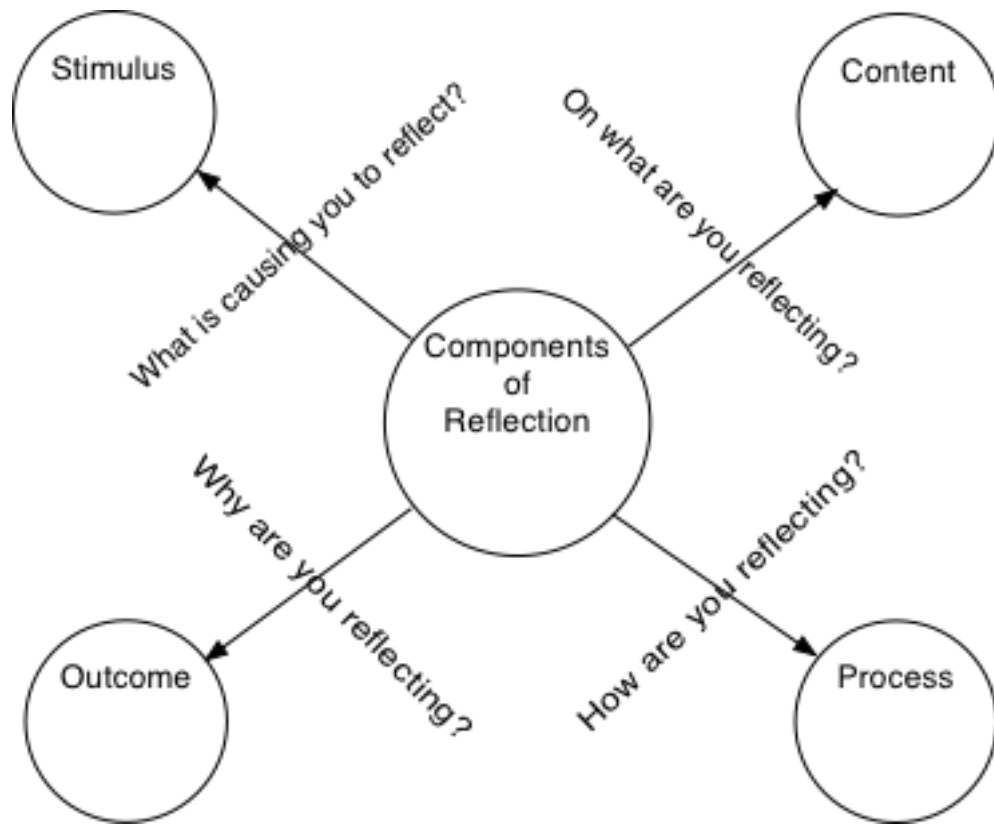
Figure 1-2. Components of reflection. This figure illustrates the components of reflection in teacher education.

Table 1-1. A heuristic describing orientations to and components of reflection in teacher education.

Orientation	Stimulus	Content	Process	Outcome	Seminal Work
Technical	Episode of teaching performance	Own teaching behaviors derived from research; external authority structures; comparison to list of competencies	Retrospective, individual or supervision in writing or oral; behaviorist techniques	Efficient instruction; faithful implementation of best practices	Cruickshank & Applegate, 1981
Reflection-in and on-action	A puzzling situation present in the reflective practicum	Not specified	Anticipatory or retrospective (on-action); contemporaneous (in-action); framing or problem setting and reframing; making the tacit explicit; reciprocal dialogue with expert coach in the reflective practicum	Professional artistry in practice; development of practical knowledge	Schön, 1983, 1987; Loughran, 1996
Deliberative	Interaction with any of Schwab's commonplaces (subject matter, students, teachers, milieu)	Own decisions about instruction, curriculum, students, school, context; consideration of multiple sources of knowledge	Anticipatory, retrospective; individual or collaborative	Relevant and meaningful student learning; effective communication; effective decision making & personal judgment	Valli, 1993
Personalistic	Varying contexts	Own personal and professional beliefs, attitudes; self-development; internal source of knowledge	Introspective, individual, autobiography, personal theorizing	Personal development	LaBoskey, 1994
Critical	Any situation in schooling	Schools as political structures; issues of power and injustice	Outwardly directed	Political liberation; improving situation of disadvantaged	Van Manen, 1977

CHAPTER 2
REVIEW OF THE LITERATURE

Introduction

Writing in 1992, Alan Tom identified the "explosion of interest" (p. viii) in the topic
of reflection in teacher education that occurred in the late 1980s. The journal *Reflective*
Practice appeared in 2000 emphasizing themes such as the purposes and practice of
reflection and the ways it is meaningfully taught and learned. The American Educational
Research Association has a special interest group dedicated to reflection in teaching
and teacher education. The Association of Teacher Educators recently published a
volume summarizing the work of a national commission charged with investigating the
impact of reflectivity on "teacher performance, teacher retention, student learning, and
other important aspects of teaching, learning, and teacher education" (ATE, 2010, p.
xv). Reflection is clearly a topic of high interest in teacher education.

Scholarly writing on reflection in teacher education tends to be based on one of
three types. The first type emphasizes the explicit teaching of the process of reflection,
engaging pre-service teachers in specific individual or collaborative activities designed
to foster reflection (Hatton & Smith, 1995; Jay & Johnson, 2002; Pultorak, 1993; Sparks-
Langer, Simmons, Pasch, Colton, & Starko, 1990; Yost, Sentner, & Forlenza-Bailey,
2000). The second type traces the development of pre-service teacher reflection
through levels or stages by examining some form of text, such as journals, portfolios, or
interviews, but without a deliberate focus on the structures of experiences that facilitate
development (Alger, 2006; Dome, Prado-Olmos, Ulanoff, Ramos, Vega-Castaneda, &
Quiocho, 2005; Fox & White, 2010; Nagle, 2009; Sumison, 2000). The final section of
the literature is comprised of a large quantity of theoretical writing, focusing on the

historical and philosophical bases of reflection (Dewey 1933; Rodgers, 2002; Russell, 2005; Schön; 1983, 1987; Smyth, 1989; Van Manen, 1977).

The two-dimensional heuristic for describing and interpreting reflection in teacher education programs presented in Chapter One (Table 1-1) is used to organize the major part of this review of the literature. The two dimensions of orientations to and components of reflection articulated in the heuristic do not consider every aspect of reflection or establish strict boundaries that confine interpretations to one row or column. The heuristic structure provides a useful way of thinking about how specific practices and language are representative of specific orientations. Many studies that do not explicitly stake out a particular orientation can be classified implicitly based on how one or more of the various components are implemented.

The review begins with seminal writing on how and why reflection is classified into different orientations, followed by articles that discuss the second dimension of components of reflection. Representative studies that focus on the function of the various components within each orientation are then considered, organized by the heuristic. The chapter concludes with a comprehensive examination of studies addressing reflection in science teacher education.

Orientations to Reflection

Max van Manen's *Linking ways of knowing with ways of being practical* (1977) provides a seminal influence on the practice of applying a taxonomy to the construct of reflection. In this paper, he relates the three major traditions of social science (empirical-analytic, hermeneutic-phenomenological, and critical-dialectical) as ways of knowing and modes of action, essentially connecting theory with action by means of reflection. Scholars of reflection in teacher education apply some variation of van Manen's levels

to approaches, content, and definitions nearly universally (Dinkelman, 2000; Genor, 2005; Larrivee, 2010; Pultorak, 1996; Sparks-Langer et al, 1990; Valli, 1997; Wellington & Austin, 1996; Zeichner & Liston, 1987).

From these three traditions of social science, van Manen describes three levels of reflectivity, which correspond with descriptions of the practical. At the first level of *technical* reflection, the emphasis is on faithful application of established knowledge. Empirically derived educational research supplies theories, principles, and recommendations for implementation. Deliberation among alternatives is governed by standards of economy, efficiency, and effectiveness. Van Manen observes that the classroom is a much more complex environment, and will need a higher level of deliberation beyond that offered by technical reflection. At this higher level of interpretive reflection, practical action is informed not by external authority but by analysis of multiple aspects of the educational experience. These facets may include individual and social experiences, preconceptions, perspectives, and prejudices. While this level aims to develop understanding of learning experiences, it does not deliberate on the value of those experiences. At the highest level of critical reflectivity, questions of the worth of knowledge and how society is organized to consider what is worthy are examined.

The lower two of van Manen's levels have appeared under various names, including technical rationality and practical action (Zeichner & Liston, 1987), technical and practical reflection (Genor, 2005) and descriptive and comparative reflection (Jay & Johnson, 2002). The third level is typically referred to in education literature as critical reflection (Larrivee, 2010).

Van Manen uses the concept of orientation to describe the nature of these different levels of reflectivity. An orientation includes specific ways of looking at the world and the rules for making meaning from looking at the world: "An orientation has the uncanny quality of encapsulating the person who has learned to adopt it" (van Manen, 1977, p. 211). In some sense, the meaning of an orientation is akin to a paradigm, as characterized by Kuhn (1996). Van Manen observes that the transition from one orientation to another is a dramatic one, "a shift from one reality to another" (1977, p. 212).

Wellington and Austin (1996) agree that van Manen's levels of reflection are both hierarchical and encompassing, with unanswerable questions at one level forcing the questioner to the higher level. Based on their research experience and review of the literature, they extended van Manen's original hierarchy of reflection by including more orientations. In addition to the technical, deliberative (practical), and dialectic (critical) orientations, Wellington and Austin suggested an *immediate* orientation and a *transpersonal* orientation. Activities at the immediate level are focused on survival, basically non-reflective or simple reporting of events. The immediate orientation is not connected to an underlying social science tradition or professional knowledge base. The authors' *transpersonal* orientation is influenced by Eastern thought, emphasizing personal liberation, resistance to established authority, and an individualized and holistic pedagogy.

In a similar manner, Valli (1997) puts forth a hierarchy of five different types of reflection. Using content of reflection and quality of reflection as measures of distinction, she added reflection-in and on-action and personalistic reflection to the three familiar

levels of technical, deliberative, and critical reflection. Reflection-on-action and reflection-in-action originate with Schön (1983), focusing on the development of practical knowledge, developed from the teacher's own unique experiences. Personalistic reflection is similar to Wellington & Austin's (1996) transpersonal orientation, in its focus on personal growth.

While Valli does acknowledge the hierarchical nature of these five types of reflection, she also recognizes the shortcomings of each type, with respect to both content and quality of reflection. Technical reflection and reflection-in and on-action both concentrate on problems originating from instructional and management situations. Personalistic and critical reflection tends to neglect pedagogical concerns, focusing on relational or political issues. Deliberative reflection may result in teachers' rationalizing of their actions, since personal judgment is the criterion for instructional decisions.

Because of the limitations of each type, Valli recommends that teacher education programs should encourage reflection in all types, relevant to the concern being considered, an approach adopted by many teacher educators (Genor, 2005; Jay & Johnson, 2002; Spalding & Wilson, 2002; Zeichner & Liston, 1996). While she notes that types of reflection may be hierarchical, with some levels prerequisite to others, she suggests that another consideration in a hierarchy of reflection is the kind of questions or issues that are addressed, arguing that, "Reflecting on how to make schools more just and democratic, for example, might be more important than trying to maximize time on task" (Valli, 1997, p. 74).

In this chapter, Valli's typology of orientations to reflection will be used to organize the review of the literature. Figure 2-1 shows the relationship between the three models

discussed above. These three authors agree about the nature of reflection with respect to its increasing complexity moving from the technical to critical levels, as shown in the figure from left to right. Arrows indicate the variance within which the critical or transpersonal orientation is placed at the highest level of the hierarchy.

Since Wellington & Austin's (1996) immediate orientation is essentially non-reflective, it has limited value as an approach in teacher education, so it is not included in the literature examined. Valli's (1997) hierarchy includes reflection-in-and on-action. It is used to examine the various orientations to reflection. Table 2-1 shows the research on these different orientations to reflection, indicating teacher education studies that are relevant to specific components of reflection.

Components of Reflection

Reflection has been conceptualized in ways other than van Manen's levels and additional adaptations that focus on epistemological foundations. Jay and Johnson (2002) acknowledged that a definition alone was highly inadequate for the purpose of describing pedagogy of reflection, and asserted the need to examine the processes and content of reflection. Calderhead (1989) agreed, noting the need for teacher education programs to consider the processes of reflection, what pre-service teachers reflect upon, and the interaction of the kinds of tasks in which they are engaged and the context in which they work.

The perspective taken by Grimmett, Ericksen, MacKinnon, and Riecken (1990) considered the relationship between knowledge and reflection in terms of three distinctions: the source of knowledge for reflection, the mode of reflection, and the purpose of reflection. They developed a heuristic that examined different epistemological perspectives (instrumental/technical, deliberative, and

reconstructive/critical) on the basis of these three foci. The source of knowledge is that which is reflected upon, such as propositional knowledge derived from educational research in the instrumental perspective. Mode refers to the processes engaged in during an act of reflection, such as the reflective dialogue of a pre-service teacher and university supervisor. The authors identified three purposes for reflection: directing or controlling, informing, or transforming practice. While they acknowledge that the distinctions represented by their heuristic are neither exhaustive nor mutually exclusive, they advance the utility of the heuristic as one way of making sense of the literature of reflection.

LaBoskey (1993) initially designed a framework for reflection that considered the conditions, process, and content of reflection. Conditions refer to those contextual factors relating to how pre-service teachers interact with episodes of their own teaching. These factors include such artifactual and interactive components as discussions with supervisors and peers, and written or video-recorded records of instruction. Process includes not only steps in reflective thought of problem definition, means and ends analysis, and generalization taken from Dewey (1933), but also underpinning attitudes of open-mindedness, responsibility and wholeheartedness. LaBoskey affirms the importance of explicitly recognizing the content of reflection: "teacher education programs should give attention to the nature and breadth of the topics requested and encouraged by their reflective assignments" (1993, p. 26).

After a multi-case study of pre-service teachers, LaBoskey modified the initial framework to include direct attention to the impetus for and purpose of reflection. The study identified the need for emphasis on the motivation to reflect. She asserted that

since much of the reflection requested of pre-service teachers is externally motivated, the structural features of the task of reflection should be purposefully considered. Ultimately, the outcome of reflection should enable the development of new abilities, attitudes, beliefs, and emotions that result in the pre-service teacher moving further along a continuum of pedagogical thinking.

The current study uses a heuristic (Table 1-1) to explore approaches to reflection in science teacher education in terms of these two dimensions of orientations to and components of reflection. The heuristic represents a synthesis of ideas from Valli (1997), and Wellington and Austin (1996) in characterizing orientations to reflection, and the ideas of Calderhead (1989), Grimmett et al. (1990), and LaBoskey (1993), related to the dimension of components of reflection. Grimmett et al. (1990) identified heuristics like this one as effective tools for orienting the novice to the disorienting and even contradictory array of approaches to reflection. They noted that by identifying the key features of the prevalent modes, previously overlooked aspects may be revealed. Finally, they recognized the importance of this sort of "conceptual mapping" for the clarification and advancement of the study of reflection.

In this review of the literature on reflection in teacher education, the heuristic organizes important studies within each orientation, as shown in Table 2-1. While the heuristic is helpful in organizing studies of reflection, it does not function as an all-inclusive set of criteria. As such, not every study is easily classified into a particular orientation, and some studies identified as belonging to an orientation do not manifest all components. Studies were selected for this section of the literature review that represented significant aspects of specific components within the various orientations.

Technical Reflection

The teacher education model that is most frequently identified with the technical orientation of reflection is Cruickshank and Applegate's *Reflective Teaching* (1981). This program was designed as an on-campus laboratory peer teaching experience. The objectives of the program emphasize efficiency and utility, providing an immediate measure of student learning and making use of simple and accessible materials. As a form of peer teaching, the prepared reflective teaching lessons are designed to provide opportunities for reflection on accomplishment of specific behaviors such as describing or demonstrating.

The content of reflective teaching lessons should be unfamiliar to learners, so that the focus is on analysis of the teaching process. After each lesson, an assessment is administered to measure learner achievement and satisfaction, followed by reflection in the form of small group and whole class discussions of the lesson. Discussions typically involve difficulty of lessons, teacher thinking during preparation and instruction, and alternative teaching methods.

The results of Cruickshank's own empirical study (Cruickshank, Kennedy, Williams, Holton, & Fay, 1981) evaluating the outcomes of the reflective teaching program were mixed. The researchers examined three hypotheses regarding pre-service teachers who had participated in the reflective teaching program: (1) these students would be better able to think and talk analytically about teaching and learning; (2) these students would be better able to identify variables that influenced teaching; and (3) these students would be more positively inclined toward teaching. Data was collected from several instruments, including a questionnaire about teaching and learning, a list of variables contributing to or detracting from a videotaped teaching

episode, Likert-scale surveys addressing attitudes and beliefs about teaching, and a scale related to the concept of self as a teacher. Analysis of these data provided partial support for the first hypothesis concerning the promotion of analytical thinking, but the other two hypotheses were not supported. The researchers suggest that the exposure of pre-service teachers to the program (which lasted six hours) was inadequate to produce an effect.

Gore (1987) sternly critiqued this approach to reflective teaching, warning that the focus on process "restricts the focus of reflection to means, that is, methods for achieving pre-specified goals, and in so doing, risks these means becoming ends in themselves" (p. 33). Richardson (1990) also cautioned against the "technologizing" of reflection in the teacher education process, which risks reducing the abstract and complex nature of reflection "into a behavior that is generalizable, observable, and teachable" (p. 14). She describes how the use of a positivist research paradigm represents a threat to the development of reflection in teacher education programs, asserting that research questions from such a paradigm focusing on measuring reflection will not provide answers that further reflective practice.

This behaviorist nature of the technical orientation is evident in Freiberg and Waxman's (1990) description of the reflective inquiry teacher education program. The stimulus for reflection takes the form of an observation of an act of classroom teaching. Content of reflection consists of descriptions of the exemplary behaviors demonstrated: "Such observations enable prospective teachers to focus on specific teaching skills studied in their pedagogy courses" (p. 121). Training in the use of classroom observation and self-assessment procedures facilitates the process of reflection.

Microteaching episodes provide another stimulus for reflection, and the pre-service teacher's own performance in the microteaching lesson becomes the content of reflection, examining skills such as higher-level questioning and nonverbal cues. The process of reflection on microteaching involves feedback from a supervisor while viewing a videotape of the lesson. Other systematic assessments facilitate the process of reflection, including analysis of instructional audiotapes for such behaviors as "identification of motivating set and closure" and "identify number of positive statements made by teacher" (p. 128). The objectives of the program emphasize expertise and effectiveness as measured by systematic observation instruments.

While many researchers suggest that such a technical orientation is an important one to include in a teacher education program (Genor, 2005; Hatton & Smith, 1995; Jay & Johnson, 2000; Richardson 1990; Valli, 1997; Wellington & Austin, 1996), very few examples of how this should be implemented are articulated. Other teacher educators assert technical reflection is a stage to be moved through, most typically to reach the final stage of critical reflection (Larivee, 2010; Yost, Sentner, & Forlenza-Bailey, 2000). The characteristics of the components of technical reflection are represented in Figure 2-2.

Reflection-in and on-Action

In his critique of the technical rationality approach to the development of professional practice, Schön identifies dichotomies inherent in the paradigm: the separation of means and ends, research and practice, and knowing and doing. These dichotomies are rejected by those who espouse Schön's view, "Practice *is* a kind of research. In their problem setting, practitioners frame the means and ends of their action interdependently; what they do in certain situations depends on what they 'see' in

46

those situations" (MacKinnon, 1987, p. 138). Schön warns against a repetitive and routine approach to practice, resulting in the knowledge of practitioners becoming increasingly tacit and unexamined, a situation he calls "overlearning." Reflection is the correction to overlearning. "Through reflection, [the practitioner] can surface and criticize the tacit understandings that have grown up around the repetitive experiences of a specialized practice, and can make new sense of the situations of uncertainty or uniqueness" (Schön, 1983, p. 61).

In this orientation, the process of reflection-in-action is critical to the development of professional knowledge. MacKinnon (1987) examines how this process occurs in pre-service teachers' dialogues with their supervisors. He notes that beginning teachers are typically focused on personal survival concerns, such as being liked by students, controlling the class, and getting a job. MacKinnon suggests these survival concerns may inhibit the application of educational theory to their developing practice. He draws upon Schön's notion of reflection-in-action, particularly the rejection of the dichotomy of thought and action, as a way for pre-service teachers to link theory and practice.

In the study, MacKinnon looked for evidence of pre-service teachers' reflection-in-action on the basis of two aspects of a cycle of reflection, problem setting and reframing. Problem-setting is the initial naming of the puzzling event presented in practice, identifying the context and implications of the problem. Reframing is the uncovering of new aspects of the problematic situation that allow for new understandings and new possibilities for action. He used an analytical framework based on this cycle to identify instances of reflection in transcripts of teaching episodes and

supervision conferences. The main focus of the analysis was the transition of pre-service teachers from teacher-centered to learner-centered perspectives.

MacKinnon examined the teacher-supervisor dialogue for evidence of (1) phases of the reflective cycle in the dialogue; (2) change in perspective on the problem; (3) change in conclusions about the problem; and (4) use of personal experience to understand the problem. These clues correspond to aspects of reflection-in-action: problem-setting, reframing, resolving, and repertoire.

MacKinnon asserts reflection-in-action is characterized by "a willingness to examine and reexamine teaching experience from a variety of perspectives and theoretical platforms; it is not the case that the practice of teaching can be informed by one 'right' perspective" (p. 144). He suggests this framework for a cycle of reflection and the clue structure for detecting reflection in supervision dialogue is an effective method of studying reflection-in-action.

In addition to the aspects of problem-setting and reframing, another characteristic of Schön's approach to reflection is the presence of the reflective practicum. A practicum is an environment constructed for the purpose of learning a practice. Schön (1987) contends that the appropriate focus of a practicum should be not be on technical and procedural knowledge applied to typical problems, but rather on "the kinds of reflection-in-action through which practitioners sometimes make new sense of uncertain unique or conflicted situations of practice" (p. 39). As Valli (1997) recognized, "the unique case, rather than the generalized rule, is the important teaching tool" (p. 71). While Schön refers to the profession of design in his description of the reflective practicum, he could be describing teaching:

The non-routine situations of practice are at least partly indeterminate and somehow must be made coherent. Skillful practitioners learn to conduct frame experiments in which they impose a kind of coherence on messy situations and thereby discover consequences and implications of their chosen frames. . . It is this ensemble of problem framing, on-the-spot experiment, direction of consequences and implications, back talk and response to back talk that constitutes a reflective conversation with the materials of a situation. (p. 157-8)

An example of the reflective practicum is present in Wilson and I'Anson's (2006) study of microteaching in a teacher education program. They characterize the reflective practicum as being located between the university and the school, an intermediate space not designed to replicate the complexity of the real world, but instead to reduce the complexity of the real world. They assert that the complexity of the school setting generates undue stress on pre-service teachers at an early stage of their education. Another problem lies in pre-service teachers potentially conforming to identities and roles they witness in schools. The reflective practicum should serve as a safe place to entertain alternative pedagogies and explore diverse identities without the high stakes of an actual classroom.

They implemented microteaching experiences to serve this purpose, engaging students in designing and teaching a short lesson that is videotaped. Following the lesson, the pre-service teacher discusses the lesson with the university tutor and school-based teacher fellow. The next semester, pre-service teachers design and teach a sequence of lessons, followed by reflection in conference with the university tutor and teacher fellow. The pre-service teacher, supervisors, and peers view the video and participate in collaborative reflection, which functions to generate multiple perspectives on the microteaching episode. The authors suggest that this process can generate a new performative text, providing further opportunities for reframing problems of practice.

49

This approach represents a fundamental contrast to the emphasis on technical performance advocated by Cruickshank and Applegate (1981) as discussed above.

In contrast to Wilson and I'Anson's reflective practicum taking place between the university and school, Lee and Loughran (2000) describe a school-based teaching program as the stimulus for reflection. In this program, pre-service teachers spend an entire term in a school, with coursework conducted in the setting of the school using the issues and concerns of experience as the motivation for study. While this experience does not embody the reflective practicum to the degree of the microteaching model described above, the deliberate extension of time and the reduction of student teaching load in the school-based program, does provide a lessening of complexity from actual practice. The authors agree with the conclusion of Russell and Munby (1991) on the importance of a rich source of experience as stimulus for reflection. The school-based program provides many puzzles of practice through the extended period of direct teaching experience and immersion in the school context.

Lee and Loughran focused the study on the process of reflection occurring through a cycle of framing, reframing, and resolution. Framing, or problem setting, is the stage in which an initial problem or puzzle is recognized. The initial frame sets a boundary around the problem and determines strategies for possible solutions. Schön (1983) asserts the importance of practitioners' recognition of their initial frames: "When a practitioner becomes aware of his frames, he also becomes aware of the possibility of alternative ways of framing the reality of his practice" (p. 310).

Reframing involves the practitioner constructing a new understanding of the problem using a repertoire of theories, models, and techniques. Even though the

puzzling situation may be unique, it may be reframed and seen as a familiar case with a new set of strategies. Resolution does not necessarily suggest a solution to the problem, but more a state of improved understanding and new appreciation.

The authors identified three important aspects of the program that enabled reflection. The wide range of activities and interactions experienced in the context of a school facilitated pre-service teacher thinking on their tacit beliefs about teaching and learning. The amount of experience, in terms of time, served as a critical stimulus for reflection, supplying a greater opportunity for repertoire building. Finally, the extended time and reduced load allowed exploration of, and experimentation with, a wider variety of frames.

Russell and Munby (1991) examined the process of reflection-in-action through reframing in their study the use of language by two experienced teachers to describe puzzles of practice. When Diane, an experienced elementary teacher, was interviewed, she referred to the challenge of finding a "balance of activity" (p. 167) in the classroom. She initially framed the puzzle as a management problem, applicable to her role in directing students. The next year, she reframed the issue as one of learning, which allowed her to ponder a different realm of ideas: "Diane can invoke what she knows about learning at this age: Practice, time, and patience are required" (p. 169). This recasting enabled her to interpret the puzzle in terms of a balance between theory and practice.

The outcome of reflection-in-action through the process of reframing is the development of professional knowledge that is dynamic. "A new frame does not mean an end to puzzles and problems; the scrutiny of one's practice continues, but it moves

51

to more elaborated views of practice" (p. 173). The authors see the process of reframing as part of a cycle of professional knowledge development, characterized by changes in the descriptive language of teachers. They acknowledge that the experiences that drive these changes and the capabilities that facilitate teachers' reframing are not well understood, but suggest the need for consistency between theory and practice as a critical factor.

The authors note the difficulty of researching reflection-in-action. "We would not expect to observe directly the 'event' of reflection-in-action" (p. 185). They found promise in the strategy of interviewing teachers over time concerning changes in their teaching approaches and perspectives in the classroom context, looking for variations in the metaphors and symbols used to describe classroom practice.

Russell and Munby note the failure of teacher education approaches which focus on directly translating propositional knowledge into practice. "This premise fails because it cannot explain how the act of teaching is used by the beginning teacher to acquire practical knowledge" (p. 185). They advance reflection-in-action as a way to improve the outcome of the development of professional knowledge in teachers.

Another important aspect of the process of reflection-in and on-action is the presence in the reflective practicum of a coaching relationship. Schön (1987) carefully describes the nature of the conditions necessary for the continually evolving relationship:

> Building a relationship conducive to learning begins with the explicit or implicit establishment of a contract that sets expectations of the dialogue: What will coach and student give to and get from each other? How will they hold each other accountable? These questions are not answered once and for all at the beginning but are continually being raised and resolved in new ways throughout the life of the practicum (p. 167).

Schön (1991) states the primary concern of the coach is enabling pre-service teachers to recognize and make explicit what they already know, "the understandings already built into the skillful actions of everyday practice" (Schön, 1991, p. 5).

Wood (1991) described how this coaching relationship is operationalized in the actual student teaching practicum, emphasizing teamwork and partnership. Teacher educator roles and responsibilities are shared between the cooperating teacher and university faculty. The unique background knowledge and experience the pre-service teacher brings to the classroom becomes the starting point of the practicum, assessed by the cooperating teacher. The emphasis is on realizing "the value of teaching as a collaborative activity rather than one of isolation" (p. 203). Wood also recognizes the personal benefits from the relationship through exposure to emerging pedagogy and theory.

Themes from the literature on reflection-in and on-action are summarized in Figure 2-3.

Deliberative Reflection

While the reflection-in and on-action orientation emphasizes the process of reflection, the deliberative orientation has a greater focus on the content of reflection. Valli (1997) characterized the deliberative orientation as one emphasizing teacher decision-making from consideration of a variety of perspectives. Colton and Sparks-Langer (1993) agree, seeing the teacher as a "reflective decision maker . . . intrinsically motivated to analyze a situation, set goals, plan and monitor actions, evaluate results, and reflect on their own professional thinking" (p. 45).

This orientation is present in Zeichner and Liston's (1987) description of a teacher education program that prepares teachers "who are both willing and able to reflect on

the origins, purposes, and consequences of their actions" (p 23). The program encourages the outcome of teachers developing and exercising judgment concerning their own practice. Through pre-service teachers' development of Dewey's (1933) attitudes of open-mindedness, responsibility, and wholeheartedness, reflective teaching is facilitated, empowering teachers to "exert more control over the content and processes of their own work" (p 26).

In this program, the authors recommend that content of reflection encompass all three of van Manen's (1977) levels of reflectivity. They emphasize the practical and critical levels, focusing on "the worth of competing educational ends" (p. 24) and moral and ethical criteria in reflection.

Reflection is stimulated through the encounters of pre-service teachers with Schwab's (1973) commonplaces of instruction: teachers, students, subject matter, and the milieu of learning. Pre-service teachers (while still students) are prepared by the program to view the knowledge they are taught and that which they will be teaching as problematic and socially constructed, rather than certain. They should also view the role of the teacher as one of a moral craftsperson instead of a technician. Curriculum is ill-structured and broad in scope, with content negotiated by teachers and students. Knowledge should flow in both directions. The milieu of the program is characterized as inquiry-oriented, valuing initiative and critical thought in students and teachers, and collaboration is augmented to facilitate the breakdown of traditional hierarchies of authority. Teachers are represented as moral crafts-persons, whose knowledge and views should be consistent with the program's priorities. Interactions with the

commonplaces are expedited through five curricular components: student teaching, inquiry projects, seminars, journals, and supervisory conferences.

One study of the program (Tabachnick & Zeichner, 1984) found that the experiences did not significantly change pre-service teachers' views about teaching, but these views were more skillfully articulated and implemented after completion. The authors note that while pre-service teachers completing the program did not view themselves as moral crafts persons, the effects of the experiences may not be apparent at the end of student teaching. Another study (Zeichner & Tabachnick, 1982) examined the perspectives emphasized by supervisors with respect to level of reflection. This study found a small proportion of supervisors emphasizing a technical-instrumental approach, with the majority focusing on issues of personal growth or moral and ethical concerns.

Zeichner and Liston (1987) identified several factors undermining the program's achievement of its goals of reflective teaching. Student teaching is traditionally viewed as an apprenticeship in which pre-service teachers demonstrate acquired skills. Effort devoted to inquiry and reflective activities is perceived as detracting from time for teaching and planning. A second factor is the small part played by the student teaching experience in the socialization of pre-service teachers into the profession of teaching. Pre-service teachers do not typically engage in problematizing practice in coursework outside the student teaching program. The authors suggest, "much unlearning has to go on before most students are willing to accept the need for a more reflective approach to teaching" (p. 42). They also note that opportunities for meaningful contact between university supervisor and pre-service teachers are limited, and tension exists between

the roles of the supervisor and the cooperating teacher. Discussions of cooperating teachers' decisions and practices may be threatening, and formal authority structures discourage alternative approaches. Finally, the role of cooperating teachers is made difficult due to the lack of explicit resources for their own reflection and inquiry.

In general, the authors observe the lack of a unifying perspective on the program. Instead, the program is characterized as containing a wide variance in ideology, yet lacking integration. They recognize a serious inconsistency existing between the program's view of the teacher as professional decision-maker and society's view of the teacher as efficient technician: "To some extent we may be preparing student teachers for a teaching role that does not now exist" (p. 44). Despite these gaps and weaknesses, the authors assert reflection as a critical component of an effective teacher education program.

Collier's (2010) study focused on both the content and process of teachers' reflective decision-making, examining how the social nature of deliberative reflection encouraged the consideration of multiple perspectives on pre-service teachers' theories of teaching and learning. The content of reflection in this study concerns the development of theories of learning and how those theories impact instruction. Specifically, reflection was "not on what to teach and how but rather on why certain instructional choices are made and how that is connected to student learning" (p. 47). Content becomes a window into the thinking of pre-service teachers about student learning rather than teaching performance.

Collier characterizes the process of reflection as a communal one. This criterion draws from Rodgers's (2002) revisiting of Dewey's (1933) writing on reflective thinking.

Rodgers identified reflection occurring in the community, with the benefits of affirming one's experience, providing alternative meanings, and supporting inquiry. Collier positioned her study in a problem-solving community of pre-service teachers. She proposed dialogue, conceptualized not only as spoken conversation but also as written thought in the form of dialogue journals and electronic communication, as a key factor in the process.

Collier found a marked difference between written individual reflection and collaborative reflection. Pre-service teachers typically viewed written reflection as a task without much value, "little more than just another course requirement" (p. 57), perceiving that their course instructors did not take journals seriously in facilitating learning. Collier structured reflective journal entries for the study with specific prompts after focus-group interviews, with at least a week to respond, and found the resulting written reflections to be more valuable in their depth and detail.

Despite this value associated with written reflection, pre-service teachers in the study expressed a greater need for social reflection. They conceived this type of reflection as one that would be available during their own professional practice, anticipating peer observation and debriefing as a powerful form of collaboration. They characterized reflective problem solving as a multi-step process of (1) the teacher sharing a problem with the community, (2) the community sharing perspectives with the teacher, and (3) the teacher combining these multiple points of view with personal ideas to construct meaning. This multiple "layering" of reflective interaction parallels what I'Anson, Rodrigues, and Wilson (2003) call "refractions" of experience. Hatton and Smith (1994) also found pre-service teachers' ability to examine multiple perspectives

on teaching experience facilitated through social interaction in "critical friend" dyads and peer group discussions.

Collier asserts the outcome of this approach to reflection as the development of teachers "who are equipped to consider how specific instructional choices relate to student understanding" (p. 67). Social reflection enabled pre-service teachers to consider connections between theory and practice, an effort in which they do not typically engage.

The components of deliberative reflection as characterized in the literature are summarized in Figure 2-4.

Personalistic Reflection

While the previously described orientations are concerned primarily with professional practice, Valli (1997) characterizes the personalistic orientation as more concerned with personal growth and relational issues, connecting the personal with the professional. Teaching becomes a vehicle for achieving life goals, and the teachers' interest extends to their students' whole lives, not just their academic ones; an orientation influenced by Noddings' (1984) philosophy of caring. The content of reflection focuses on pre-service teachers' own lives, examining influential events and beliefs (Yost, Sentner, & Forlenza-Bailey, 2000). Wellington and Austin (1996) propose "universal personal liberation" as the outcome of this orientation, with roots in Eastern thought. Questions are often directed inward, addressing issues of personal and professional growth and responsibility.

Yinger's (1990) description of the "conversation of practice" is aligned with this outcome, valuing place, participation, conversation, and community. Yinger compares teaching to the practice of farming or poetry, with the goal being human interaction that

58

is moral and healthy. He rejects the narrow emphasis on teacher as manager, executive, or information processer, and asserts a broader and more personal image: "the real meaning of teaching and learning and the real work is closer to home and within ourselves" (p. 93).

The personalistic emphasis on values and beliefs in the content of reflection is examined in Griffin's (2003) study of the influence of a "latent philosophy" of teaching and learning, constructed from educational experiences. The critical incident strategy was used to examine pre-service teachers' reflective language and thinking, orientation toward growth and inquiry, and modes of reflective thinking.

Critical incidents are rich and concrete narratives of experiences that are evocative in some way to the pre-service teacher, with the meaning of the incident revealed through a detailed written reflection and analysis. Guidelines for writing the critical incident call for description of emotions raised and articulation of personally held beliefs. In the study, pre-service teachers generated five critical incidents from field experiences prior to student teaching. These reflections were classified using the seven level framework for reflective language and thinking developed by Sparks-Langer et al. (1990), LaBoskey's (1993) continuum of reflective thinking (concrete thinker, alert novice, and pedagogical thinker), and van Manen's (1977) levels of reflectivity (technical, practical, and critical).

While Griffin found no pattern of development in the use of reflective language, analysis using the framework showed pre-service teachers' increasing use of principle and theory and consideration of context as time passed. Most critical incidents were written on technical or practical levels. While very few reflections were written at the

critical level, there was an increase in writing at the practical level over the six weeks of the field experience. The most apparent development revealed by the study was the increased attention to personal growth and inquiry into practice, as measured on LaBoskey's continuum.

Griffin recognizes the limitation of relying on written reflections solely as evidence of growth. She also discovered that pre-service teachers may not have placed much value on written reflection, since the weighting of the assignment was low in the overall grading scheme.

The autobiographical nature of personalistic reflection is present in Sparks-Langer and Colton's (1991) study of teachers telling their own stories. This narrative element of reflection emphasizes the "validity of teachers' judgments drawn from their own experiences" (p. 42). Teachers' narrative interpretations of the context of practice focus their awareness on their own thinking.

Brown (1999) adopted the narrative approach in her study of how a literacy autobiography promoted reflection in pre-service English/language arts teachers. Pre-service teachers in the study responded to a series of prompts on their own literacy history, producing a narrative of their experiences with reading, writing, and language arts teaching. Brown characterizes the entire experience of the literacy autobiography, including the assignment form, process of writing, autobiography product, and other course context as a "common text," similar to Wilson and l'Anson's (2006) use of reflection on videotaped microteaching as a "performative text." Brown found pre-service teachers used their autobiographies in journal entries as a source for connecting theory examined in class to the practice of their own experience. These experiences

became content for reflection examined through the lens of their evolving notions of teaching and learning. "Prospective teachers should examine their past experiences in light of theory in order to understand the theories that informed their teachers' practice" (p. 408). While Brown found individual autobiographies contained little evidence of critical reflection, when presented with questions about common themes from the autobiographies, the whole class engaged in discussion that included issues of social justice.

Tann (1991) also considered the powerful effect of pre-service teachers' personal educational histories: "these life-time experiences of the function and structure of education are likely to have contributed towards a definite conception of teaching roles and relationships to which the students cling" (p. 55). These experiences contribute to the development of "personal theories" of teaching: informal, often implicit ways of thinking used to guide action. Tann agrees with Goodman's (1984) assertion that pre-service teachers need to be encouraged to identify and examine their personal theories in order to consider alternative theories.

Tann examined how personal theories of pre-service teachers are revealed during lesson planning and evaluation activities. Lessons featuring health and safety concepts were planned collaboratively and taught to classes of approximately thirty elementary-age students. The writings of pre-service teachers in lesson plans (aims objectives, methods, resources, and rationale) and evaluations (what was learned, what was planned next) were analyzed for features of reflection.

Tann found two major themes. The first was a shift in the perspective of pre-service teachers from an initial retrospective, superficial, and *descriptive* evaluation to a

second stage of explanation, involving reasons and connections within context. The third stage of exploration included consideration of alternative factors and more generalized issues of practice. Reflections changed in focus from self-oriented aspects of performance to peer-oriented observations.

The second major feature detected was a shift in the reasoning processes of pre-service teachers. By week four, a smaller proportion of pre-service teachers' remarks were characterized by unsubstantiated judgments or implicit reasons. The emphases on lesson evaluations shifted from negative aspects (what went wrong) to consideration of modified instructional strategies and decisions about future learning.

Tann concludes that teacher educators need to take a stronger role in enabling pre-service teachers to identify, articulate, and challenge their personal theories. One area of difficulty pre-service teachers have with this process concerns what Tann calls a "personal-public link." In the early part of their professional education they are unfamiliar with the language of education. Tann observed, "They had difficulty in articulating their experiences in anything other than colloquial terms" (p. 68). She recommends that this process of reflection would be facilitated through providing students with a professional vocabulary for sharing experiences of practice in initial teacher education courses.

Themes from the literature on personalistic reflection are presented in Figure 2-5.

Critical Reflection

Many teacher educators portray critical reflection as the level to be reached, after progressing through the technical and practical levels (Larrivee, 2010; Nichols, Tippins, & Wieseman, 1997; Smyth, 1989). Others suggest that the critical type of reflection is one of several that pre-service teachers should encounter in their education (Jay & Johnson, 2002; Spalding & Wilson, 2002; Valli, 1997; Zeichner & Liston, 1996).

Dinkelman's (2000) case study of three pre-service social studies teachers provides an insightful representation of the development of the critical orientation. He initially defines critical reflection broadly, consistent with the framework of other researchers (Valli, 1997; van Manen, 1997, Wellington & Austin, 1996) as teachers' consideration of the moral and ethical aspects of teaching. Critical reflection guides instructional practice, resulting in critically reflective teaching. Dinkelman makes an important point about his definition. He admits that since definitions of reflection are so diverse, researchers can put forth their own views, but asserts that any proposed definition of reflective teaching should contain an explicit description of good practice. His orientation makes use of van Manen's (1977) idea of levels of reflection (technical, practical, and critical) and Zeichner and Liston's (1996) description of the social reconstructionist tradition of reflective teaching, to produce a stricter definition. This social reconstructionist definition of critical reflection includes "social, historical, political, and cultural contexts of education," but also emphasizes deliberation on "relationships between educational practice and the construction of a more equitable, just, and democratic society" (p. 199).

The importance of the component of stimulus for critical reflection was evident in the attention to contextual factors in the design of the teacher education curriculum. The study took place over two semesters, a semester-long social studies methods course, followed by a semester of student teaching, where the author served as course instructor and practicum supervisor. Dinkelman used interviews, observation notes, and various written data sources to examine critically reflective teaching and the factors that influenced its development.

Dinkelman identified several specific stimuli as factors of influence. Both the methods course and practicum seminars made use of readings, assignments, and activities that incorporated a critical orientation. Pre-service teachers and the supervisor gave explicit attention to critical reflection, regularly using the phrase during observation conferences. These pre-service teachers who were part of the multi-case study cited their participation as an important influence on their thinking. They also noted the impact of the supervision process, particularly the presence of a trusting and supportive relationship, in confronting critical issues. The placement of student teachers in alternative high schools enabled them to have freedom to experiment with curriculum and incorporate topics that facilitated attention to critical issues.

The content of reflection emphasized the classroom climate, how "the moral and ethical dimensions of teaching play out in the relations among class members" (p. 201). While the journals and observation conferences of the pre-service teachers primarily concerned practical issues of the classroom, they also explicitly valued goals of equity and empowerment. Reflections also focused on lesson planning, such as a particular lesson that focused on the topic of obedience to authority and harmful gender stereotypes. Pre-service teachers' reflections revealed understanding of the moral and ethical implications of teaching, as one noted "the fragility of many of his students, students who had been harmed by their past experience in schools and with those in authority" (p. 215).

All three pre-service teachers were clear about the outcome of the development of critical reflective practice. One saw as her goal how she might use her own practice to help her students "start questioning the world" (p. 206). Another directly stated his

objective to his high school students, "This society does not have the answers that will solve the violence and the hate. It is up to you to make this world a better place" (p. 213). Each of them articulated a message of commitment to education in the construction of a more equitable and democratic society.

While the components of stimulus, content, and outcome showed up clearly in Dinkelman's study, the process of reflection was not described. Pre-service teachers completed journals and took part in interviews, but the author gave no explicit attention to either how they were reflecting or why the process was important.

Genor (2005) focused on the process of critical reflection by pre-service teachers involved in a semester-long study group. She adopted Zeichner and Liston's (1996) social reconstructionist tradition to provide an orientation for pre-service teachers that supports the development of a critical lens. Genor also incorporated van Manen's (1977) notion of becoming rooted in an orientation if not compelled to move from it. While she recognizes the hierarchical nature of frameworks for reflection, she rejects the idea that these levels represent "a sort of reflective leader" (p. 50), with the goal of climbing to the top rung and staying there. She asserts instead the importance of reflection at and growth within each level.

Genor's framework provides a description of the ways in which pre-service teachers question and critique issues of interest. Pre-service teachers were engaged in a semester-long study group during which they discussed topics of their own choosing. The framework does not analyze content, but rather prioritized the process of reflection by examining the kinds of discourse and interactions that occurred during discussion.

Instances of reflection on teaching were classified as unproblematized, problematized, or critically problematized.

Unproblematized reflection consists of generalized questions and descriptions of practice, without examination of the underlying issues and assumptions. Genor gives the example of a pre-service teacher concerned with classroom discipline. The unproblematized discussion consists of a general description and solicitation of new ideas. The pre-service teacher's beliefs about classroom management are not considered, and larger issues of school and community context are ignored. While unproblematized reflections are typically superficial, they may lead to deliberation about underlying beliefs and important contextual issues in the problematized level of reflection.

Problematized reflection occurs when pre-service teachers engage issues deliberately, work to build understanding of the issue in context, and then question and critique that understanding. The key to solving this problem is a situation of collaborative reflection, where multiple perspectives are generated and considered. Problematized reflection consists of careful questioning and recasting ideas in a way that demonstrates a new sense of understanding. Genor presents an example of problematized reflection where pre-service teachers challenged each other to more clearly focus on the purpose of a classroom project. She notes that pre-service teachers can problematize their own beliefs, but still not consider the larger ethical and moral aspects of practice.

In the critically problematized level of reflection, these social and political implications are not just considered, but are used to transform practice. This radically transformed practice results from fundamental changes that occur in problematizing

thinking about teaching. It involves expanding the context beyond the classroom to include social and political influences on schools. The consequence of critically problematized reflection is the development and implementation of curriculum, instruction, and policy that demonstrate the importance of these ethical and moral concerns. Genor found most of the pre-service teachers' reflection occurred in the unproblematized category, and found no examples of critically problematized reflection, possibly due to the limited time of the study.

Genor acknowledges the need for support of pre-service teachers involved in collaborative inquiry, recognizing that it is insufficient to "simply ask my students to 'reflect' on their teaching without ever examining the reflective process itself" (p. 46). She proposes this framework as a model of the critical reflection process and as a tool for teacher educators, placing "value on the way in which teachers reflect upon the questions they have about their teaching" (p. 52).

The components of critical reflection are represented in Figure 2-6.

Reflection in Science Teacher Education

Some studies of reflection in science teacher education are easily mapped onto the two-dimensional heuristic of orientations to and components of reflection. Others focus on a specific component of reflection without an explicit statement of a theoretical framework that guides reflection, but still represents a particular orientation based on an emphasis on problem setting and reframing (reflection-in and on-action), multiple perspectives (deliberative), or personal beliefs (personalistic). Still others emphasize features that are particular to science education, such as scientific inquiry or the nature of science. The applied nature of these science education studies of reflection, as opposed to the more theoretical writing examined in the first part of this chapter, makes

classification into singular orientations less feasible. Table 2-2 shows the organization of this section of the literature review.

Technical Reflection

As examined in the first part of this chapter, the technical orientation to reflection frequently involves examining an episode of one's own teaching with reference to some externally derived standard of performance. Studies by Britner and Finson (2005) and Yung, et al. (2007) both provide insights into how components of the technical orientation are implemented in science teacher education.

Fidelity to some external authority's performance criteria is evident in both of these studies. Britner and Finson examined pre-service teachers' experiences in an inquiry-oriented science methods course. Requirements for conducting an inquiry investigation were carefully delineated. Students in the methods course were required to follow a prescribed sequence of activities, including composing the research question, designing and conducting the experimental study to test the hypothesis, and reporting results and conclusions. The authors emphasized the need for students to "utilize what he or she knows and has learned during the early part of the course regarding inquiry" (p. 44), with a focus on the use of specific process skills. After reporting their results, pre-service teachers individually designed lesson plans based on the inquiry investigations, using the Activities Integrating Mathematics and Science (AIMS) format. The AIMS format provides a clear blueprint for the lesson plan. "The format is useful to beginning teachers in that it provides specific elements which are important in developing lesson plans and can thus serve to guide students through the process" (p. 44). A performance assessment, aligned with the lesson plan and with a similar level of specificity, was

another required component of the course. These emphases on externally (higher) imposed criteria indicate a technical orientation to reflection.

Yung, Wong, Cheng, Hui, and Hodson (2007) used repeated viewing of a video representing exemplary science teaching as a stimulus for reflection. While the study contains some references to Schön and the development of reflective practitioners, the authors made no explicit statement of the theoretical orientation to reflection taken in the study. However, the emphasis on essential features of good science teaching reveals a technical orientation towards reflection.

Pre-service science teachers enrolled in a science methods course participated in the study, with the identified purpose of understanding and monitoring their changing conceptions of effective science teaching throughout the course. At the beginning of the course, they were prompted to evaluate the quality of their own science learning at different educational levels, and to describe what they considered good science teaching. They were then given a CD-ROM of two lessons demonstrating various reform-oriented instruction, including hands-on activities, emphasis on science process skills, encouragement of student discussion, and infusion of the nature of science into lessons. After viewing the lessons, they were to identify the instances of good science teaching and aspects that could be improved. From these initial reflections, the authors selected a group of pre-service teachers for interviews on the major factors influencing their conceptions of good science teaching.

The authors make a strong case for the use of video as a stimulus for reflection. Watching the video lessons prior to the beginning of the methods course "activated some student teachers to question, reflect on and restructure their conceptions in

search of solutions to various complex situations they are likely to face in their future teaching" (p. 250). They also noted that repeated viewing of the same video with different emphases or perspectives enabled pre-service teachers to consider how effective teachers manage the complexity of classroom practice.

While components of technical reflection are certainly present in these two studies, the previously noted overlap of orientations in science teacher education is evident here. Britner and Finson reveal technical influences in the stimulus of and content of reflection. This influence is demonstrated via external criteria for performance and a consideration of one's own performance. Other features of their study were of a more deliberative nature, particularly within the broader context of the inquiry experience, which stimulated reflection on three of the commonplaces: teachers, students, and subject matter. Pre-service teachers were cast into different roles – as students learning about inquiry, and as teachers making decisions about the science curriculum. The content of their reflections revealed struggles in their deliberations on the multiple aspects of scientific inquiry. While Britner and Finson were not explicit regarding their orientations to reflection, the study is consistent with Valli's (1997) recommendation that the learning of pre-service teachers should progress through encounters with multiple types of reflection.

The study of Yung, et al. (2007) contains aspects of a reflection-in and on-action orientation with an emphasis on the development of practical knowledge. An important finding was the acknowledgment by the pre-service teachers of the actual existence of accomplished teaching, which they had previously considered purely theoretical. "With the video, I knew that it's really possible to plan for a lesson and then teach accordingly.

. . . the video told me about the possibility rather than the importance" (p. 249-250). This excerpt demonstrated how the pre-service teacher is situating theory (lesson planning) encountered in coursework into a practical context. The authors (Black & Atkin, 1996) also recognized "the crucial role played by the video in providing proof of existence of the importance of lesson planning" (p. 250), enabling the pre-service teacher to value planning in a practical manner, rather than the theoretical one typically presented in methods courses.

One interesting recommendation made by Yung, et al. concerns the use of exemplary cases. They call for presentation of a range of models, demonstrating different levels of competence from novice to expert, designed to "avoid demotivating student teachers by showing only the consistently high standard of exemplary teaching" (p. 254). Some exemplars should be at a level of competency accessible to novice teachers. They also advise that video lessons selected for viewing should represent diversity in teachers, students, and classrooms, to stimulate deeper reflection concerning situations of practice. Since the purpose of the video exercises is to promote change in pre-service teachers' ideas of good science teaching, they should be encouraged to not only identify instances of good teaching, but also to examine why they think it is good. The authors acknowledge that this examination of underlying attitudes and beliefs is an under-researched area in science education.

Reflection-In and On-Action

A significant aspect of the process of reflection described by Schön is the reflective practicum. This process component involves a coaching relationship between mentor and student, and includes structures to enable reframing and to make the tacit explicit.

MacKinnon and Erickson (1988) examined how a reflective practicum was operationalized as a stimulus for reflection within the constraints of a secondary student teaching experience. They focused on the role of the cooperating teacher as coach in the reflective practicum, with particular attention to a reflective science teacher with a constructivist orientation. The authors used two of the models of a reflective coaching relationship described by Schön, "Follow me!" and "Joint experimentation" (1987) as the processes for engaging a pre-service teacher in reflection. The authors clearly acknowledge the influence of Schön in their approach, indicating an orientation towards reflection-in and on-action.

Follow me! involves the coach explaining and demonstrating and the learner observing and following. Both the coach's expertise and the learner's open-mindedness are critical. "A coach's artistry consists in his ability to draw on an extensive repertoire of media, languages, and methods of description . . . the student's artistry consists in her ability to keep many possible meanings alive in her mind" (p. 297). In joint experimentation, the coach works to establish and maintain a process of collaboration, a process made difficult with expertise in the problems of practice. Here the coach must resist the temptation to explain or demonstrate a solution. The coach and learner work together to construct thought experiments of problem-setting and reframing.

The authors presented three propositions about a reflective science teacher with a constructivist orientation. A reflective science teacher will:

1. Recognize that learners are constantly constructing meaning from observed phenomena;

2. Attempt to see science phenomena from students' perspectives; and

3. Be better positioned to teach children about orthodox science.

Through an analysis of supervisory dialogue, the authors found evidence that Mr. Kelly, the cooperating teacher, used the models of reflective coaching.

MacKinnon and Erickson refer to the tendency proposed in (2) above, where the teacher thinks about classroom phenomena from the perspective of learners, as "intellectual empathy" (p. 122). Mr. Kelly characterized this disposition when he asked Barry, the pre-service teacher, "Do you see what goes through kids' minds?" (p. 124). Mr. Kelly drew upon his repertoire of experience to explain to Barry the typical difficulties that learners have with particular concepts. In other dialogue excerpts, Mr. Kelly modeled how intellectual empathy develops through interaction with students. Barry's later reflections-on-action incorporated this approach, where he discussed making use of a student's experience with electronics in a demonstration. The authors identify this as a Follow me! type of coaching, where Barry is developing autonomy as a teacher based on the manner in which Mr. Kelly responds to his reflections. Mr. Kelly and Barry later engaged in the model of joint experimentation when they had a hypothetical discussion about different mental models students might have for electrostatic properties.

MacKinnon and Erickson conclude that certain conditions are necessary for this type of reflection. The first is the ability of the supervising teacher to "articulate and demonstrate a coherent perspective of teaching practice. . . . supervisors must be able and willing to reflect on their own practice" (p. 133). Mr. Kelly's consistent emphasis on the constructivist features of student learning embodies this first condition. The second condition is the establishment of an environment of trust and safety for both parties.

73

"Experimenting and the inevitable 'mistakes' that follow are encouraged, discussed, and viewed as departure points for growth" (p. 133).

Roychoudhury, Roth, and Ebbing (1993) examined the importance of the practicum experience as a stimulus for the development of reflection-in-action. Their study recognizes that practical knowledge is often tacit, and requires the critical stimulus of experience. "We believe with Schön that reflective practice is grounded in learning from one's own experience through a process of deliberation" (p. 70). Practicum experiences thus serves to provide authentic situations that engage pre-service teachers in reflective practice.

The authors' case study concerned a pre-service elementary teacher involved in a year-long field experience in a second grade classroom, concurrent with special methods courses. Embedded in the practicum was an action research component that focused the pre-service teacher on problems of practice directly and personally experienced in the classroom. Journals, lesson plans, observation notes, and transcripts of discussions with the researchers comprised the data for the case study.

In the first case presented in the study, the authors examined the specific process of reframing a problem encountered by Judy, the pre-service teacher in the practicum. In her early journal reflections, she showed concern about the state of science teaching she encountered in the classroom. The expectations she developed as a student of a student-centered, teacher as facilitator, active engagement-oriented classroom were incompatible with her experiences in the practicum. "Little time was allowed for the students to engage in the interactions that took place in the classroom. The teacher was more concerned with covering the material" (p. 75). Judy agreed with her cooperating

teacher that while the classroom teacher was free to design instructional activities, external authority determined the scope of curriculum. Judy's initial problem was framed as "too much to cover in a limited time."

Judy noted in her journal that a language arts teacher she observed could benefit from integrating topics and activities from a spelling curriculum. Through discussion with one of the researchers, she reframed her initial problem into "topics within a field need to be integrated for better use of time" (p. 77). Judy later observed a different teacher who taught science every day, and with some guidance, she reframed this problem into one of integrating not just within but also across subject areas. Judy's practice changed due to this reframing, resulting in concerns focusing on thematic teaching rather than time. The authors cite Judy's reframing as a powerful connection of theory to practice:

> Beginning teachers often feel that they have been shortchanged during their academic experiences. What they have learned during various courses did not prepare them for their profession. We argue that the crux of real-classroom situations lies in their complexity and in the problem of turning knowledge-about-practice into knowledge-in-practice. (p. 79).

The authors presented a second case of reflection-in-action, that of making the tacit explicit. Judy believed learning was enhanced through small group discussions and sharing, and implemented group activities in her practicum classroom. She did not indicate why she felt these activities were effective, and her early reflections focused only on the affective features of cooperative learning. As she reflected in more detail on the merits of group work, aspects of her reflections revealed connections to research on collaborative learning, such as development of social skills, support from peers, and elaborating an argument.

In one of her reflections, Judy realized that one group's lack of progress was due to unequal roles within the group. She then altered the activity based on her own

experience in laboratory collaboration, providing more structure and accountability. The authors contend that this explicit understanding of cooperative learning developed through reflection became a part of Judy's repertoire of practice.

The authors recognize the limitations of the traditional professional education sequence. "Pre-service teachers learn to apply theory to clear-cut problems. Most real-life situations, however, are complex" (p. 83). While these complex puzzles of actual practice benefit from the reflective processes of reframing and making the tacit explicit, the authors contend that the traditional teaching practicum will not provide sufficient time. Based on the results of their study, they recommend four features for an effective program:

1. Reflection should begin in methods courses;

2. Collaborative reflection should be initiated during coursework;

3. Practicum experiences should begin with an observation/reflection phase blending into a teaching/reflection phase; and

4. Observation phase experiences should provide diverse milieu for developing knowledge of practice.

The reflective practicum was also significant in Eick and Dias's (2005) study of the content of pre-service teachers' reflection from an online discussion board. Their framework for reflection combines aspects of Schön's orientation to reflection and the deliberative orientation. Authentic puzzles of practice arising from personal experience formed the content of reflection, considered in collaboration. The authors assert that careful examination of the context of practice can facilitate the progress of pre-service teachers from consideration of purely technical concerns such as management or questioning, to more deliberative issues focusing on student learning and ethical aspects of schooling.

The co-teaching science classes examined in the study employed a structured inquiry curriculum that used technology-based kits and student/teacher guides on various topics. Structured inquiry consists of students engaging in many aspects of scientific inquiry while learning predetermined science concepts. Pre-service teachers began their experience in a peripheral manner, mostly observing and assisting the cooperating teacher. After a few weeks, more responsibility for teaching occurred. Dialogue about the pre-service teacher's lesson occurred later that day, typically addressing technical issues, but with a contextual perspective.

Reflective narratives were posted to an electronic bulletin board each week, relating to issues of interest or need encountered in co-teaching experiences. Each reflection concluded with a request for advice from the methods class community (pre-service teachers and the methods instructor). By not including the cooperating teacher in the electronic reflection forum, the instructors believed a more critical perspective on classroom issues could be achieved. Pre-service teachers were required to post a number of responses to colleagues, and the instructor also replied to each entry in a manner that focused more on the deliberative rather than the technical aspects of practice.

One development revealed in the study was the transition undergone by pre-service teachers from an "initiation to teaching" perspective to a more contextual view. Early reflections dwelt on technical issues of classroom management and teaching as trial-and-error. While reflections on practice continued in a technical mode, many pre-service teachers demonstrated an improved level of personal understanding towards their students. "They acquired an appreciation for the unique nature of their students

77

and felt positively about the challenge of reaching them, along with the excitement when they were successful with difficult individuals" (p. 480). Reflections evolved into an appreciation of the benefits of structured inquiry without concentrating on its difficulties.

In early reflections on issues and difficulties with teaching inquiry in the co-teaching classroom, pre-service teachers typically made connections to learning from coursework. Responses to problems contained references to ideas from content reading, special education, or methods courses. Early advice often took the form of random suggestions or decontextualized generalities.

Later, their reflective narratives and responses drew less from coursework and more from the experience of co-teaching. Suggestions now consisted of strategies employed by their cooperating teacher or the participants themselves, specific to the context of their own classrooms. Eventually, the focus of their reflection shifted from descriptions of what occurred in the classroom to analysis of how their thinking and experience guided their decision-making. Online discussions transformed from an advice forum to a communal dialogue about the dilemmas of getting to know students, understand student difficulties, and the nature and goals of inquiry.

The authors posit the use of the electronic discussion board as a vehicle for pre-service teachers to make thinking explicit. By experiencing successful modeling of the use of structured inquiry, these pre-service teachers were able to gain competence in their own technical abilities, enabling them to integrate formal learning from coursework with their experiences in the classroom. Practical knowledge, characterized by understanding of learners, developed as pre-service teachers began to examine issues from their own perspective of practice. "Data from this study allude to this tacit

dimension of teaching that methods students articulated through reflections on knowing

their challenging students and successfully working with them" (p. 485). The pre-service

teachers' development of a positive attitude regarding structured inquiry was facilitated

by the co-teaching situation, where they could gain technical proficiency and begin to

develop practical knowledge. The authors also assert that sharing practical knowledge

through the electronic discussion board was a vital aspect of the practicum.

Echoing the recommendations of Roychoudhury, Roth, and Ebbing (1993), the

authors call for extensive practicum experience to develop practical knowledge,

particularly with respect to the use of inquiry in science education. They acknowledge

the value of program coursework in providing a foundation for teacher knowledge, but

warn of the inadequacy of formal learning alone. "Even with a modicum of technical

competency, beginning science teachers will have less chance of success in

implementing inquiry without the practical knowledge of understanding students and

how best to teach and manage them" (p. 486).

Deliberative Reflection

Deliberative reflection emphasizes the development of effective instructional

decision-making through consideration of multiple sources of information. Reflection is

stimulated through some encounter with curriculum, learners, teachers (including the

self), and the context of schooling. Teachers' decision making is frequently the content

of reflection.

The challenges of implementing inquiry in science classrooms provided the

content of pre-service teachers' reflection in the study by Melville, Fazio, Bartley, and

Jones (2008). The authors posit opportunity for reflection as an essential aspect of the

development of positive attitudes in pre-service teachers regarding inquiry. LaBoskey's

(1994) framework for reflection was adopted for analysis of data in the study. This framework includes the components of content; process; attitudes of open-mindedness, responsibility, and wholeheartedness; and the context of reflection. Pre-service secondary science teachers in the study were classified, on the basis of their inquiry experiences, into the categories of limited, moderate, or extensive. Questionnaires and semi-structured interviews led to a narrative analysis strategy.

The authors found differences in the content of pre-service teachers' reflections based on their level of inquiry experience. With extensive inquiry experience, the group focused their reflections on guiding the development of students during the processes of scientific inquire. While pre-service teachers in the moderate experience group were supportive of inquiry, they expressed anxiety about a number of aspects, such as the "fit" of inquiry into the curriculum. The limited experience cohort, having no familiarity with scientific inquiry in either education or employment, emphasized various implementation difficulties with inquiry, such as time, curriculum, and materials. This group also anticipated the reactions of students, parents, and colleagues as impediments to inquiry. The authors contend that these perceptions are "a manifestation of the science education that these pre-service teachers have themselves received" (p. 485).

The authors characterize the process of reflection as an iterative operation of problem definition and deliberation on alternatives. Requisite for this process is an appropriate knowledge base, enabling consideration of multiple perspectives and implications of decisions, indicating a deliberative orientation to reflection. The extensive inquiry cohort demonstrated a substantial change in perceptions, questioning both their

80

own beliefs about science, and their ideas about how to actualize those beliefs in the classroom. Some members of the moderate experience group, while struggling with typical inquiry issues of time and curriculum, approached these issues by deliberately examining issue definitions and considering alternative solutions. The authors assert these modes constitute the capacity of the pre-service teachers to engage in the process of reflection. This capacity was not demonstrated by the members of the limited inquiry cohort, who failed to engage in this process of questioning, problem setting, and examining multiple viewpoints.

The extensive inquiry experience group displayed the attitudes of open-mindedness, responsibility, and wholeheartedness most clearly, expressing both a willingness to implement inquiry and dedication to the value of inquiry in their classrooms. Even though the attitudes of pre-service teachers about inquiry were brought into question by their experiences in schools, "their response was to persevere with inquiry in their placements" (p. 488). The members of the moderate experience cohort were more limited in their attitudes, expressing some concerns about implementing inquiry. The limited experience group did not question the lack of attention to inquiry that they witnessed in schools. They did not demonstrate any personal responsibility for teaching inquiry, instead associating the problems of inquiry with the reactions of students, teachers, parents, and schools.

Pre-service teachers in both the extensive and moderate inquiry experience groups described the importance of dialogue and reflection with colleagues in the schools and in the larger science education community. They expressed a sincere interest in connecting with science teachers in other schools, science education faculty,

and informal science groups. The authors assert this view of engagement with colleagues represents an important aspect of the context of reflection. They noted the reluctance of the limited experience cohort to collaborate on issues of inquiry in the classroom, and for some members, an outright rejection of inquiry in their practice.

The authors make a strong case for the interrelationship of inquiry experiences and opportunities for reflection. They note, "Knowledge and experience with inquiry appears to be crucial in providing the content for pre-service teachers' reflections. Without content, the process and attitudes of reflection are undermined – and the capacity of pre-service teachers to reflect – appears compromised" (p. 490). They identify two implications for science education research. First, they recognize that extensive subject matter coursework in the absence of inquiry experiences does not facilitate any problematizing of pre-service teachers' beliefs about teaching and learning science. Second, they note the absence of any objective method of quantifying and situating those previous inquiry experiences.

Yoon and Kim (2010) studied the collaborative reflection of five pre-service teachers, one in-service teacher, and one teacher educator stimulated by dilemmas of science practical work. Practical work included hands-on activities, experiments, and demonstrations, and the authors recommended explicit opportunities for science teachers to examine the role of practical work in teaching and learning science.

As in other studies examined in this review, components of reflection spanned different orientations in Yoon and Kim's program. The authors' discussion of reflection reveals the influences both of Schön and deliberative approaches. The use of dilemmas of practical work as the stimulus for reflection is characteristic of Schön's notion of a

puzzle of practice. They state the outcome of reflection as teachers becoming "transformative practitioners who can critically question, think, contextualize, and reform their understandings and practice" (p. 284), a view consistent with Schön's goal of the development of practical knowledge. They also call for the development of a "more connected, supportive community of elementary science education" focusing on "consideration of issues involving elementary science teaching from diverse perspectives" (p. 300), goals of a deliberative orientation. The components of content and process also extend across these two orientations.

To examine the content of reflection, the researchers engaged teachers in writing dilemma cases. Guidelines for writing the dilemma cases encouraged reflection on personal background and experiences, learning goals and conflicts. The most challenging situations and the decision-making about the situations was the content of reflection in these cases, which were uploaded to a class webpage to be shared with the other participants. During two group discussions, participants presented their dilemma cases, considering which case was most problematic.

The first set of findings from the study addressed the dilemmas of teaching practical work. Pre-service teachers tended to reflect on their own teaching performance (LaBoskey 1994), while the in-service teacher and teacher educator reflected more on interactions with learners. Pre-service teachers conveyed disappointment with the lack of institutional support for practical work, citing laboratory conditions and materials as hindering their efforts. Their reflections also revealed a tension between student engagement in laboratory activities and student safety, which they agreed was the most difficult dilemma, as communicated by this pre-service teacher: "Practical work is

difficult to get students focused and its success is not guaranteed. It threatens students' safety. So we . . . prefer alternatives . . . But, teachers' demonstrations will also bore students . . . Nothing's easy" (p. 292). The in-service teacher identified a different dilemma dealing with students' lack of interest and motivation, noting, "students' attitudes seem inert and dull" (p. 292). The teacher educator's reflections focused on the interactions between teacher and students, particularly the routine nature of practical work. "Students rarely question why and what they are doing, and teachers seldom provide students with questions and time to think. Their bodies are busy doing but their thinking minds are not engaged" (p. 292).

The second set of findings concentrated on aspects of the collaborative reflection process. Through the sequences of sharing and discussion, pre-service teachers' perceptions of success in practical work evolved. "Our focus was on whether or not we could succeed [sic] experiments, not much on students' learning. . . . But I realized that we looked at lessons with a narrow perspective. We could have had more interaction and discussion" (p. 294). Discussion in the first session concerned the definition of and techniques for effective practical work. The content of the second reflective discussion moved to a more deliberative level focusing on the topic of inquiry learning. The pre-service teachers struggled to construct a workable meaning of inquiry learning. Different perspectives from the in-service teacher who emphasized teacher mastery of science process skills and the teacher educator who communicated a more holistic vision of inquiry provided opportunities for reframing of the problem. "Their ideas were opened up and narrowed down to develop feasible ways of scientific inquiry on their own" (p. 296).

Some aspects of the discussion resembled Schön's "Hall of Mirrors" process of reflection, where the coach and learner trade roles, learning from each other:

> Inservice teacher and teacher educators' ideas stimulated pre-service teachers to think about their own views in different ways. The in-service teacher also had a chance to reflect his own teaching during discussion and questioned how to improve his inquiry teaching for all students. The teacher educator learned from pre-service and in-service teachers' difficulties and perspectives on inquiry through practical work to debrief her own teaching. (p. 296).

The researchers identified two major constraints to collaborative reflection. They detected among pre-service teachers the belief that the purpose of the discussions was to arrive at a singular solution to the dilemma under consideration. The researchers also noted issues of authority in the community, with pre-service teachers attributing greater authority to the in-service teacher and the statements of the teacher educator during discussions. The authors caution that teacher educators need to devote attention to issues of power and authority in collaborative reflection, recommending the study of the dynamics of group interaction as a significant area of further research.

Personalistic Reflection

The hallmark of the personalistic orientation to reflection is an emphasis on personal growth. The content of reflection in this orientation focuses on an examination of one's own ideas and beliefs, often through autobiographical exercises.

Rosenthal (1991) presented a rationale for a reflective approach in an elementary science methods course that draws from research on the importance of pre-service teachers' negative attitudes about teaching science. This rationale emphasized reflection as enhancing self-learning, reducing anxiety about teaching science, transforming attitudes about teaching and learning science, and offsetting views of science as elitist and unrelated to students' lives. Rosenthal's focus on growth through

examination of personal beliefs is representative of a personalistic orientation to reflection.

Rosenthal describes a series of reflective strategies to enable the process of reflection in an exploratory way in a science methods course. These activities include science education autobiographies, critical incidents (Griffin, 2003), reaction papers on provocative journal articles, and journals. Her descriptions of many of these activities center on pre-service teachers' personal attitudes and beliefs about science teaching:

> Encourage them to describe the feelings they recall in connection with their science education. . . . Ask students to reflect on their science education and identify the one best and worst experiences they can recall. . . . Ask them to imagine a classroom in which they feel comfortable teaching science (p. 4).

While most proponents of reflection advocate for an infusion of the construct in a holistic manner throughout a teacher education program (Houston, & Clift, 1990; Korthagen & Kessels, 1999; Nagle, 2009; Yost, Senter, & Forlenza-Bailey, 2000; Zeichner & Liston, 1987), Rosenthal suggests a more discrete approach: "instructors who want to experiment with the reflective approach need not change their curriculum; the only change needed is to introduce reflective activities" (p. 3). She does caution that time for reflection is the most problematic aspect of implementing reflective activities, so science educators need to make conscious decisions about their curricular choices.

Abell and Bryan (1997) present an explicit case for reflection as an orientation to science teacher education. They describe orientations to teaching as using a teacher's knowledge and beliefs about the purposes for teaching to guide decisions about instruction. Different orientations are distinguished by goals, characteristics of instruction, and perspectives on subject matter. The authors note that science methods courses are frequently characterized by content addressed, such as misconceptions,

practical work, and assessment. Development of science process skills (Rezba, Sprague, McDonough, & Matkins, 2008) and scientific inquiry (Britner & Finson, 2005) are other orientations in methods courses. The authors propose a reflection orientation for learning to teach science as analogous to the process of science itself, involving reconsidering and reforming one's theories based on new evidence. In this personalistic approach to reflection, pre-service teachers identify and describe the attitudes, beliefs, and ideas that they have about science teaching and learning. Reflection on these notions is stimulated by experiences in different learning contexts that engage pre-service teachers in confronting and revising their personal theories.

Their design for the elementary science methods course is unique in how the stimulus for reflection is introduced. The most typical stimulus for reflection is a field-based experience in a school, where pre-service teachers observe the planning and instruction of science teachers or engage in their own teaching on a limited basis (Mackinster, Barab, Harwood, & Andersen, 2006; Yerrick & Hoving, 2003). Other stimuli involve inquiry experiences (Blanchard, Southerland, & Granger, 2009) or viewing videotapes of exemplary science teaching (Yung, Wong, Cheng, Hui, & Hodson, 2007). Abell and Bryan present four separate stimuli for reflection: the teaching of others via media cases of conceptual change science teaching; one's own teaching via field experiences; expert opinions via course readings, and using themselves as science learners via involvement in science learning activities. While these four stimuli are presented as separate opportunities for reflection, the authors assert, "it is only by weaving all four components together that we create an integrated fabric for helping pre-service elementary teachers become reflective teachers of science" (p. 155).

The videocase stimulus focused pre-service teachers on articulating their own personal theories of science teaching and comparing them to the teaching observed in the specific videocases. The purpose of this exercise was to enable pre-service teachers to interact with their attitudes, beliefs, and ideas as the content of reflection, and to recognize alternative theories of practice from the teachers in the videocases. Reflective processes of autobiography, such as personal learning histories, and visions of themselves as science teachers, facilitated their thinking. From these early reflections, the authors found pre-service teachers held the ideas that science was difficult, and first-grade students were only capable of learning the most basic concepts. After viewing and reflecting on one videocase, Seeds and Eggs, these personal theories were reconsidered, as illustrated by this pre-service teacher's reflection:

> My expectations for a first grade science lesson have really changed after viewing the seeds and eggs lesson. The first graders are able to handle hands-on a lot better than I thought they would. I thought the teacher would mainly do all of the talking and experimenting. I saw these students, even though they are young, being able to conduct and observe experiments on their own. (p. 159).

The field-based stimulus consisted of several teaching experiences, including team teaching with the cooperating teacher and developing and delivering a short conceptual change unit. Pre-service teachers engaged in anticipatory reflection prior to teaching their own lessons, responding to prompts about their expectations, predictions, and concerns. After teaching, the content of reflection again focused on the development of their own ideas about teaching and learning science. The authors found these experiences caused pre-service teachers to rethink their visions of themselves as science teachers. These initial visions typically emerged as reactions to personal experiences of learning science in a didactic, information-oriented manner. Pre-service

teachers often reject this approach in favor of engaging learners in enjoying science, with methods that are described as "hands-on," "discovery," and "active." Again, these early notions are perturbed by the reflective stimulus of the field experience, and tensions develop between this ideal vision and the reality of classroom practice. The authors posit these puzzles as appropriate and necessary for meaningful reflection, drawing from Dewey (1933). "As long as our activity glides smoothly along from one thing to another, or as long as we permit our imagination to entertain fancies at pleasure, there is no call for reflection" (p. 122).

Course readings and class discussions functioned as the third stimulus for reflection on pre-service teachers' maturing personal theories. "When students are assigned a course reading, they are also asked to write about what they read in order to fit the reading into their ever-evolving system of ideas, beliefs, and values" (p. 162). Pre- and post-reading strategies focused on relating issues examined in the reading to what they encountered in the videocases and field experiences. The authors assert that this approach presents science education researchers as only one of many sources of influence on personal theory development. One reading that occurred at the same time as the Seeds and Eggs videocase and early field observations concerned developmental characteristics and age appropriate science activities. Pre-service teachers compared theory from the article with examples of effective teaching and actual classroom contexts, realizing "that general characteristics cannot be applied directly to individual children and that the teacher has an important role to play in judging developmental appropriateness" (p. 162).

The fourth stimulus of "self as science learner" placed pre-service teachers in a position of empathy with the students they will teach. The authors described the range of emotions experienced by methods students involved in a study of the phases of the moon. "They feel frustrated when they fail to see the moon for days on end, elated when a sighting is finally made, and perplexed by the patterns they see" (p. 163). In their struggle to understand moon phases, pre-service teachers reevaluated science learning experiences that did not result in constructing understanding. Once again, the content of reflection is their changing theories of science teaching.

Abell and Bryan recommend these stimuli to science educators as ways to understand and perturb the thinking of pre-service science teachers. They state this process of personal growth, through articulating and reevaluating personal theories, is a primary outcome of a reflective approach to teacher education, noting that "becoming a reflective science teacher is a lifelong journey" (p. 165).

Van Zee and Roberts (2001) focused on pre-service science teachers' positive science learning experiences as the content of reflection. Van Zee, the instructor of an elementary science methods course, engaged her students, of which Roberts was one, in "pedagogical inquiries," explorations of teaching and learning issues. Themes revealed in these inquiries became the basis for learning in the course and in pre-service teachers' development of a personal framework for science teaching. The focus on personal narrative and learning history reveals a personalistic orientation to reflection.

The use of positive experiences as content for reflection draws from research on learners' intuitive knowledge (Minstrell, 1993; Smith, diSessa, & Roschelle, 1993/1994).

One purpose of the study involved examining what the long-term effects of reflections were on positive science learning experiences in the development of practice. Van Zee deliberately approached the course design with an emphasis on minimizing the negative experiences of many elementary education majors. "I believed there must be some contexts within which the prospective teachers had learned science and had enjoyed the experience" (p. 738). She used an adaptation of the "draw-a-scientist" activity (Chambers, 1983; Mead & Metraux, 1957) to elicit pre-service teachers' positive science learning experiences. They were asked to draw pictures of these experiences, write captions for the pictures, and identify factors that cultivated learning. Class members generated a list of common themes across all experiences, which the instructor used to make connections to science policy documents, texts, and science education literature.

In reflective journals throughout the semester, pre-service teachers continued this kind of thinking with descriptions of science learning situations and analysis of the factors that contributed to learning in those situations. At the conclusion of the course, pre-service teachers analyzed their own journals for common themes, to develop their personal frameworks for science teaching, which were then articulated in lesson plans.

The positive approach to reflection explicit in the methods course carried through into Roberts' own professional practice: "a reflective practitioner is someone who has a question about something positive that's occurring in the classroom and researches and reflects on that question to better understand one's teaching practice" (p. 749). This view of positive situations as the content of reflection is atypical in the literature on reflection. While both Dewey (1933) and Schön (1983, 1987) identify reflection as

focusing on problems, puzzles, difficulties, requiring consideration of "what is wrong and in what directions the situation needs to be changed" (Schön, 1983, p. 40), van Zee and Roberts assert episodes of success can serve as effective puzzles for reflection. While the authors acknowledge the bias in an intentional focus on only positive science learning experiences, they contend this attention is important in alleviating the apprehension pre-service teachers have about teaching science.

Wallace & Oliver (2003) studied the content of pre-service secondary science teachers' reflection in journals, as stimulated by experiences in a school-based science methods course prior to student teaching. The authors support the notion that pre-service science teachers enter professional education courses with a carefully structured system of attitudes, beliefs, and understandings about teaching and learning science, and these "personal practical theories" exert a strong influence on their instructional decisions (Sweeney, Bula, & Cornett, 2001). They further assert the need to provide experiences that enable pre-service teachers to make these personal beliefs public, so they may be interpreted in a meaningful way. As teacher educators become aware of their own students' belief systems, learning experiences can be structured to fit with learners needs. The authors adopted the recommendation for the use of personal narratives and life histories (Carter & Doyle, 1996) as a way to identify and interpret pre-service teachers' beliefs. This extensive attention to personal beliefs is indicative of a personalistic orientation to reflection.

The authors describe four categories of reflection: technical, personal, problematic, and emancipatory. Their definitions of the technical, problematic, and emancipatory categories correspond to van Manen's (1977) stages of technical,

practical, and critical, and the personal to Valli's (1997) personalistic type of reflection. They acknowledge the importance of all of these categories, but suggest, "the sequencing of these categories represents relatively more and more sophisticated thinking about science education. . . . they represent a progression towards the use of reflection for framing and solving problems" (p. 163).

The authors found that the content of the journal entries did have some variety, but were typically focused on the teaching habits of the mentor teachers and the pre-service teachers' own teaching styles. Only one of the four pre-service teachers did not reflect on his mentor teacher's teaching, but did focus extensively on his own planning and instruction, and that of his peers. Four of the eight pre-service teachers reflected on their students' natures and their learning styles. "When these pre-service teachers did reflect on students and student learning, they indicated superior insight into their own growth in knowledge of students" (p. 167).

The interests displayed in pre-service teachers' reflections changed throughout the experience, from an initial technical emphasis, to greater attention to personal, problematic, and emancipatory issues. The authors suggest reflection in these more complex categories resulted when pre-service teachers examined their own teaching, rather than their mentor teachers. A different group of pre-service teachers also began reflection on technical interests, but included some personal and problematic elements. This group quickly discarded technical concerns and focused more specifically on the problematic and even emancipatory issues. The authors also found the cognitive level represented in the journals changed throughout the experience. Writing was coded into three levels, reporting, analysis/synthesis, and evaluation. The writing of pre-service

teachers who began with a high level of reporting developed into a blend of reporting, analysis/synthesis, and some evaluation. Those whose initial writing contained small amounts of reporting moved quickly to the higher levels. The authors categorized the deepest reflection as that which analyzed specific interactions with high school students or new concepts from the methods course.

Wallace and Oliver propose journaling as an effective vehicle for pre-service teachers to explore their science teacher identity. The matrix of teacher knowledge, affect, and action connecting with aspects of practice, provided guidance in writing, and "seemed to be effective in promoting both reflection and change" (p. 171). The authors suggest that explicit instruction in different reflection interests (technical, personal, problematic, and emancipatory) could better enable pre-service teachers to deliberate at higher levels.

Critical Reflection

The science teacher educator program studied by Yerrick and Hoving (2003) contains personalistic and critical features. The program placed pre-service science teachers in a field-based secondary methods course working with rural Black students in lower track classes. The authors used interviews, journals, focus groups, and teaching episodes as data sources to investigate the beliefs of pre-service teachers, resulting in three themes: focus on teaching and evaluations; beliefs about good science teaching; and experiences and sources of pre-service teacher knowledge.

The authors drew from research on the role of pre-service teachers' attitudes and beliefs in the development of knowledge of practice (Feiman-Nemser et al, 1989; Lortie, 1975; Richardson, 1996). They acknowledge that without a broad perspective beyond their own learning, pre-service teachers are "armed only with their egocentric

interpretation and a singular vantage point to view the problem at hand . . . [they]

believe what they are able to see (from a few bright students) and see only what they

choose to believe in advance" (p. 393). The authors advance critical reflection as an

essential element in fostering alternative views of science teaching.

The researchers' description of the field experience as a stimulus for reflection

comprises aspects of both personalistic and critical orientations, as revealed by these

course design considerations:

> In designing field experiences, we asked ourselves, 'What are important
> components of a field experience that perturbs individual beliefs, enables
> reflection on historical experiences, and supports the construction of
> revised teacher knowledge? What kinds of experience can best equip
> novice teachers for their future roles and what kinds of education theory can
> best guide needed change in classrooms? (p. 395).

They took a purposeful strategy to address the propensity of middle-class White

teachers who have little experience with diversity to approach science teaching as a

value-free exercise. The authors caution that this tendency to teach as they were taught

(or best learned) does not acknowledge the promotion of inequality inherent in these

instructional choices. Rejecting an overemphasized technical approach to teacher

education, the authors adopted Zeichner and Liston's (1996) social reconstructionist

tradition, espousing an outcome of reflection focusing on issues such as the ingrained

racial inequity in local schools.

Data analysis produced two categories of pre-service teachers: producers, whose

reflections indicated meaningful consideration and revision of their own personal

theories of science teaching; and reproducers, whose reflections indicated open

resistance to change in their personal theories. The authors characterized the goals of

95

the second group "as a desire to reproduce their own high school science experiences" (p. 399).

Pre-service teachers from both categories tended to reflect on their early lessons from an egocentric perspective, addressing teaching effectiveness from the basis of their own science learning experiences. This unproblematic approach to lesson design was evident in this pre-service teacher's response when asked how she determined the importance of the lesson content: "Well, I didn't. I need like a standard course of study or a curriculum to tell me what is important" (p. 401). The effectiveness of these first lessons was determined by assessing personal behaviors and appearance, such as walking around the room or mumbling.

The authors found the reproducers structured their instructional decisions based on a transmission model of science learning. Even though the value of recipe-type lab activities was strongly criticized in assigned methods course readings and class discussions, reproducers showed preference for teacher-centered instruction and rigidly structured verification labs throughout the semester. This group continued to focus the content of their reflections on their own performance, rarely referring to students. One pre-service teacher's journal contained fifty-seven references to herself and only seven references to students. The authors characterized the attitudes about inquiry of such reproducers as insincere. "Students were able to profess one set of beliefs while their practices demonstrated quite another. . . . they would not really be able to teach that way because it would be too time-consuming or too risky with certain populations" (p. 405). This group of pre-service teachers also attributed instructional difficulties to student ability or attitudes. Their observations of students were highly judgmental,

associating their need for strict management procedures with "undisciplined" or "lazy" students.

The interaction with lower track students as a stimulus for reflection achieved a different outcome with the producers. This group deliberated on changes to their personal theories of science teaching and learning, viewing themselves as learners of a new realm of practical knowledge. The value of reflection is apparent in this pre-service teacher's description of a choice made in the midst of instruction:

> They're at that point of feeling uncomfortable, they're questioning, and I don't want them to lose that. So I didn't want to say, 'This is the answer.' I did that in my first lesson, and I felt rushed and felt like they're leaving and I thought, 'I have to tell them.' But in this one I had reflected on that and said, 'What's the point of telling them?', because if I want meaningful learning, telling them isn't going to do any good. (p. 408).

This group's focus in reflective journals and interviews shifted quickly away from personal actions to a concern for student learning. References to themselves were in relation to meeting the needs of their student. "I am worried about being able to find something that will connect their experience to the topic" (p. 409). Producers also considered larger issues relevant to schooling when analyzing difficulty encountered in lessons. One pre-service teacher problematized the difficulty of engaging diverse students as a function of their intelligence and "the many different experiences they bring into the classroom" (p. 411). While the reproducers viewed the source of their knowledge about teaching as residing in their subject area coursework, the producers valued the special methods course highly, questioning prior beliefs about learning. One producer clearly articulated this need for change:

> You know, they are teaching to the test. And I think that's what's wrong with teachers today. They teach like they've been taught, and what they've learned through being taught. I think it's important for them to look at their beliefs and see that they might need to be changed. (p. 412).

97

The authors posit their results as a vital outcome of pre-service teachers' reflection on their attitudes and beliefs about science teaching. They acknowledge the influence of the often naïve and egocentric understandings that pre-service teachers bring into their professional education programs, but also assert the need for experiences to perturb that knowledge and present alternatives. "Just as misconceptions about science interfere with students' understanding of science, misconceptions about teaching interfere with prospective teachers' understanding of what it means to teach and learn science" (p. 414).

Danielowich (2007) calls for a repositioning of reflection in teacher learning. He rejects the characterization of reflection as an individual cognitive tool for tracking any changes in teacher practice toward reform-oriented ideals. In his study of pre-service science teachers, he formulates reflection as an examination of the struggle between the teachers' own goals and practices as a source of change in practice.

He presents a heuristic that describes the range of complexity in van Manen's (1977) three levels of reflection (technical, interpretive, and critical) with their different functions in teacher deliberations (the relationship between means and ends of teaching, context of reflection, content of reflection, and outcomes of reflection) on their practice. Contrary to many researchers (Valli, 1997; van Manen, 1977; Larrivee, 2010), Danielowich does not suggest these three levels represent a developmental hierarchy. He notes how widely varying contexts may produce interconnections between the different levels and their functions, such as an apparent technical goal (raising test scores) enabling a less discernible critical goal (redressing social inequities). He instead asserts that the specific contexts of teachers' reflections must be carefully considered in

order to interpret how reflection influences practice. He cautions against the promotion of critical reflection as an end:

> When teacher educators directly encourage critical reflection outside actual school contexts or in isolation from the other two forms of reflection, they may unintentionally promote it as a predefined tool teachers carry into their classrooms to challenge oppressive conditions rather than as an intellectual endeavor where teachers help create, develop, and act on new knowledge about critical change in their own schools. (p. 632).

In his study of four practicing secondary science teachers, Danielowich examined how these teachers negotiated the conflicts between their own goals and practices. Using a descriptive case study approach, he focused on the process of reflection in which pre-service teachers first become aware of and then took action to come to terms with these conflicts. Despite his caveat regarding critical reflection, the orientation of the program he described contains some components of critical orientation. The content of reflection consisted of issues of reform, safe environments for learning, the role of the teacher, and consideration of the needs of all students. Interviews, group meetings, and observations comprised sources of data.

The study's findings support Danielowich's renouncement of reflection as a tool for guiding teaching toward reform-oriented practice. While the teachers in the study did move in their reflections from technical to more interpretive and critical forms, they did not address how these more complex goals could be enacted in practice. One of the teachers, Rachel, shifted her reflections' content from technical to more interpretive deliberations, but she did not enact those more student-centered practices. The author describes Rachel's failure to recognize this conflict. "Rachel was apparently not convinced that playing a facilitative teaching role was 'right' for her, even though she suggested that playing such as role might have been 'right' for her ELL students" (p.

99

647). Danielowich concludes that a mere shift in the level of reflection does not necessarily manifest a corresponding change in practice.

Another finding inconsistent with current frameworks for reflection involved how these teachers used reflection-in-action to modify practice. Reflection-in-action is that spontaneous recognition of moments of uncertainty in practice coupled with the ability of professionals to "improvise" or exploit these instances (Schön, 1983), and is asserted as a natural goal of retrospective reflection (Hatton & Smith, 1995, Korthagen & Kessels, 1999). Danielowich suggests that the teachers who displayed reflection-in-action were more likely to use those episodes as stimulus for future reflection and continue to problematize their goals for instruction. Iris and Steve, two other teachers in the study, did not recognize any instances of impromptu modifications of their lessons based on some surprise or puzzle, but their goals for instruction were more well-defined than those of Yvonne and Rachel, who did identify cases of reflection-in-action. Danielowich asserts that the explicit choice of reflection-in-action, driven by surprising or puzzling events in practice, is a stimulus for more complex and deliberate reflection-on-action, rather than the result of it.

Danielowich's third finding recognizes the role of the social context for reflection in the choices made by teachers about goals for their own learning. He noticed that the teachers who reflected in a more interpretive manner initially were more prominent in the group's interactions later. Danielowich acknowledges his own possible privileging of the teachers' discourse: "By asking the teachers to identify and teach toward interpretive goals at the start of the second phase, I may have unintentionally honored the reflections of Yvonne and Steve in the group meetings as more advanced and thus

100

more valuable" (p. 657). He recommends teacher educators recognize the effects of

their own choices as facilitators of the context of reflection.

Authors	Levels, Types, or Orientations				
Valli, 1997		Technical	Reflection-in and on- Action	Deliberative	Personalistic Critical
Wellington & Austin, 1996	Immediate	Technical		Deliberative	Dialectic Transpersonal
Van Manen, 1977		Technical Rationality		Practical Action	Critical Reflection

Development of reflectivity
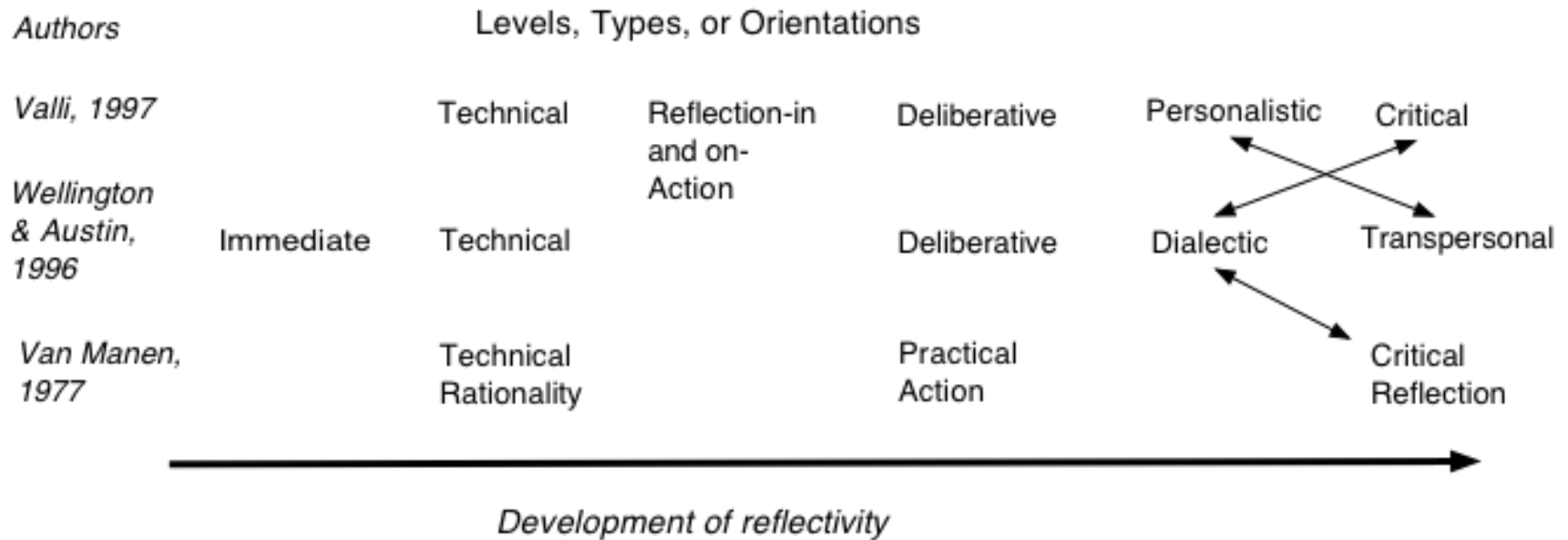
Figure 2-1. Development of reflectivity in different orientations

102

Table 2-1. Organization of literature on reflection in teacher education programs based on orientations to and components of reflection.

Component Orientation	Stimulus	Content	Process	Outcome
Technical	Episode of teaching performance (Cruickshank & Applegate, 1981; Freiberg & Waxman, 1990)	Own teaching behaviors derived from research; external authority structures; comparison to a list of competencies (Cruickshank & Applegate, 1981; Freiberg & Waxman, 1990)	Retrospective, individual or supervision in writing or oral; behaviorist techniques (Cruickshank & Applegate, 1981; Freiberg & Waxman, 1990)	Efficient instruction; faithful implementation of best practices (Freiberg & Waxman, 1990)
Reflection-in and on-action	Some problem present in practice (Wilson & l'Anson, 2006; Lee & Loughran, 2000)	Not specified	Retrospective (on-action) or contemporaneous (in-action); problem setting or reframing; making the tacit explicit; coaching relationship (Lee & Loughran, 2000; MacKinnon, 1987; Russell & Munby, 1991; Wood, 1991)	Professional artistry in practice; development of practical knowledge (Russell & Munby, 1991)
Deliberative	Interaction with any of Schwab's commonplaces (subject matter, students, teachers, milieu) (Zeichner & Liston, 1987)	Own decisions about instruction, curriculum, students, school, context; consideration of multiple sources of knowledge (Collier, 2010; Zeichner & Liston, 1987)	Anticipatory, retrospective; collaborative & social (Collier, 2010)	Relevant and meaningful student learning; effective communication; effective decision making & personal judgment (Zeichner & Liston, 1987)
Personalistic	Varying contexts	Own personal and professional beliefs, attitudes; self-development; internal source of knowledge (Griffin, 2003)	Introspective, individual, autobiographical, personal theorizing (Brown, 1999; Tann, 1993)	Personal development (Yinger, 1990)
Critical	Any situation in schooling (Dinkelman, 2000)	Schools as political structures; issues of power and injustice (Dinkelman, 2000)	Outwardly directed (Genor, 2005)	Political liberation; improving situation of disadvantaged (Dinkelman, 2000)
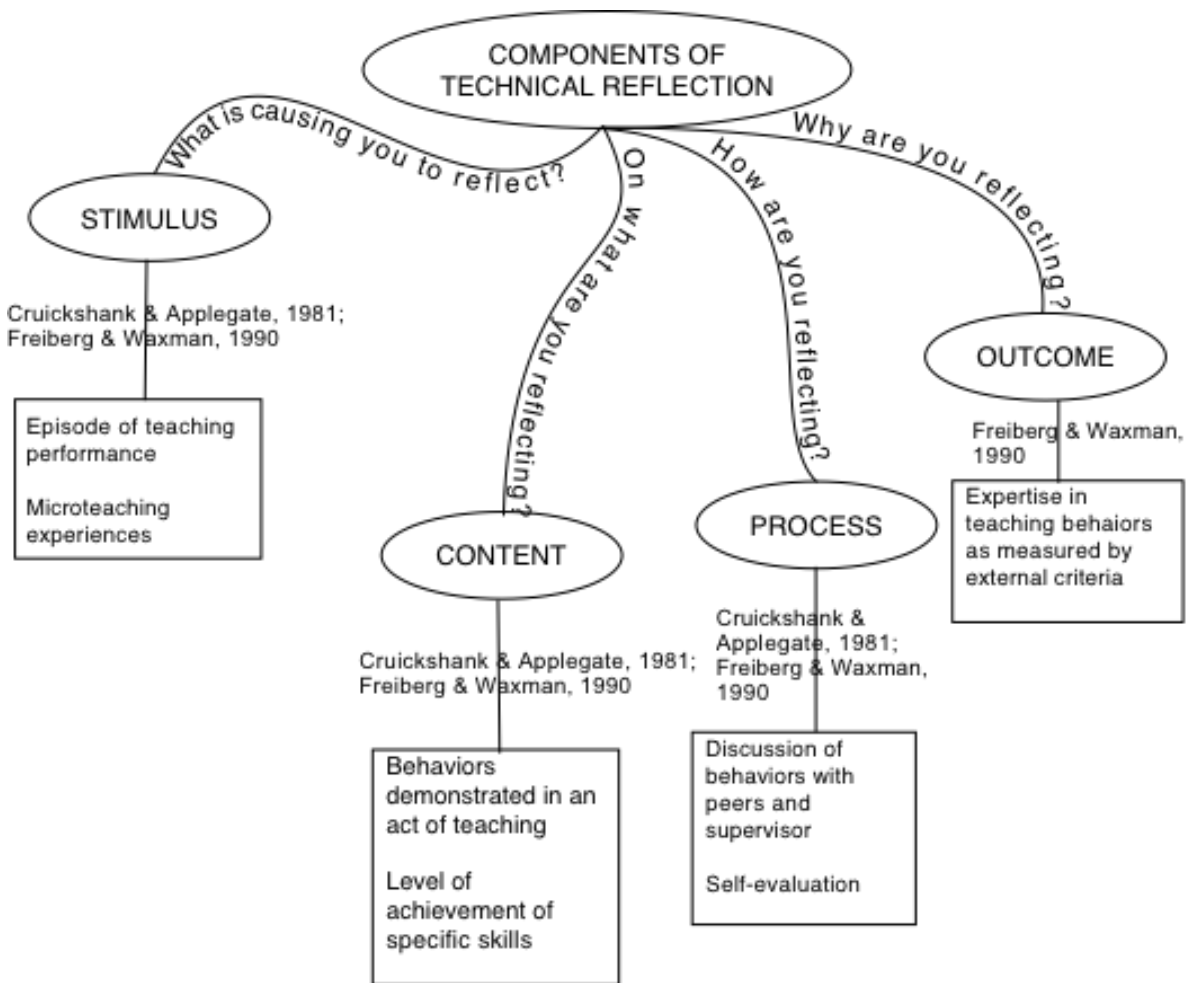
Figure 2-2. Components of technical reflection as operationalized in selected literature.

COMPONENTS OF
REFLECTION-IN AND
ON-ACTION

What is causing you to reflect?

On what are you reflecting?

How are you reflecting?

Why are you reflecting?

STIMULUS

Lee & Loughran, 2000;
Wilson & Anson, 2006

Reflective practicum

Wide range of
experience

Extended time of
experience

CONTENT

Lee & Loughran, 2000

Problems of
practice

Puzzling situations

PROCESS

Lee & Loughran, 2000;
MacKinnon, 1987;
Russell & Munby, 1991;
Wood, 1991

Cycle of framing,
reframing, and
resolution

Reframing through
shifts in descriptive
language

Coaching
relationship

OUTCOME

Russell & Munby,
1991

Development of
professional
knowledge

Figure 2-3. Components of reflection-in and on-action as operationalized in selected literature.
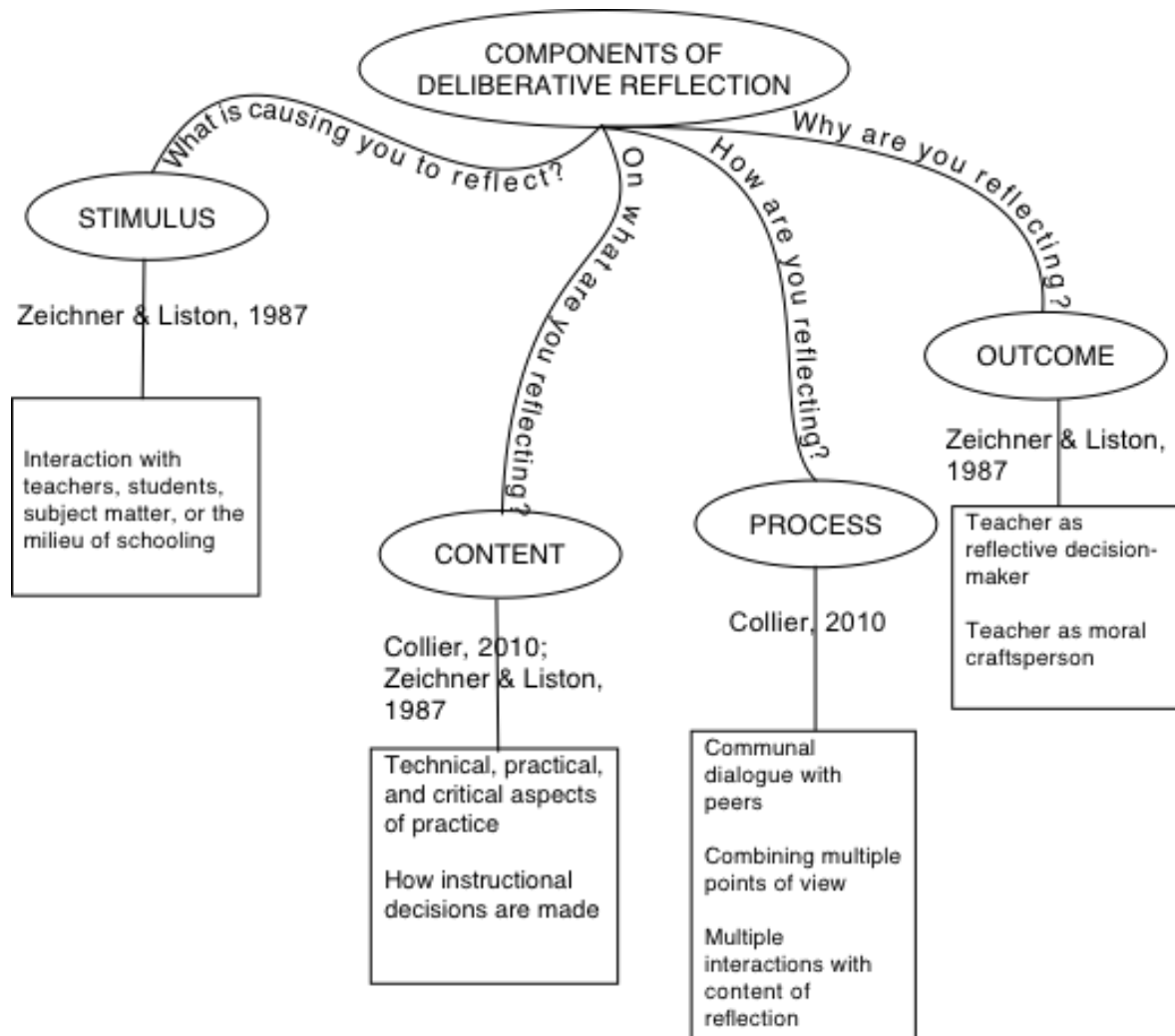
Figure 2-4. Components of deliberative reflection as operationalized in selected literature.

COMPONENTS OF PERSONALISTIC REFLECTION

What is causing you to reflect?

On what are you reflecting?

How are you reflecting?

Why are you reflecting?

STIMULUS

Some encounter with personal beliefs

CONTENT

Griffin, 2003

Influential aspects of teachers' lives

Personal attitudes, beliefs, emotions, knowledge

PROCESS

Brown, 1999; Tann, 1993

Analysis of critical incidents from one's own life

Autobiography

Narrative

Personal theorizing

OUTCOME

Yinger, 1990

Personal liberation

Personal image of teaching

Relationships

Figure 2-5. Components of personalistic reflection as operationalized in selected literature.
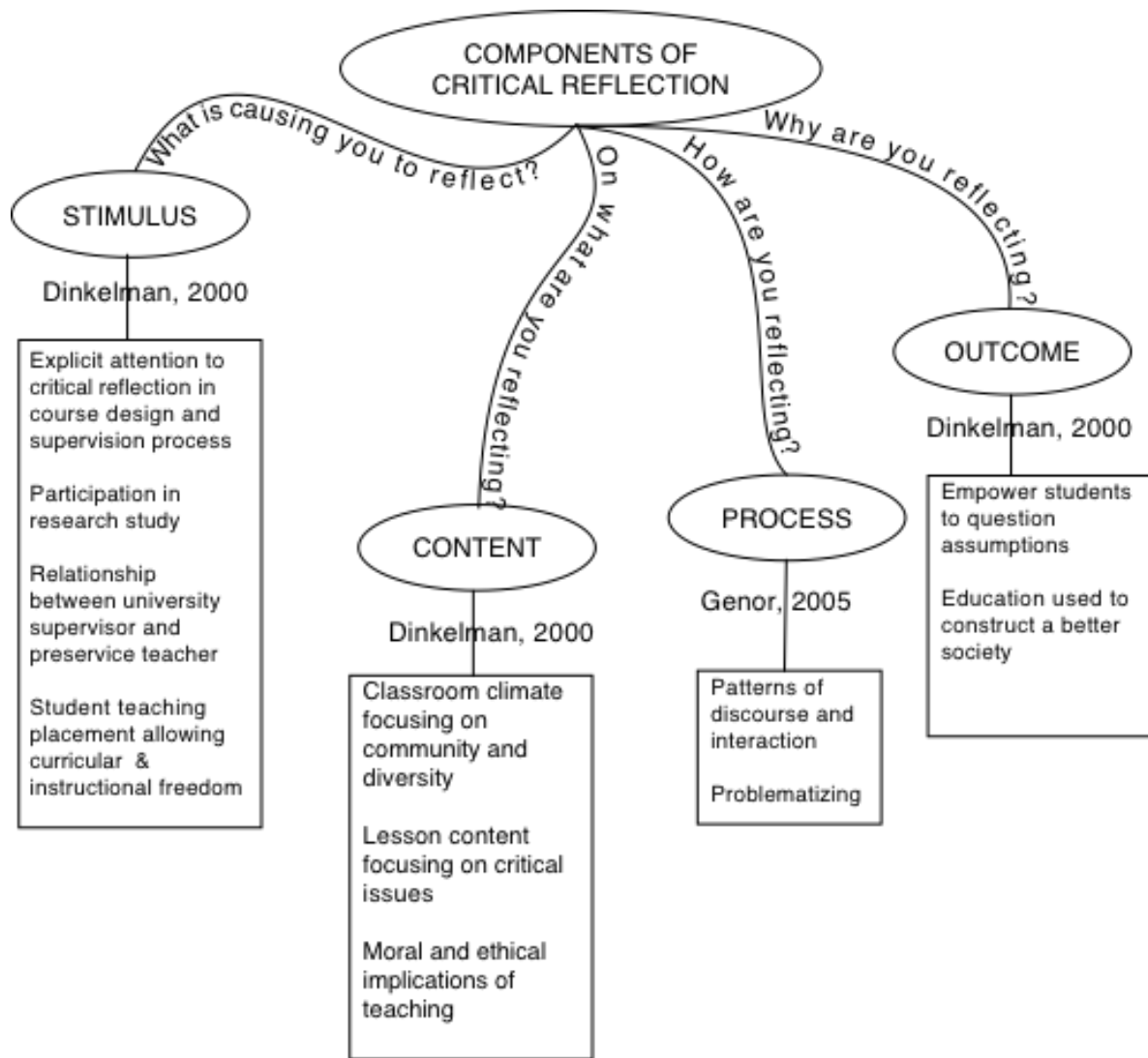
Figure 2-6. Components of critical reflection as operationalized in selected literature.

Table 2-2. Organization of science education literature based on orientations to and components of reflection.

Component Orientation	Stimulus	Content	Process	Outcome
Technical	Britner & Finson, 2005; Yung et al, 2007	Britner & Finson, 2005		
Reflection-in and on-Action	MacKinnon & Erickson, 1983; Yoon & Kim, 2010	Eick & Dias, 2005	MacKinnon & Erickson, 1983; Roychoudhury, Roth, & Ebbing 1993; Yoon & Kim, 2010	Yoon & Kim, 2010
Deliberative	Britner & Finson, 2005	Britner & Finson, 2005; Eick & Dias, 2005; Melville, et al, 2008; Yoon & Kim, 2010	Yoon & Kim, 2010	Yoon & Kim, 2010
Personalistic	Abell & Bryan, 1997; Wallace & Oliver, 2003; Yerrick & Hoving, 2003	Abell & Bryan, 1997; Rosenthal, 1991; Van Zee & Roberts, 2001; Wallace & Oliver, 2003; Yerrick & Hoving, 2003	Abell & Bryan, 1997	Abell & Bryan, 1997
Critical	Yerrick & Hoving, 2003	Yerrick & Hoving, 2003; Danielowich, 2007	Danielowich, 2007	Yerrick & Hoving, 2003

CHAPTER 3
METHODOLOGY

The purpose of this study was to explore and describe science teacher educators' conceptions of and intentions for the teaching of reflection in university-based science teacher education programs. In simpler terms, the inquiry examined the ideas about reflection that science teacher educators hold, and their plans for putting these ideas into practice when teaching pre-service secondary science teachers to reflect.

The teacher education community accepts at a nearly universal level the notion that effective professional practice should include reflection, but there is less agreement on how that construct is operationalized within teacher preparation programs. Reflection has been described variously in the literature as a skill in which to be trained (Cruickshank & Applegate, 1981), a disposition to be acquired (LaBoskey, 1994), a thinking process to be learned (Dewey, 1933), and integrations of these and more (Valli, 1997).

Opportunities for reflection include such activities as course readings (Abell & Bryan, 1997), student interactions (Genor, 2005), and instructional evaluations (Yung, Wong, Cheng, Hui, & Hodson, 2007). Ideas considered within reflection range from one's own performance of a specific task (Cruickshank & Applegate, 1981) to broad philosophical conceptions of teaching and learning (Yinger, 1990). The vehicles for recording reflection are similarly varied. The larger goal of this study was to capture this variety of interpretations through an examination of science teacher educators' definitions, goals and plans related to the development of reflection by pre-service teachers.

In this chapter, the methodological framework for the study is presented, followed by the research design, including descriptions of the phases of the inquiry, sampling strategy, data collection and analysis, and procedures for establishing trustworthiness. The chapter concludes with a subjectivity statement and summary. This research design reflects Lincoln and Guba's (1985) elements of a naturalistic inquiry.

Methodological Framework

A constructivist orientation to knowledge is highly relevant to a study of reflection. Ernst von Glasersfeld's (1989) view of constructivism asserts that (1) knowledge is not passively received, but rather is actively constructed by individuals; and (2) knowledge is used to make sense of the world of experience, not to discover reality. Knowledge consists of those ideas that "make sense" of the world, consistent with the experiences of the individual. Since individuals construct their own understanding of the world, constructivism denies the existence of an independent objective reality. In this paradigm, learning takes place not through the transmission of information from an expert to a novice, but through a construction of explanations "in the head" of a learner. Key to this construction is a collection of experiences that interact with existing ideas. New experiences can be integrated into existing patterns of understanding through the process of assimilation. If new ideas cannot be assimilated into an existing framework, then a new framework must be constructed into which the new ideas make sense, a process known as accommodation.

This constructivist orientation is compatible with a naturalistic approach to research. Lincoln and Guba (1985) describe the naturalistic paradigm by juxtaposing it with the positivist paradigm in five axioms. The first axiom contrasts the positivist notion of an objective reality, accessible through experimental methods of prediction and

111

control of variables, with the naturalistic assertion of multiple constructed realities to be examined holistically. While individuals may agree on common referents that provide some description of a construction, within those individuals different meanings and responses will reside.

The second axiom rejects the positivist assertion of the independence of the scientific observer and the phenomenon under observation. In the naturalistic paradigm, the inquirer and the inquired-about are intertwined. Just as Heisenberg postulated that the act of measuring a particle's momentum changed that measurement, so too does the naturalistic inquirer interact with what is being investigated.

The third axiom concerns generalizing the outcomes of the inquiry. In the positivist paradigm, research aims to generate statements that are universally true, unhindered by connection to specific time and context. Similarly inappropriate are those idiographic statements that are so uniquely context-bound that they have no utility in the field of study. The naturalistic view of generalization takes an intermediate position along this continuum, where a working hypothesis developed in the inquiry may be transferable from one context to another, based on the degree of similarity of the two contexts.

The fourth axiom rejects the positivist idea of causality in favor of the concept of mutual simultaneous shaping, in which "everything influences everything else" (p. 151).

The final axiom addresses the role of values in inquiry. Contrary to the positivist view of inquiry as value-free as a function of its objective methodology, inquiry in the naturalistic paradigm is value-bound due to the values of the inquirer, the guiding paradigm, the substantive theory, and the values inherent in the context of the study. These values may serve to either reinforce the inquiry or conflict with it.

While the naturalistic inquiry inherently avoids explicit identification of many typical aspects of design, certain elements of the design need to be considered. Descriptions of each of these elements in the context of the current study, including the alignment of the axioms of the naturalistic paradigm to this study, comprise the remainder of this chapter.

Focus of the Inquiry

This study focused on how science teacher educators conceptualize and plan to incorporate reflection in science teacher education. Lincoln and Guba (1985) describe a research problem as "something that is not understood or explained" (p. 226), with research serving to accumulate knowledge leading to understanding. Currently, the ability of science teacher educators to conceive the notion of reflection and intend their orientations to be implemented as specific activities and opportunities for pre-service secondary science teachers is not well understood. Teaching pre-service secondary science teachers to reflect is also not well described in science teacher education research. A detailed description of this phenomenon can guide the preparation of science teachers as reflective practitioners.

Based on this focus, these research questions were considered in this study:

1. What orientations to reflection do science teacher educators hold?

2. What influences have contributed to the development of these orientations?

3. How are science teacher educators' orientations to reflection manifested through components of reflection in the intended curriculum of secondary science teacher education programs?

4. How do science teacher educators perceive the constraints and limitations on the enactment of their intentions for the teaching of reflection?

I began the study with a tentative focus on these questions, and while there was some evolution to question 4 based on emerging understanding as data were collected and analyzed, the overall emphasis remained relevant. Based on the responses of participants, it was evident that constraints and limitations was a limiting characterization of the many external influences on how science educators intended to operationalize reflection. The adaptive nature of a naturalistic inquiry provided for this dynamic approach to the development of understanding of the research questions.

Naturalistic Fit

The naturalistic paradigm needs to be compatible with the research focus. This degree of "fit" can be determined by examining each of the axioms of the naturalistic paradigm with respect to the features of the present inquiry. This alignment is summarized in Table 3-1.

The first axiom concerns the question of how the reality of a phenomenon is represented. In the naturalistic paradigm, individuals construct reality; therefore no single reality exists to be discovered through research. Descriptions of reality are meaningful based on the connections they have to the everyday life of those individuals creating the descriptions. This orientation is particularly appropriate for the present study, since its purpose was to examine the many different ways in which reflection is defined and intended for implementation by various individual science teacher educators, not to arrive at a single meaning of the construct.

The second axiom relates to the interaction and influence between the inquirer and the object of inquiry. One aspect of this axiom concerns the impossibility of measuring a phenomenon with ultimate precision, referred to by Lincoln and Guba as "indeterminacy" (1985, p. 97). This means that this examination is not of the

phenomenon directly, but of the phenomenon's *response* to our methods of inquiry. Acknowledging this state of indeterminacy facilitates a collaborative approach to data collection, where "investigator and respondent together create the data of the research" (p. 100). The direction of data collection depends on what has been collected.

In this study, data sources consisted of responses from a web-based survey, interviews, and documents (see Data Sources section below). The survey served as a purposive sampling method for identifying those science teacher educators who articulate an intensive emphasis on reflection. The direction of interviews was informed by questions arising from survey responses and document examination. For example, one respondent supplied a description of the importance of context in providing experiences that stimulate reflection. This topic of context was then explored and elaborated on in the interview. This continuous unfolding of data collection is impossible without an acknowledgement and acceptance of the interaction between the inquirer and the inquired-upon.

Another facet of this axiom refers to the interdependence of facts and theory. Multiple theories may be derived from one set of facts, but facts are meaningful only within some theoretical framework. As Lincoln and Guba conclude, "one can have no facts without theory, and no conclusive theory without an infinite number of facts" (p. 101). The solution to this conundrum is for the researcher to exercise some degree of judgment upon the inquiry; to achieve a balance such that appropriate facts support the developing theory without specifying that theory so exclusively that it has no utility. This interaction between the inquirer and the inquiry facilitates the process of purposive sampling. In this study, it was critical to acknowledge the influence of the initial heuristic

describing the orientations to and components of reflection in teacher education. This construction, derived from careful examination of theoretical and research-based literature in the field, significantly informed the design of the inquiry. This influence being acknowledged, the heuristic was not a determinant, but rather one source of guidance when new information was encountered. I used the heuristic to develop initial semi-structured interview questions, but additional questions based on survey responses and document examination emerged. Lincoln and Guba note the advantages of these ongoing interactions are only possible because the instrument of research is a human being, capable of developing cooperative relationships with the respondents in the investigation.

The tension in the third axiom concerns the degree to which research findings are either bound to a unique context or context-free and generalizable. The naturalistic paradigm works to achieve a position between these two poles, aiming for the development of working hypotheses that describe individual cases. These working hypotheses indicate the degree of similarity between the context of the research and another context to which they could be transferred. It was not the purpose of this study to identify a singular "best practice" for reflection in science teacher education. Instead, the perspectives of science teacher educators who conceive reflection deliberately and intend their pre-service teachers to learn it explicitly were examined, to understand how reflection is defined and valued. It is also acknowledged that while there were some similarities among the situations of the science educators surveyed and interviewed, there were significant differences in the contexts of their work. Interviews and document

analyses enabled methodological triangulation (Lincoln & Guba, 1985), with three data

collection techniques contributing to the establishment of the credibility of the inquiry.

The fourth axiom addresses the need for the results of the inquiry to provide

explanations. While the naturalistic paradigm argues against positivist notions of

causality, the need to construct some understanding of the patterns of interactions

recognizes that events are influenced by other events. Mutual simultaneous shaping is

the construct that describes these interactions. What influences an outcome at one time

may be different from another time. Understanding of events and influences is not a

statement of causality, but rather one of plausibility. Since the inquiry was a descriptive

one, there was no need to establish causality in reflective practice. The interaction of

the commonplaces (Schwab, 1973) emerged as an important interpretive framework for

understanding the influences on the conceptions of reflection of the participants. The

broad nature of the study allowed for consideration of multiple influences on the

development of reflection.

The final axiom asserts the influence of values on the inquiry, including the values

of the inquirer, the investigation paradigm, the substantive theory guiding the research,

and the context. The extent to which these values reinforce each other is defined by

Lincoln and Guba as "value resonance" (p. 38), and will determine if results are

meaningful. My own personal values are highly consistent with the naturalistic paradigm

and a constructivist approach to knowledge. The investigation paradigm was a

naturalistic one, and the inquiry made use of data collection and analysis methods that

are congruent with that view. While no specific theory of reflection was employed in this

study, the two-dimensional heuristic (Table 1-1) describes and values multiple and

varied orientations to the construct. The context of the study was one of exploration and description, not evaluation. Decisions regarding the direction of data collection and analysis were influenced by these values, providing for value resonance.

Phases of the Inquiry

The phases of the inquiry consisted of purposive sampling of secondary science teacher educators through the use of a web-based survey, examination of course documents, semi-structured interviews, and follow-up interviews, culminating in the development of a set of information-rich cases. The sequence of phases is illustrated in Figure 3-1.

The web-based survey (Appendix A) was developed from examination of the theoretical and research literature on reflection, and from preliminary interviews of a small number of science teacher educators. From these guiding sources, key issues regarding reflection were identified. A variety of course and program documents were solicited and examined for emphases on reflection. By examining course documents such as course syllabi and assignment descriptions, decisions were made regarding specific texts that can be most useful in later stages of the inquiry. Analysis of these data sources, along with the heuristic describing the orientations to and components of reflection in teacher education, informed the development of questions for the web survey. An expert panel including science teacher educators and research methodologists reviewed the survey content and design, and the instrument and informed consent processes were approved by the University of Florida Institutional Review Board (Appendix B).

The first phase of the study was the administration of the web-based survey, designed for the wider audience of science teacher education faculty at regional

118

universities, as explained in the sampling section below. This survey served as a tool for selecting a purposive sample. The function of this sample was to identify those science teacher educators who articulated an explicit approach to the teaching of reflection with their pre-service secondary science teachers. These educators were selected for course document solicitation and interviews (see Sampling section below).

Documents were the first pieces of data solicited from participants, with solicitation occurring after all survey responses were received. Each document was analyzed as it was received, guiding the specific issues discussed in initial interviews, which occurred shortly after document review. Some participants were interviewed prior to the receipt of documents from other participants. Follow-up interviews clarified and elaborated on previous interviews.

Analysis of survey responses and course documents guided the semi-structured interviews conducted with science teacher educators. Issues and ideas stated in survey responses or documents such as syllabi informed interview questions. Interviews were conducted via the phone or Skype™ internet video application. Follow-up interviews allowed for continued clarification of interpretations, exploration of emerging topics, and member checking (see Trustworthiness section below).

Sampling

The paradigm of naturalistic inquiry calls for deliberate considerations of the sampling processes in a study. Lincoln and Guba (1985) recommend that plans for sampling should provide for (a) an identification of the initial elements of what is anticipated to be the final sample, (b) a process through which elements are logically and selected in an orderly fashion, (c) a continuous refinement of the sample based on the emerging salient aspects of the inquiry, and (d) an attention to termination of

sampling. Since the study is aligned with the naturalistic paradigm, sampling was completed with specific purposes in mind. At different stages of the inquiry, different sampling strategies were used, as summarized in Table 3-2.

When the web survey was implemented, the group of potential respondents was a criterion sample (Patton, 2002) of science educators. This sample consisted of science educators at institutions who satisfied two criteria: (a) the teacher education college, school, or department belonged to the Teacher Education Council of State Colleges and Universities (TECSCU), and (b) the teacher education program was accredited by the National Council for Accreditation of Teacher Education (NCATE). The sample was compiled from the membership lists of both organizations, available on their respective websites. These two criteria are highly relevant to the inquiry for several reasons. TECSCU members are not research-intensive universities where teacher education courses are taught by a number of different graduate students. TECSCU schools are regional institutions, publicly funded, and tend to have only one or two science education faculty members. These faculty members typically teach science methods courses and are heavily involved with the science teacher preparation program, including activities such as field supervision and program design and evaluation. TECSCU institutions account for approximately 70% of the teachers prepared in the United States (L. G. Daniels, personal communication, December 8, 2010).

Accreditation in NCATE involves documentation of compliance with six teacher education program standards. The first standard concerns pre-service teacher knowledge, skills, and dispositions, and contains extensive references to the

development of reflection. The third standard addresses field experience and clinical practice and also emphasizes reflection (NCATE, 2008).

These two criteria of TECSCU membership and NCATE accreditation provided a population of approximately 100 science education faculty members. From the criterion of NCATE accreditation, some emphasis on reflection should be present. From TECSCU membership, due to the nature of these institutions, science teacher education should be the responsibility of one or two faculty members. These programs should therefore manifest the vision and ideas of the science educators who respond to the survey.

Response rates from web-based surveys vary widely. In 2000 Cook, Heath, and Thompson conducted a meta-analysis of 49 electronic surveys and found a mean response rate of 39%. A more recent study comparing web-based and paper-based survey administration showed response rates of 52% for web surveys and 42% for mail surveys (Greenlaw & Brown-Welty, 2009). A comparison of web surveys with different pre-notification and follow-up modes produced a response rate of 76% (Converse, Wolfe, Huang, & Oswald, 2008). Given this lack of consensus on response rates, I initially estimated a conservative response rate of 30% for the web survey. I implemented the survey over a four-week timeframe and sent weekly reminders. Valid responses were received from 42 science educators.

Responses from this group of 42 science educators was carefully analyzed to provide a group of useful informants; persons who communicated "an 'inside' view of the norms, attitudes, constructions, processes, and culture" (Lincoln & Guba, 1985, p. 258) of their ideas about reflection.

The first section of the survey described the informed consent process. The second section collected information regarding the faculty member's years of experience and the characteristics of the secondary science education program. The third section identified the science teacher educator's familiarity with and role within the program, specifically addressing the degree of influence the faculty member has over the design of curriculum for the overall program and the science methods course. The fourth section asked the respondent to identify specific stimuli, content, process, and outcome components intended for implementation in the program. For each component, respondents were asked to elaborate on their approaches in free-response items. The final section provided informed consent for the document submission and interview portion of the study.

The process for selecting interviewees is illustrated in Figure 3-2. These survey responses comprise the first decision point:

1. NCATE report writers;
2. Methods course instructors;
3. Student teaching intern supervisors;
4. Top quartile of responses for "Degree of influence on program design;"
5. Top quartile of responses for "Degree of influence on methods course design."

Respondents who satisfied the majority of these five criteria were further considered through examination of responses to the questions addressing components of reflection.

A second layer of criteria identified informants for document solicitation and interviews:

- Respondents who indicated the use of more than three specific stimuli for reflection in the science methods course;

- Respondents who indicated the use of more than three specific content topics;

- Respondents who indicated the use of more than three specific processes for learning how to reflect;

- Respondents who provided elaborated responses to any of the component items.

Respondents who satisfied any of these four criteria (provided they agreed to submit documents and be interviewed) were solicited to participate in the document and interview phase of the study. Patton (2002) describes this mode as theory-based sampling, where participants are selected based on likely representation of theoretical constructs. Based on these criteria, documents were solicited from nineteen respondents.

The purpose of sampling this final group of science educators was to construct a set of information-rich cases that provide a vivid portrayal of science educators' conceptions of reflection. Given the criteria for document solicitation and interviews, selection of these participants took place after all surveys had been received. Lincoln and Guba (1985) describe the decision to terminate sampling as that which occurs at *redundancy,* that point at which no new information appears from newly sampled informants. Recognizing the need for some degree of pragmatism in naturalistic design, Patton (2002) recommends specifying a minimum sample that should provide "expected reasonable coverage of the phenomenon given the purpose of the study" (p. 246). After analysis of survey responses, nineteen respondents were solicited to provide course and program documents. From this group, eight science educators submitted documents, and six agreed to be interviewed.

Data Sources

Lincoln and Guba assert the "instrument of choice in naturalistic inquiry is the human" (1985, p. 236). One consequence of this characterization is the ability of the

instrumentation to improve as the study advances. One example of this capacity in the present inquiry is the refining of each data collection strategy, incorporating the constructions of respondents from previous data collection. Lincoln and Guba describe this process as the development of instrumentation that is "grounded in the data that the human instrument has produced" (p. 239), allowing unforeseen concepts and themes to emerge from the data, rather than employing instruments that function only on the basis of *a priori* theory. Additionally, while particular data collection and analyses may inform certain research questions, naturalistic inquiry aims to construct a "holistic portrayal" (Erlandson, Harris, Skipper, & Allen, 1993, p. 85) of the construct under investigation. While some data sources may contribute a larger proportion of meaning to various questions than others, this holistic portrayal is developed from multiple data sources rather than one data source exclusively informing one research question. Three forms of data collection were used in the inquiry: a web-based survey followed by documents and interviews.

The web-based survey provided 42 valid responses. Its purpose was to identify science teacher educators who articulated a clear conception of reflection and who conveyed explicit intentions for the teaching of reflection. The survey design used forced choice questions to recognize deliberate emphases on the different components of reflection, such as stimuli, content, and process. Other items focused on explicit orientations to reflection. Open-ended questions provided more nuanced information, such as clarification of specific selections. Survey data was used to identify useful informants for document solicitation and interviews.

Web Survey

While surveys are frequently considered as a quantitative source of data and therefore more aligned with a positivistic paradigm, Erlandson, Harris, Skipper, and Allen (1993) note the usefulness of "quantitative methods as a preliminary tool to obtain a quick picture of typical and atypical cases and a map of where the outliers may be found in order to facilitate further in-depth investigation" (p. 36). Quantitative measures such as surveys can be used to locate sources that provide both typical and unusual characteristics. The critical consideration in the naturalistic paradigm is the expansion of multiple constructions of reality, rather than their reduction into a single reality. This characterization aligns well with the purpose of the survey in this study: identifying significant representations of reflection by science teacher educators.

Of paramount importance in effective survey design is the notion of salience. Dillman (2007) characterizes salience as a measure of the relevance to potential respondents of the issues examined in the survey. Questionnaires that ask about topics of importance to the respondent, addressing current behaviors or interests, are characterized as highly salient. In the present inquiry, the content of survey questions was motivated by notions considered not only in the heuristic for describing the components of, and orientations to reflection, which is informed by both theoretical and research literature, but also from science educators' conceptions of reflection as expressed in preliminary interviews and document analysis. This direct relationship between science educators' conceptions and questions asked provides salience in survey content.

Documents

Lincoln and Guba (1985) cite documents as a "singularly useful source of information" (p. 276), due to the characteristics of availability, stability, and richness. Documents are available with minimal effort on the part of the investigator. They are stable in that they provide a record of previous actions or decisions, and do not undergo change from one occasion of analysis to another. While they are rich as a source of information due to the contextual relevance and detail presented, one limitation of documents examined in this study is that they are representative of an intended curriculum only.

The use of documents for the construction of understanding in a naturalistic inquiry is more nuanced than a simple examination of text. It is important to consider the *context* in which a document exists and the *process* of document creation (Altheide, 1996). The forces that influence the generation of a document may be significant to understanding the message it conveys. This is of particular importance in the present study, since one aspect of the sampling strategy involves an external influence, that of NCATE accreditation. Conceptual frameworks for teacher education programs have emphases that may determine the content of a course syllabus. Other influences are important to consider, such as theorists cited in a syllabus rationale contributing to the objectives of a course.

Another consideration in understanding the meaning of a document concerns the sequence through which meaning emerges over time. Emergence of meaning is a gradual development of understanding from interpretation of documents and from applying interpretations to activities. Descriptions of reflective activities in a course syllabus are understood by conceptualizing those descriptions as intended experiences.

Meaning further develops though comparison with other data sources, such as interviews, in which these interpretations are discussed.

Altheide (1996) describes the purpose of ethnographic content analysis as concerned with understanding meaning. A high degree of interaction between the inquirer, concepts, data collection, and analysis characterizes this method. Clear descriptions and definitions based on concept development are sought, rather than a verification of hypotheses.

The process begins with the identification of the unit of analysis to be examined in pertinent documents. In the present study, specific sections within descriptions that portrayed reflection in science teacher education formed this unit of analysis, and included course descriptions, goals and objectives, assignment descriptions, and other passages that communicated the intent of the instructor. The inquirer needs to be familiar with the process and context of the relevant class of documents, and examine a small number of examples. In the preliminary work that informed survey development, a small number of science teacher educators were solicited for any course and program documents that would help to understand how reflection was implemented in their programs.

The most relevant document that indicated the science teacher educator's intentions for the teaching of reflection was the course syllabus. Although syllabi vary widely in construction, most included a course description, goals and objectives, and assignment descriptions. These units of analysis provided insight into how the science teacher educator plans for the development of reflection. Another document that served

this purpose was an assignment grading rubric, which indicated what is of value to the instructor, relevant information in examining orientations to reflection.

The process also involves the construction of a tentative protocol. Altheide describes a protocol as "a way to ask questions of a document; a protocol is a list of questions, items, categories, or variables that guide data collection" (p. 26). Naturalistic protocols employ narrative and description, with coding and meaning generation occurring after data collection. A document protocol for this inquiry is presented in Appendix C. The protocol examined specific sections of the course syllabus for references to reflection, including the course description, goals and objectives, assignment descriptions, and bibliography. Assignment descriptions and grading rubrics were also examined in the protocol, considering the explicitness of reflection components and evaluation of reflection.

Interviews

The everyday notion of an interview is one of an interviewer extracting information from an interviewee in a one-way transaction. The naturalistic approach to the interview is one of a conversation, with the purpose of understanding the participant's view from his or her perspective. Kvale and Brinkmann (2009) conceive this interaction not as a series of questions and answers, but rather an "inter-change of views between two persons conversing about a theme of mutual interest" (p. 2), focusing on the construction of knowledge.

While the simplicity of this conversational approach may be appealing, effective interviewing in a naturalistic inquiry requires significant preparation and reflection. These conversational interviews typically occur without many pre-structured or standardized procedures, and require the interviewer to make spontaneous decisions

during the interview. An interviewer therefore needs to bring to the situation a different skill set, making use of considerable familiarity with the interview topic and an understanding of knowledge construction through conversation.

Kvale and Brinkmann identify seven stages of interview inquiry: thematizing, designing, interviewing, transcribing, analyzing, verifying, and reporting. The first three of these stages will be addressed in this section. Transcribing and analyzing will be considered in the data analysis section, and verifying in the trustworthiness section.

Thematizing identifies the why and what of the inquiry, the purpose of the study and background of the salient issues about the topic of investigation. These considerations are identified in the first two chapters of the present study. Since the study focuses on how reflection is portrayed in science teacher education through the vision and actions of that education, interviewing was a particularly relevant instrument.

Designing addresses the how of the study: the procedures and techniques of the data collection through interviewing. An important area of deliberation in the design stage is the temporal dimension. Kvale and Brinkmann recognize the interdependence of decisions about method made at different stages of the inquiry, which may serve to both expand and restrict future alternatives. They recommend a process of "pushing forward" and "spiraling backwards" (p. 111) between stages, as informed by continuous reflective thematization of the topic. An example of this temporal deliberation is clarification of interview prompts based on respondents' statements; essentially an on-the-spot analysis with the purpose of improving the original interview.

Initial interviews occurred after receipt and analysis of course documents, and questions were generated from examination of survey responses and documents.

Statements in open-ended survey responses about orientations were clarified and expanded upon. Aspects of the intended components of reflection identified in course syllabi were further explored, including perceptions of constraints and limitations on implementation of specific components. The semi-structured interview protocol is presented in Appendix D.

This process of moving forward and backward through interview and analysis, while at the same time constructing understanding of the inquiry topic, influenced the design of the follow-up interviews that occurred in the final stage of data collection. Follow-up interviews occurred after all initial interviews were conducted and coded. The issues addressed in these conversations were informed by questions arising from previous interviews, documents supplied, and other informants' interview responses. Topics that were not explored in depth in the initial interview were discussed in greater detail. Follow-up interviews also provided the opportunity for member checking, giving participants the opportunity to respond to interpretations of documents and previous interviews (see Trustworthiness section below).

It is also relevant to consider the logistics of the interviews. Given the potential geographic range of informants (science teacher educators across the United States), it was not feasible to conduct multiple face-to-face interviews. To enable a more personal level of communication than is possible by telephone, interviews in this study were conducted using telephone and Skype™ Internet video. These audio/video sessions were digitally recorded and transcribed.

Data Analysis

The point at which data analysis begins in a naturalistic study is not absolute. Because a naturalistic inquiry has a dynamic and emergent nature, data collection and

data analysis are intertwined processes. Patton (2002) points out that ideas for analysis

occur during the course of fieldwork, as patterns and themes appear. Subsequent data

collection is informed by working hypotheses from initial themes. The sequence of data

collection and analysis moves from initial tendencies that are generative to later stages

that "bring closure by moving toward confirmatory data collection—deepening insights

into and confirming (or disconfirming) patterns that seem to have emerged" (p. 436). At

these later stages of inquiry, analysis is organized based on two sources: (1) the

original research questions generated during the design stage of the inquiry; and (2)

analytic perceptions and interpretations that emerged from data collection. Data

analysis was facilitated in this inquiry through the use of the qualitative analysis

software NVivo.

The Method of Constant Comparison

Analysis in this inquiry used the method of constant comparison developed by

Glaser and Strauss (1967). This process involves stages of "(1) comparing incidents

applicable to each category; (2) integrating categories and their properties; (3) delimiting

the theory; and (4) writing the theory" (p. 105). Lincoln and Guba (1985) recognize that

a significant purpose of this method is the derivation of theory, not merely a data

processing method. Nevertheless, Lincoln and Guba do provide an "enthusiastic

endorsement" (p. 340) of the approach, where each stage informs the next stage

throughout the entire investigation. Figure 3-3 illustrates the flow of analysis steps in this

method.

Data were unitized according to the process described by Lincoln and Guba

(1985). They describe unitizing as delimiting those pieces of information (incidents) to

be categorized. Two qualities characterize the individual units. Units should possess

heuristic value, providing understanding of the context or utility for further action in the inquiry. Second, units must be the smallest piece of independent information, "interpretable in the absence of any additional information" (p. 345). Units of data in this study consisted of survey response summaries, course and program documents, emails, and interview transcripts. Each unit of data was imported into the NVivo project file and labeled with information such as the data source, respondent type, and data collection episode.

The first stage involved comparing incidents applicable to each category. Lincoln and Guba note the problematic aspect of this stage is the source of the categories into which incidents are classified. Erlandson, et al. (1993) suggest categories of ideas will "emerge intuitively as the researcher's own background and latent theory interact with these data" (p. 118). This approach was highly relevant for this study, as the heuristic for describing orientations to and components of reflection (Table 1-1) is strongly representative of the extant literature, providing a starting point for categorization, but not a set of *a priori* hypotheses to be tested. Provisional codes (Miles & Huberman, 1994) used in this study included the five orientations to reflection (technical, reflection-in and on-action, deliberative, personalistic, and critical) and the four components of reflection (stimuli, content, process, and outcome).

This process of emergent category designation focuses further data collection, through the strategies of extending, bridging, and surfacing data (Lincoln & Guba, 1985). Extending involves working from an emergent category as a base for new questions, with the goal of making the category more complete. In this study, the extending strategy involved moving from the structural category of constraints and

limitations to the new category of external influences. Bridging begins with known but unrelated pieces of data in the same category. Data analysis in the bridging strategy seeks to identify and understand the relationship. Bridging involved looking at note simply problems that science educators perceived with implementing reflective activities, but also considering opportunities for expansion due to external influences. Surfacing involves the proposition of new information that should be found within the tentative boundaries defined by analysis. As the inquirer becomes more familiar with the area of inquiry, he or she becomes aware of potentially rich sources of data that were previously unknown. By reframing constraints and opportunities into external influences, the conceptually rich interpretation of Schwab's (1973) commonplaces became relevant.

Lincoln and Guba recommend four criteria to consider for terminating the data collection and analysis process: (1) exhaustion of sources; (2) saturation of categories, when continued data collection does not provide significant new information; (3) emergence of regularities; and (4) overextension, when new information is not relevant to or does not further understanding of the viable categories. After stopping data collection and processing, the entire category set was reviewed.

In this study, information-rich cases providing description and interpretation of individual science teacher educators' conception of and intentions for the teaching of reflection were constructed. It was therefore appropriate to examine all sources of data from individual educators as a set informing that case, rather than considering each type of data from all educators.

Documents

After participants were selected based on responses to the web-based survey, documents were solicited, which generally consisted of course syllabi, assignment descriptions and guidelines, and grading rubrics. A memo was written for each document, providing a paragraph or so of descriptive information about the document, including identifying characteristics, a brief summary, and general impressions of its significance. These memos were not written about specific details, but rather refer to the whole document. A format for document memos is illustrated in Appendix E.

Given the variability of form and content in these materials, it was useful to employ different coding methods. For the first round of coding, documents were coded using holistic coding and provisional coding (Saldaña, 2009). Holistic coding is an exploratory method, assigning a tentative label to a large unit of data to garner an impression of the overall contents. Shorter documents such as course syllabi were read as a whole or in large chunks, rather than line-by-line. Each syllabus was read for references to reflection in various sections such as course description, course rationale, goals and objectives, assignment descriptions, grading procedures, course policies, and bibliography. Assignment descriptions and guidelines were read for references to reflection as a whole and in sections such as prompts, examples, and procedures. Grading rubrics were read for references to reflection as a whole, and in sections such as evaluation descriptors and levels of performance. Each of these large chunks was coded with a single descriptive code. These codes were informative during interviews, as they focused interview questions on significant themes in documents, such as the "enduring understandings" theme in Dan's syllabus.

The second method of initial coding of documents was provisional coding (Miles & Huberman, 1994). These initial codes came from the heuristic and research questions, influenced by the literature, and are listed in Table 3-3. Accompanying this list of provisional codes are code definitions, developed initially from the literature review and preliminary work. This set of code definitions was clarified as the inquiry progressed. An example of a code definition is presented in Appendix F. In this round of coding, each document was read line-by-line and coded simultaneously for reference to these and other emergent codes. As new codes emerge and provisional codes were focused, code definitions were revised. New codes were named based on the concept described in the document.

Rather than waiting until all documents were received, document coding occurred as they were obtained from individual participants. This ongoing process exposed sources of bias and incomplete data clarified in the interview rounds of data collection, such as explanations of specific reflective assignments.

Interviews

Interviews were conducted using telephone and Skype™ Internet video, recorded, and imported into the NVivo qualitative analysis program. Each interview was coded as it was completed. Initial coding of interviews followed a structural method (Saldaña, 2009), where particular areas of the inquiry functioned to label and index data. Chunks of conversation from the interview, including participant's responses, interviewer's questions, probes, and follow-up questions were organized based on specific research questions. Structural codes were content-based or conceptual phrases applied to these segments. Since questions in the semi-structured interviews were guided by research questions, it was appropriate to organize the interview dialogue in this way. While this

method is similar to the holistic coding applied to the first round of document analysis, it is less exploratory and guided by specific research questions. Since research questions and issues from initial interviews that require clarification guide follow-up interviews, they were coded in the same way.

In the initial semi-structured interviews (see Appendix D), specific questions correspond to specific research questions. The interview questions, "Where did these ideas come from?" and, "What experiences have influenced how you view reflection?" correspond to research question 2, "What influences have contributed to the development of these orientations?" Responses to these questions were chunked for structural coding relevant to research question 2, with codes representing the participant's particular explanation.

Second Cycle Coding

The first cycle of coding (holistic document, provisional document, and structural interview coding), summarized segments of data. After all data were initially coded, these summaries were grouped into a smaller number of themes using pattern coding (Miles & Huberman, 1994). Pattern codes move beyond identification of initial labels to provide explanatory or inferential analysis of the data. Pattern codes group initial codes into a smaller number of themes, and focus the search for rules and explanations.

Pattern coding was conducted by collecting similarly initially coded passages from the data, using NVivo query functions. After determining some level of coherence from review of these first cycle codes, a pattern code was assigned to the group. This pattern code was used to generate "a statement that describes a major theme, a pattern of action, a network of relationships, or a theoretical construct from the data" (Saldaña, 2009, p. 154). From this process, the tables summarizing data that represented

136

significant constructs were prepared, such as the tables summarizing individual participants' conceptions of reflection and influences on conceptions.

Case Analysis

At the conclusion of pattern coding for the data constructed from a particular participant, a case analysis (Miles & Huberman, 1994) was conducted. This process involved a peer debriefing (Lincoln & Guba, 1985) guided by questions about the following topics:

1. Main themes, impressions, summary statements;
2. Explanations, speculations;
3. Alternative interpretations, explanations, disagreements;
4. Next steps for data collection, follow-up questions;
5. Revision and updating of coding scheme (Miles & Huberman, 1994, p. 76).

Prior to the peer debriefing session, I prepared a brief (one or two page) memo addressing the above topics and forwarded this to the peer reviewer. Documents and other data were available during the session. The peer debriefing process was important to the development of the influences on conceptions of reflection framework, aligned to Schwab's (1973) commonplaces. I developed the graphic model that describes the relationships between conceptions, influences, components, and orientations as a result of peer debriefing.

After each case description was completed, I compared the six cases to each other to determine patterns between them. The first comparison examined demographic differences, such as years of experience. I analyzed demographic data from the initial web-based survey, and then generated tables summarizing these comparisons. Another comparison considered the influences on their personal conceptions of reflection. External influences of students, subject matter, and the milieu of learning were other patterns compared. These comparisons were informed by the tables and figures that

137

characterized individual cases, such as the tables that represent the components of reflection for each science educator. The presence of various components of reflection with the curricula of the six science educators was also examined, as well as the different orientations manifested. Tables and graphics representing these patterns were generated and interpreted.

Logistics of the Inquiry

Another important set of considerations in the design of a naturalistic inquiry involved the logistics of the study. These factors included resources relevant to time, personal effort, materials, and compliance.

Survey development, deployment, and analysis were facilitated through the expertise of a knowledgeable colleague, who was familiar with the web-based survey application Vovici Enterprise. This colleague was consulted during the construction of the survey, and also participated in evaluation of the survey. He later provided assistance with contact efforts and analysis of response data. I implemented the other major aspects of the inquiry, including composing requests for documents and interviews. I conducted and electronically recorded all interviews myself, and the recorded interviews were fully transcribed. A colleague who was familiar with the inquiry and my own professional interests collaborated in peer debriefing.

The schedule for the inquiry planned for data collection efforts to occur in the fall of 2011. A list of potential survey participants was assembled in the spring of 2011. It was critical for contacts to be made with science education faculty during the fall semester, to arrange for document collection and interviews. After survey deployment, four weeks were allowed for responses, with repeated contacts made through the web survey application. Data analysis continued into the spring of 2012.

Informed consent was requested through the University of Florida's Institutional Review Board. Since the inquiry offers no known risks associated with participation, expedited review was appropriate.

Planning for Trustworthiness

Trustworthiness refers to the methodological soundness of a naturalistic study. While efforts to establish trustworthiness may parallel criteria from the traditional paradigm, it is more important to recognize quality criteria that are inherent in the naturalistic paradigm. These concerns include the valuing of separate constructed realities, and the influence of researchers' values on the inquiry. Lincoln and Guba (1985) identified conventional questions of quality related to the truth value, applicability, consistency, and neutrality of an inquiry. The traditional paradigm considers these questions as the criteria of internal validity, external validity, reliability, and objectivity. While these terms may have some equivalence in the naturalistic paradigm, criteria that derive from the naturalistic axioms are more appropriate as indicators of quality. The naturalistic criteria consist of credibility, transferability, dependability, and confirmability. This section contains a description of efforts to plan for each of these criteria, and these plans are summarized in Table 3-4.

Credibility

Since the first axiom of the naturalistic paradigm asserts the existence of multiple constructed realities, any assessment of the isomorphism (one-to-one relationship) of an inquiry's findings to a single reality is inappropriate. Truth value in a naturalistic study concerns the degree to which the inquiry's representations of those multiple-constructed realities are credible to their original constructors. Lincoln and Guba describe credibility as a two-fold task: (1) the inquiry is implemented so that the probability of credible

139

findings is enhanced, and (2) credibility is demonstrated through the approval of the individuals whose constructions are being examined.

In the present inquiry, credibility was established using three techniques: methodological triangulation, peer debriefing, and member checking. Methodological triangulation makes use of different research strategies (Erlandson et al, 1993). Documents and interviews are the different methods employed in this study. Peer debriefing contributes to credibility through the inquirer's engagement with a knowledgeable professional outside the context of the study. Peer debriefing sessions enable candid discussions of emergent methodology, working hypotheses, and concerns.

In this study, a one page written reflective paper summarizing issues, concerns, emerging hypotheses, and design was prepared. This paper was shared with my peer and discussed during debriefing sessions. These sessions occurred at the conclusion of survey completion, document submission, and interviews. Less formal discussions also took place to help me with processing difficulties and unanticipated issues as well as celebrating significant progress. As described earlier, the graphic model representing conceptions, influences, components, and orientations emerged from one of these peer debriefing sessions. Member checking consisted of having those persons studied examine categories, interpretations, and conclusions for fidelity with their own constructions. In this study, there were two opportunities for member checking: (1) at the conclusion of interviews by summarizing data and allowing respondent corrections; (2) in follow-up interviews by verifying interpretations from previous interviews (Erlandson et al, 1993). The protocol for initial semi-structured interviews (Appendix D)

contains prompts for summarizing and verifying interpretations. For follow-up interviews, a one-page overview of the main ideas and interpretations from analysis of documents and previous interviews was emailed to participants. The follow-up interview began with discussion of these ideas, allowing opportunity for clarification and correction. All participants expressed agreement with the portrayals represented in the summaries.

Transferability

The traditional criterion of applicability concerns the degree to which conclusions can be generalized to other contexts within the same population as that studied. In the naturalistic paradigm, the focus is not on generalizing to a larger set of contexts but rather on sufficiently identifying the characteristics of the studied context, so that other researchers can make determinations regarding those new contexts into which findings could transfer. This deliberate description of the inquiry context is facilitated in this study through purposive sampling and a reflexive journal.

Purposive sampling proceeds through attention to emerging perceptions of questions and ideas that are important in the study. A deliberate focus on typical and divergent data maximizes the range of information available, affording details of a broad set of multiple realities. Purposive sampling in this inquiry focused on identifying those science teacher educators who were likely to hold clear orientations to reflection and intended to emphasize its development with their pre-service secondary science teachers. The design of the survey and the criteria for selection of participants based on their responses was consistent with purposive sampling.

Lincoln and Guba describe the reflexive journal as "a kind of diary in which the investigator on a daily basis, or as needed, records a variety of information about self and method" (p. 327). Information about the self provides data about the human

instrument, including insights, emotions, and values. Reflections on method communicate deliberations on methodological logistics, perspectives and choices. The reflexive journal in the present study contained three parts: (1) a daily log that described the schedule and logistics of the study; (2) a personal diary providing opportunity for reflection, speculation, and examination of values and insights; and (3) a methodological log describing methodological decisions and rationales.

Dependability

The notion of consistency underpins the conventional criterion of reliability, demonstrated through replication of the same study under similar conditions with similar findings. An assumption of replication is the static nature of the conditions under investigation. The naturalistic paradigm asserts reality as dynamic and ephemeral, making the establishment of reliability unlikely. The naturalistic criterion of dependability seeks to account for the instability of the setting and dynamic factors due to inquiry design.

Lincoln and Guba (1985) promote dependability through the technique of the inquiry audit, in which a careful record of the process of the inquiry is kept. Six categories of records are kept: (1) raw data; (2) data reduction and analysis products; (3) data reconstruction and synthesis products; (4) process notes; (5) materials related to intentions and dispositions; and (6) instrument development information. Raw data includes electronic recordings of interviews, survey responses, and original documents, as well as notes accompanying the collection of those data. Data reduction and analysis products in this study included write-ups clarifying data, summaries of notes, visual summaries of survey data, and other theoretical notes. Data reconstruction products provide evidence of the process of the emergence of themes from raw data and data

reduction. These files included notes on category structure, working hypotheses, visuals illustrating the relationship among categories, and findings and conclusions. Process notes included memos on methodology and the methodological log from the reflexive journal. Materials related to intentions and dispositions consisted of the inquiry proposal, peer debriefing notes, and a daily log from the reflexive journal. Instrument development files included schedules, interview guides, surveys, and correspondence.

Confirmability

In the naturalistic paradigm, the emphasis is not on the neutrality of the investigator, but rather on the confirmability of the data. The traditional criterion of objectivity is inappropriate in this study due to its value-laden nature and the entanglement of the inquirer and the inquired-on. This rejection of objectivity also stems from the naturalistic axiom of reality existing in multiple individual constructions. Acknowledging this axiom, it is not possible for the inquiry to describe an isomorphism between its data and reality.

Confirmability is established through the audit trail, which focuses on the products of the inquiry. Erlandson, et al. (1993) characterize the audit trail as a set of evidence that provides clearly traceable data as sources of reported assertions and conclusions. A determination of confirmability would be based on the extent to which findings are grounded in the data, inferences from data are logically constructed, the utility of category structure, the degree of investigator bias, and the effort made throughout the study to establish confirmability. The same set of carefully maintained audit records was used in establishing confirmability as was used with dependability.

Subjectivity Statement

In a naturalistic inquiry, the fundamental instrument guiding the study is the human researcher. While the human instrument offers many advantages to the inquiry, including responsiveness, adaptability, holistic emphasis, and the opportunity for exploration of atypical responses, these advantages are of dubious value if trustworthiness is not present (Lincoln & Guba, 1985). The construction of new knowledge by the human instrument is influenced by that human's own tacit knowledge and beliefs. Important components of this tacit knowledge are those experiences and perspectives that operate throughout the entire research process, including inquiry design, data collection and analysis, and conclusions (Peshkin, 1988). By acknowledging my own subjectivities, the trustworthiness of the inquiry is enhanced, and the potential utility of the study is strengthened through an improved understanding of my perceptions and deliberations.

My own identity as an educator has been strongly shaped by reflective practice. Early in my career as a high school science teacher, I took a graduate action research course that served to stimulate reflection on my own goals and purposes in teaching science. Other coursework in my master's program focused on inquiry and constructivism. At the same time I became involved in several physics teaching professional development programs, involving me in new roles as both a learner and a leader.

These experiences generated interest in alternative forms of assessment of science learning, leading to my Master's report dealing with portfolio assessment, in which my learners were engaged in a beginning level of reflection on their own learning. I found I was deliberating over more than simply evaluation of my own performance as a

teacher, and was considering multiple influences on how I viewed my role in the school. As I embraced a larger vision of myself as a science teacher that included responsibilities to the profession, dissemination of my own ideas to a larger audience, and membership in a community of learners, I sought some validation for this expanded identity through the process of National Board Certification.

With the National Board process, my focus on reflection became more explicit, as all aspects of my practice were viewed through the lens of the Core Propositions stating what a teacher should know and be able to do. These propositions ask teachers to (1) be committed to students and their learning; (2) know the subjects they teach and how to teach those subjects to students; (3) be responsible for managing and monitoring student learning; (4) think systematically about their practice and learn from experience; and (5) be members of learning communities (NBPTS, 2002). Proposition 4 was of particular relevance to my development of reflection. My preparation of portfolio entries documenting my understanding of and commitment to all the propositions required substantial effort in problematizing my practice.

These explorations of my practice resulted in the realization that my own professional goals were larger than the development of effective teaching behaviors in the classroom, and were instead focused on the ultimate outcome of my own personal growth. I now acknowledge this perception as an identification of what I characterize through the heuristic as a personalistic orientation to reflection.

As a new university faculty member trying to transition from teacher to scholar, I was introduced by a colleague to the process of teacher theorizing, in which the personal practical theories (Ross, Cornett, & McCutcheon, 1992) that guide a teacher's

decision making are uncovered and examined. Through the many conversations we had regarding my developing practice as a teacher educator, we engaged in a type of collaborative reflection in the mode of Schön's reflective practitioner. Thus, another bias towards a particular orientation to reflection was established.

When I was a high school science teacher, I vigorously embraced an approach to instruction that incorporated scientific inquiry in the classroom. This preference has been enthusiastically implemented in the science methods courses I have taught. The evolving ideas about inquiry of pre-service science teachers have been a deliberate content of reflection in those courses.

Acknowledgement of these biases is particularly germane to a naturalistic inquiry. The fifth axiom of the naturalistic paradigm asserts the presence of values in the inquiry, especially the values of the inquirer. These values are expressed in the selection and articulation of the research problem and in the substantive theory that guides data collection and analysis. In accepting this framework, I recognize the influence of my experience, ideas, and beliefs on the interpretations I have made. Lincoln and Guba emphasize that critical consideration is the degree to which an inquirer examines "his or her own values as well as the values of the content or situation" (1985, p. 177). My values played a role in the inquiry, but by taking their existence into account I recognized their impact on the construction of my understanding and likewise made some recognition of how participants' values have similar influence. As Peshkin notes, "I do not thereby exorcise my subjectivity. I do, rather, enable myself to manage it—to preclude it from being unwittingly burdensome—as I progress through collecting, analyzing, and writing up my data" (1988, p. 20).

Summary

This naturalistic inquiry sought to explore and describe how science teacher educators conceive the construct of reflection and how they intend their pre-service science teachers to develop reflective practice. Through collection and analysis of data from science education faculty members a portrayal of these orientations and intentions has been developed.

The study involved purposive sampling of science teacher educators who were likely to clearly articulate their conceptions of reflection and portray explicit intentions for the teaching of reflection to pre-service secondary science teachers. Purposive sampling was facilitated through a web-based survey of secondary science teacher educators. Those educators who met specific criteria were solicited for submission of course documents and video interviews.

Data analysis followed the method of constant comparison to generate descriptions of these science teacher educators' conceptions of and intentions for reflection in science teacher education. Trustworthiness of the inquiry was established using recommendations from Lincoln and Guba (1985) and Erlandson, et al. (1993).

Table 3-1. Fit of the naturalistic paradigm to the inquiry (Lincoln & Guba, 1985).

Axiom of the naturalistic paradigm	Alignment of the study with each axiom
Is the phenomenon represented by multiple complex constructions?	The purpose of the study was to examine the multiple characterizations of reflection held by science teacher educators, not to arrive at a singular definition.
What is the interaction and influence between the phenomenon and the inquirer?	Decisions about sampling and data collection was informed by interaction between research questions and themes emerging from analysis.
How time- and context-bound are the working hypotheses of the inquiry?	The inquiry provided a "thick description" of the contexts studied in order to establish some degree of transferability to other contexts.
How do the elements of the inquiry engage in mutual simultaneous shaping?	The descriptive focus of the study makes no assertions about causality; it is recognized that many circumstances influence but do not determine the development of reflection.
How is the inquiry value-bound?	The personal values of the inquirer are consistent with the naturalistic paradigm. Data collection and analysis methods were naturalistic and support multiple conceptions of reality. The exploratory and descriptive nature of the study provided for value resonance.
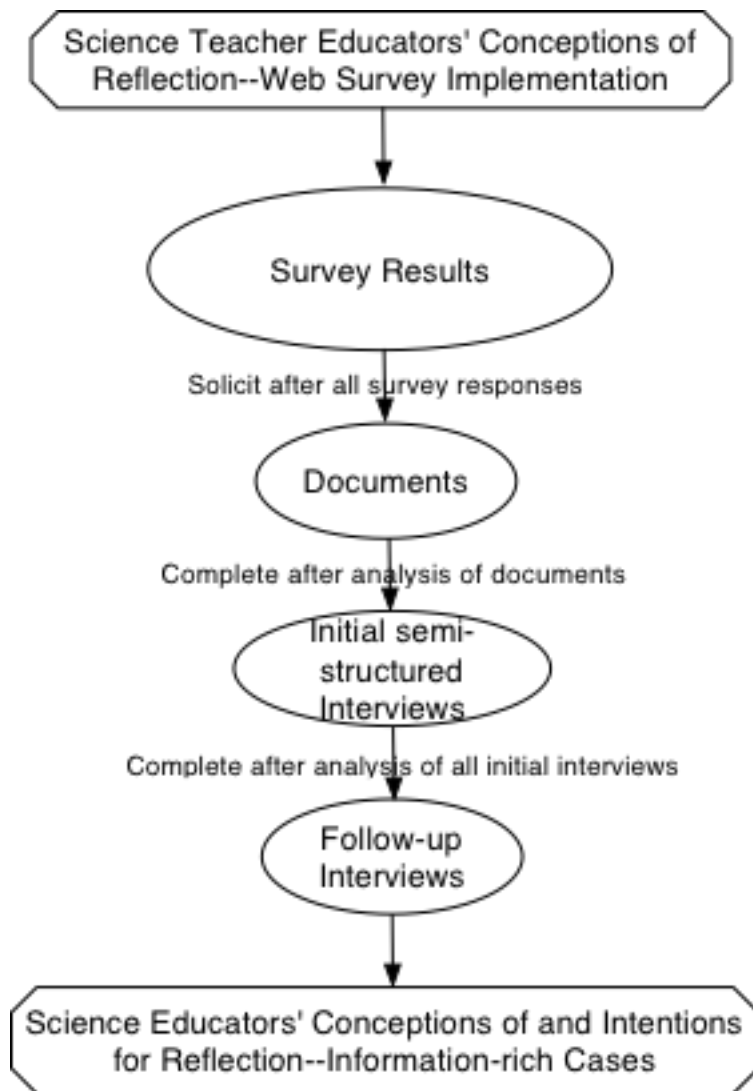
Figure 3-1. Phases of the inquiry.

Table 3-2. Description of sampling modes in different phases of the inquiry.

Inquiry Phase	Sampling Mode	Sample	Rationale
Web survey implementation	Criterion sample	Science teacher educators at TECSCU & NCATE schools (n = 100)	Identify science teacher educators who are likely to articulate a clear conception of reflection
Document analyses & Interviews	Theory-based sample	Science teacher educators selected for interviews and document analyses; selection based on survey demographic and response criteria (n = 6)	Development of information-rich cases
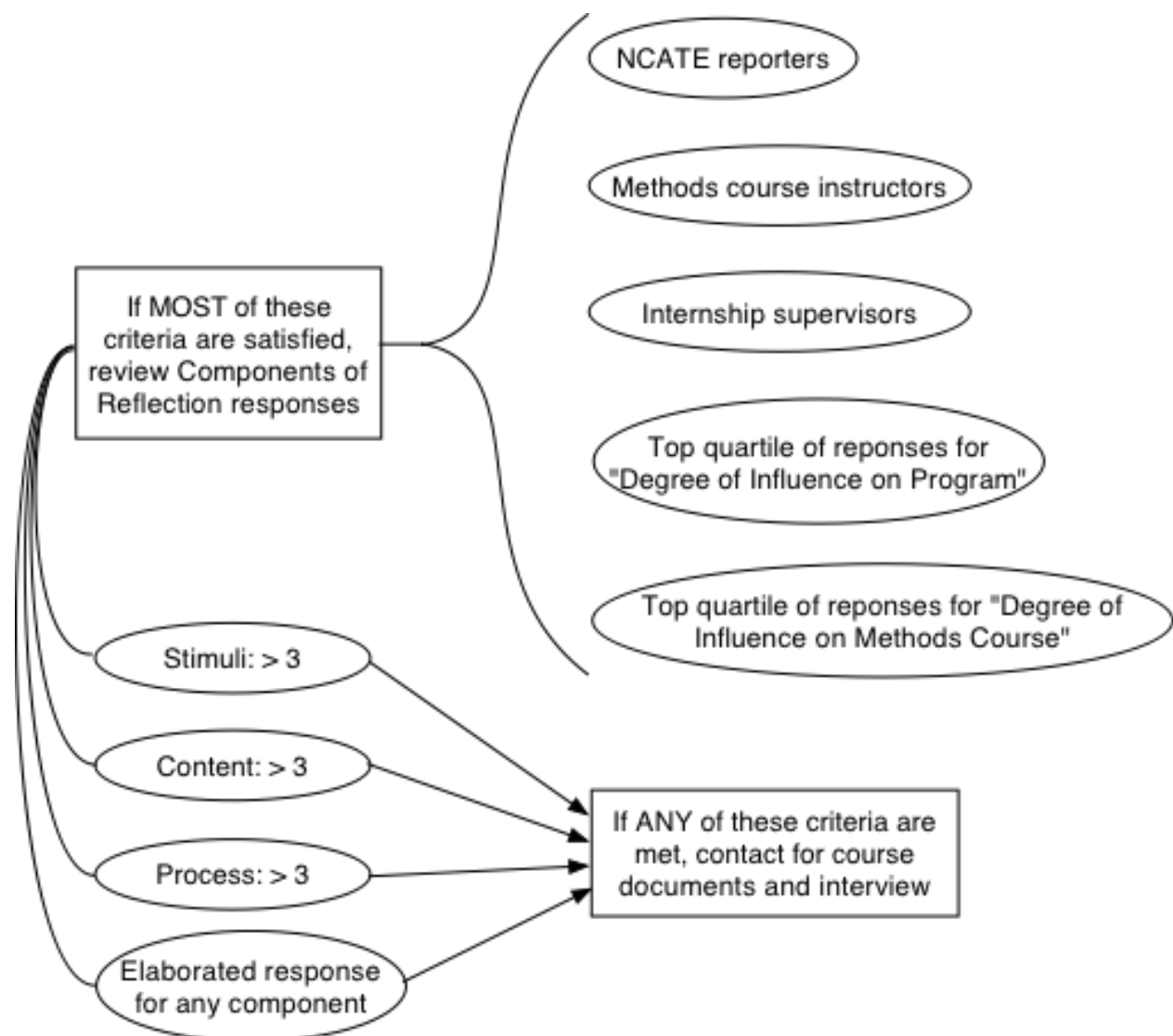
Figure 3-2. Selection criteria for document solicitation and interviews.
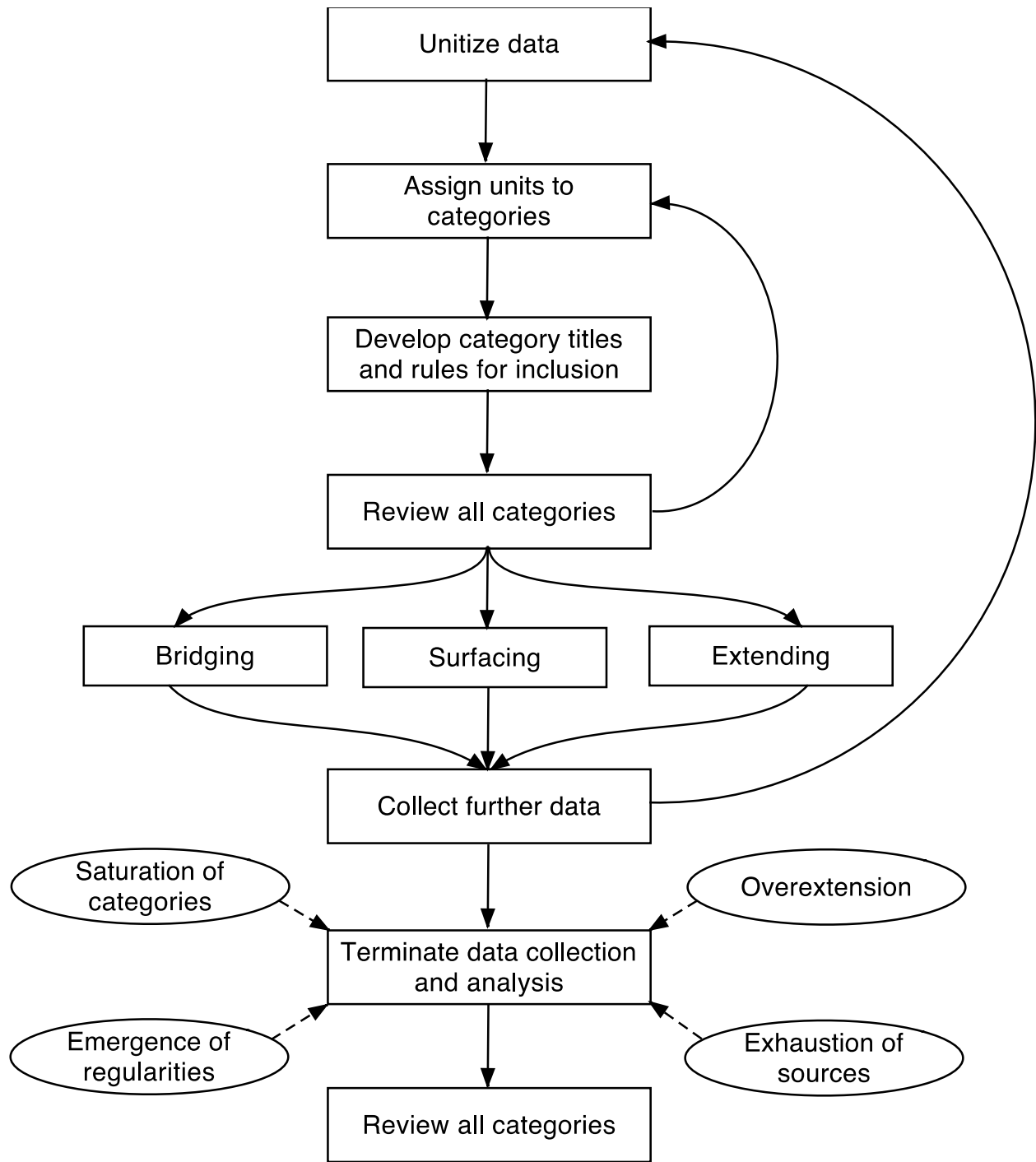
Figure 3-3. Sequence of activity in the constant comparison method of data analysis.

Table 3-3. Tentative provisional codes for documents.

General Inquiry Category	Code Label	Research Question
Orientations	Technical	1
	Reflection-in and on-action	1
	Deliberative	1
	Personalistic	1
	Critical	1
Influences	Personal experiences	2
	Professional experiences	2
	Mentors	2
	Education	2
Components	Stimuli	3
	Content	3
	Process	3
	Outcome	3
Constraints & Limitations	Definitions	4
	Preconceptions	4
	Time	4
	Setting	4

Table 3-4. Procedures for establishing trustworthiness (Erlandson et al, 1993).

Criterion	Conventional Term	Naturalistic Term	Naturalistic Techniques	Action taken in this inquiry
Truth value	Internal validity	Credibility	Methodological triangulation	Three techniques: survey, documents, and interviews
			Peer debriefing	The researcher and a knowledgeable second reviewer will analyze survey responses, document protocols, and interviews and accompanying summaries to determine the accuracy and adequacy of categorical descriptions. A written reflection on each session will be prepared.
			Member checking	These member checking opportunities will be taken: during interviews by summarizing data and allowing respondent corrections and verifying interpretations, by providing a one-page overview of interpretations and conclusions prior to follow-up interviews for discussion during follow-up interviews.
Applicability	External validity	Transferability	Purposive sampling	Science educators in each stage of the study will be purposively sampled based upon the maximum likelihood of seeing clearly articulated orientations to reflection and the intent to emphasize reflection in the development of pre-service secondary science teachers.
			Reflexive journal	The reflexive journal will contain three parts a daily log that describes the schedule and logistics of the study; a personal diary providing opportunity for reflection, speculation, and examination of values and insights; and a methodological log describing methodological decisions and rationales. The reflexive journal also provides support for dependability and confirmability.
Consistency Neutrality	Reliability Objectivity	Dependability Confirmability	Audit trail	Detailed information will be maintained of the inquiry process and product in five categories: raw data, data reduction and analysis, data reconstruction and synthesis, process notes, materials relating to intentions and dispositions, and instrument development.

CHAPTER 4
RESULTS

In this chapter I present the findings of the study. I have organized these results

for each participant, with each section addressing these four research questions:

1. What orientations (personal conceptions) to reflection do science teacher educators hold?

2. What influences have contributed to the development of these orientations?

3. How are science teacher educators' orientations to reflection manifested through components of reflection in their intended curriculum?

4. How do science teacher educators perceive the constraints and limitations (external influences) on the enactment of their intentions for the teaching of reflection?

I begin each of the participants' cases with a brief introduction of the context in which

they work as science teacher education faculty, followed by sections addressing the

research questions.

The first research question considers the personal ideas held by the science

teacher about the meaning, purpose, and value of reflection. Personal conceptions of

reflection constitute a part of a teacher's own belief system (Pajares, 1992) about

teaching and learning. These core beliefs are sometimes referred to as Personal

Practical Theories (PPTs), "the systematic set of beliefs (theories) which guide the

teacher and are based on prior life experiences" (Sweeney, Bula, & Cornett, 2001, p.

409).

In the second section of results, I explore the formative experiences that have

contributed to the development of these personal conceptions. Eick and Reed suggest

teachers "bring their belief systems to their practice" (2002, p. 402) prior to any

experience in that particular setting, so these personal beliefs are not yet influenced by

external factors of the teaching setting. Faculty would hold these personal conceptions

about reflection in whatever setting, at that time. I do not, however, suggest that the personal conceptions of participants on reflection are static. Rather, they are subject to future influences from personal or professional experiences. For the purposes of understanding science teacher educators' conceptions of reflection, these personal conceptions fall into the teacher commonplace, one of the four "vital factor[s] in educational thought and practice" (Schwab, 1973, p. 509).

The remaining three commonplaces (students, subject matter, and the milieu) are considered external influences on the science educator's personal conceptions. In an ideal educational setting disconnected from these external influences, the science educator's personal conceptions would be manifested directly in the science education program. There are, however, external influences that result in some modification of the science educator's personal conceptions, resulting in the intended components of reflection in the program and course activities. As mentioned above, these external influences can be categorized based on the commonplaces of students, subject matter, and the milieu. Schwab (1973) characterizes the milieu as those settings in which learning occurs, including the physical settings of classroom and school, but also the social settings of community and family, as well as aspects of the environment such as relations and values.

It is the intended components, those specific program and course experiences and activities that identify the science educators' orientations to reflection. By examining the components they have articulated using the heuristic developed in this study, I have identified the orientations represented in the curriculum of science teacher education

156

programs within the influence of the faculty member, typically the science methods course and associated field experiences.

For each of these research questions, I present data from the study (quotes from documents and interviews) in a series of tables for each participant. Quotes in tables are referenced to the original sources in this manner: BD1, 19-21 indicates participant Bob, Document 1, lines 19-21 of the document. DI1, 97-98 indicates participant Dan, Interview 1, lines 97-98 of the transcript. All participant names are pseudonyms. The chapter concludes with some comparisons of the more salient aspects of the six participants' approaches.

Case 1: Bob

Bob is a faculty member in the Chemistry department of a mid-sized, regional four-year university in the Midwest; one of several serving the same geographical area. He has been involved in science education for eight years. He teaches science education methods and supervises student teachers. Prior to teaching in higher education, he taught K-12 science. He is also involved in the university's efforts regarding adoption of the Teacher Performance Assessment (TPA), a performance-based assessment of pre-service teachers centered on student learning (American Association of Colleges for Teacher Education, 2011).

The program at Bob's institution offers a B.S. in secondary education with licensure in the science content areas of chemistry, earth science, life science, and physics, and averages ten graduates each year. The science methods course is common to all content areas, and is typically offered once a year. Three different faculty members have taught the course in the time Bob has been at the university.

Bob's Personal Conceptions of Reflection

Bob emphasizes reflection as a way of thinking about the practice of teaching that takes place within an authentic context. The first section of Table 4-1 includes a quote from Bob that encapsulates this dominant idea about the importance of context. While Bob asserts that reflection requires authentic experiences, he also recognizes that reflection does not necessarily result from every experience, and that, "It's possible to have boring days where there is little to reflect on" (BI1, 54).

Bob also characterizes reflection as a skill of thinking to be developed, taking time and effort. As the second quote in Table 4-1 highlights, effective reflection is an intrinsically motivated act, engaged in by the reflective practitioner.

Influences on Bob's Personal Conceptions

Bob's own experiences as a K-12 science teacher are the most significant influence on his ideas about reflection. He makes extensive use of personal anecdotes, drawing from a rich repertoire of professional knowledge, to provide meaningful examples of situations in the science classroom that pre-service teachers need to problematize. As the quote from Bob's interview in the influences section of Table 4-1 suggests, pre-service teachers will often have a limited awareness of certain aspects of teaching, due to their own background. Bob also cites his personal upbringing as a "military brat" as a significant factor in his understanding of different social perspectives. These personal examples, through Bob's description of their problems and resolutions, model reflective practice for his learners. Bob values these experiences as rich contributions to his repertoire of professional knowledge, due to their impact on his teaching practice.

External Influences on Bob's Conceptions

The external influences section of Table 4-1 identifies aspects of the three commonplaces of students, subject matter, and the milieu as impacting Bob's intentions for reflective experiences. He highlights the importance of addressing specific features of science, such as the teaching of controversial issues and lab safety concerns, as critical ideas to be problematized through reflection.

Bob also identifies students as an influence on how he approaches reflection in science methods and student teaching. While Bob places a high personal value on reflection as an intrinsic disposition, he acknowledges the need to begin the development of the skill by pre-service teachers with an external stimulus of grading points. His students' initial limited awareness of science teaching and learning is emphasized in his quote in Table 4-1, noting their tendency to think of effective teaching as "the way we think would work best for us, even if the rest of the world isn't like us" (BI1, 183-184). His students also possess limited awareness of the realities of schools, as most have limited experience outside the university's immediate geographic area.

The milieu of learning also presents a significant influence on how Bob addresses the development of reflection. Accreditation procedures require specific attention to detail to satisfy standards, resulting in the inclusion of assignments such as videocase reflections. Bob's institution is involved in the early adoption process for the Teacher Performance Assessment (TPA), a subject area specific evaluation model for pre-service teachers. He feels TPA implementation provides an opportunity to enhance the quantity and quality of meaningful reflection throughout the program, as noted in the Milieu section of Table 4-1. A structural aspect of the milieu in Bob's university relates to

the availability of placements for pre-service teachers, particularly when they are expected to deliver lessons in the methods course.

These external influences all have an effect on how Bob organizes learning experiences that generate meaningful reflection. To challenge his students' limited awareness of other socioeconomic and teaching and learning situations, he presents examples from his own personal and professional experience. Other external influences result in purposefully designed experiences, described in the next section addressing different components of reflection in Bob's program.

Components of Reflection in Bob's Curriculum

Bob's own personal conceptions of reflection, influenced by the commonplaces of students, subject matter, and the milieu, are operationalized into the intended curriculum of his science teacher education program, particularly the science methods course. Based on the heuristic I employ in this study to describe and understand reflection in science teacher education, his intentions are categorized into four components of reflection: stimuli, content, process, and outcome. Representative components in Bob's program are listed in Table 4-2. Since Bob's role and experience limit his intentions for reflection to the curriculum of the science methods course and student teaching, it is inappropriate to extend his ideas to the program level.

Bob identified specific stimuli for reflection occurring during both the science methods course and during student teaching. Within the methods course, case studies are the primary explicit stimulus. Bob uses both videocases demonstrating effective and ineffective science pedagogy and more informal cases of problematic situations, frequently drawn from his own experience, as illustrated in this quote: "What are the pros (motivation, relevance) and cons (an assignment is a bad way to learn you might

be illegitimate, adopted) of doing a personal family tree for genetics purposes (BD1, 18-21)? As described above, securing teaching placements is a problem for Bob, so his methods students often deliver lessons in such nontraditional locations as the local Alternative Learning Center or less formal settings like the detention center. His pre-service teachers also engage in reflection based on their experiences with two outreach events: science fair and science Olympiad.

The content that Bob's pre-service teachers reflect upon are generally teaching situations, including the issues that are present in the typical questions of how they would improve instruction based on feedback from observers. In the methods course, ideas problematized through reflection also emerge during class discussion from the concerns identified in individual lesson plans. While Bob does provide some reflective prompts after lesson delivery, he is more interested in the unique issues that present themselves, as highlighted in this quote: "There are prompts, a certain amount of predetermined prompts, but those are very vague and probably less interesting than going over the specific issues that came up in the teaching" (BI1, 133-137). From the outreach activities (science fair and science Olympiad), Bob focuses reflection on how those activities can be connected to content standards.

Process is the component of reflection in Bob's curriculum that is least articulated in explicit terms. The mode of reflection is most frequently written, such as analysis of written lesson plans and reflective journals used during student teaching. The other identified process of reflection in Bob's methods' course is the whole class discussion, engaged in after viewing videocases.

Bob is clearly focused on effective decision-making as the outcome of reflection for his pre-service teachers. He wants them to be able to consider "the multiple perspectives that are necessary when evaluating a lot of educational situations" (BI1, 12-13). While accreditation does require careful organization of assignments that link to standards referencing reflection, his deeper goal emphasizes problematizing teaching by developing a repertoire of practical knowledge, as he models frequently. "I'm trying . . . to provide them with some specific contexts to illustrate specific points on how teaching is maybe more complicated than they thought" (BI1, 147-149).

Orientations to Reflection within Bob's Curriculum

By applying the heuristic to these different components of reflection, the orientations to reflection in Bob's curriculum can be identified, as shown in Table 4-3. While Bob's methods course cannot be classified as exclusive to any one orientation, some consistent patterns are present.

The stimulus component in Bob's intended curriculum represents aspects of the technical and reflection-in and on-action orientations. Pre-service teachers begin reflection by examining a lesson that has been delivered. The videocase lessons highlight positive or negative exemplars in science teaching, consistent with the technical orientation. Lessons the pre-service teachers deliver occur in either the science methods course or during student teaching. The other major stimulus for reflection are the numerous personal examples and cases that Bob presents, which are consistent with the reflection-in and on-action orientation, featuring puzzling or unique situations of science teaching.

The content of reflection in Bob's intentions lies primarily in the deliberative orientation. The focus of reflective writing deals with decisions about curriculum and

162

instruction in lesson planning and analysis, considering multiple perspectives. Pre-service teachers also consider situations unique to science teaching in their writing and class discussions, indicative of the reflection-in and on-action orientation. The process of reflection consists of descriptive journal writing and supervisory conferences examining areas for improvement, typical of the technical orientation.

Bob wants his pre-service teachers to develop a rich repertoire of practical knowledge (Schön, 1983), a goal of the reflection-in and on-action orientation. He also highlights the outcome of having them become effective decision makers, consistent with the deliberative orientation.

Figure 4-1 illustrates the relationships between Bob's personal conceptions of reflection, the personal and external influences on those ideas, and the intentions for implementing those ideas through the components of reflection in the curriculum . These components in Bob's program serve to identify the orientations. The size of various elements indicates their relative importance in Bob's conceptions of and intentions for reflection. Bob's professional experiences are the primary influence on his personal conceptions of reflection, and the milieu of learning is the major external influence. The process component is emphasized the least in his intentions, while the three identified orientations have nearly equal emphasis.

The graphic also represents a model for how ideas about reflection are developed by teacher educators, and how those ideas then translate into specific courses and program curriculum. Bob's personal conceptions of reflection were initially formed by his experiences growing up and by his work as a classroom teacher. As he now teaches in higher education, the students, subject matter, and to a greater degree, the milieu of

163

learning, have modified his original ideas, making them both more concrete and more specific to his context. Different aspects of these concrete plans for course activities are categorized into the components of reflection and orientations to reflection, according to the heuristic.

Bob has eight years of experience in science teacher education, and while his ideas about reflection are clearly informed by his experience as a teacher and the context in which he now teaches, the complexity of reflection in his curriculum is limited. As Figure 4-1 illustrates, there is no predominant orientation to reflection manifest in the curriculum of his science methods course and associated experiences. Rather, his approach investigates aspects of three orientations, emphasizing the benefit of reflection on teaching practice.

Case Two: Claire

Claire teaches science methods and supervises science student teachers at a medium-sized public university in the southeastern United States. Her institution offers both bachelors' and masters' degrees in secondary science education. There are double majors in the undergraduate program, one in the content area (biology, chemistry, or physics) and a second major with a cognate in secondary education. In addition to overseeing the secondary science education program, Claire is also the teacher education department chair. The program graduates approximately ten science teachers per year. In addition to teaching the undergraduate science methods courses, Claire also teaches a masters' level course on the history and nature of science.

Claire's Personal Conceptions of Reflection

Claire views reflection as a process of thinking, with the specific purpose of personal understanding and improvement. While this may seem obvious as a meaning

of reflection, her focuses on reflection as a process for personal growth provide insights into what goes on in her science teacher education program. In her quote in the first part of Table 4-4, she emphasizes that improvement is achieved from reflection, not solely for better instructional choices, but also for better understanding of the self. Reflection becomes the key to personal development. "You can't ever get better or you can't do anything better if you don't reflect" (CI1, 172-173).

Influences on Claire's Personal Conceptions

Claire clearly recognizes the significant influence of her education on her ideas about reflection. She entered her teacher certification program with an undergraduate degree in botany and horticulture. In this program, she was involved in student teaching each day for an entire school year and engaged in reflective writing and discussion on a daily basis. In her graduate program, she worked on several grants that emphasized action research and reflective practice. During this time she also became familiar with the seminal writing on reflection of Max van Manen, as described in the influences section of Table 4-4.

External Influences on Claire's Conceptions

Science subject matter is a significant influence on how Claire intends to implement reflection in her science education program. She highlights the need for her pre-service teachers to have an understanding of such science topics from the *National Science Education Standards* (National Research Council, 1996) including inquiry, science and technology, science in personal and social perspectives, and the nature of science. She uses extensive readings from the foundation text *Science for All Americans* (Rutherford & Ahlgren, 1991) to provoke pre-service teacher "resonance and dissonance" (CD1, 74) with respect to the personal beliefs of the students about

teaching and learning science. These beliefs are continually problematized in reflective writing and other specific course activities.

Students are a secondary external influence on her plans for teaching and learning about reflection. Pre-service teacher beliefs about teaching and learning science are central to many reflective activities, including concept mapping and the methods course final paper. Additionally, she sees pre-service teacher motivation for reflection lacking, even though she cites anecdotal evidence of pre-service teachers who are unsuccessful during their student teaching experience: "[Every unsuccessful student] blames, deflects and does anything but reflect. Never reflects, never" (CI1, 147).

The milieu in Claire's program is not a significant influence on realizing her ideas about reflection, even though accreditation does require quantifying reflective practice assignments. She instead feels approaches that use rubrics to examine reflection may miss the point: "I'm not assured that the best of reflections always have answers you should be looking for" (CI1, 185-186). This attitude is consistent with her emphasis on reflection as a means to personal growth and improvement based on one's own criteria, not an externally-supplied set of standards.

Components of Reflection in Claire's Curriculum

Table 4-5 lists representative aspects of course and program experiences for the stimuli content, process, and outcome components of reflection. Claire notes that field experiences occur for pre-service teachers throughout their program and serve as a stimulus for reflection. Within the science methods course, more specific stimuli are present. Pre-service teachers write an inquiry lesson plan using the 5E design (engage, explore, explain, elaborate, evaluate), and videotape delivery of this lesson in their practicum experience. As mentioned above, she uses course readings to provoke pre-

service teachers into thinking about their own beliefs on teaching and learning. A culminating assessment in the course is a "documented description of the nature of science" (CD1, 61), drawing from reflective journaling, course readings, and online discussion notes.

The content of reflection for Claire's pre-service teachers emphasizes the complexity of science teaching, considering such topics as inquiry, lab experiences, and the nature of science. The predominant focus of pre-service teachers' reflective thinking, however, is their own ideas about science teaching and learning. This focus occurs in many assignments, from reflective journals to weekly discussions to concept maps.

Claire provides many explicit and diverse activities as processes for reflection. The secondary science methods course syllabus prompts pre-service teachers by providing weekly questions to ponder. These questions are then addressed in written reflective journals. However, Claire does not review or grade these journals, which allow pre-service teachers to be introspective and candid in their writing. Included in the guidelines for analysis of the video of the inquiry lesson are multiple prompts for pre-service teachers to consider as they analyze content, instruction, and assessment. The culminating paper in the class guides pre-service teachers in an ethnographic study of self, in which they compile all of their reflective writing throughout the semester, problematizing the various ideas encountered with respect to their own beliefs about science teaching and learning.

The outcomes for learners in Claire's science education methods course and field experience highlight instructional decision making, but more significantly the

development of an understanding of the self. Claire feels reflection contributes to the understanding by pre-service teachers of the art of teaching and the aspects of teaching that are not directly taught. This attitude emanates from Claire's recognition of her students' backgrounds: "Most of the students that get here have been raised in such an authoritarian, dictatorial manner and they think that's how you do science" (CI1, 58-59). She has designed specific assignments and experiences in her program to counter that student preconception, such as the questions used in analysis of the inquiry lesson plan. Ultimately, she wants them to identify their own identity as individuals. "This is who I am, this is who I am as a culture bearer, this is how I perceive things" (CI1, 161-162). Table 4-5 summarizes the components of reflection in Claire's curriculum .

Orientations to Reflection within Claire's Curriculum

Claire manifests a deliberative orientation to reflection through many of the components in her science methods course and field experiences. She certainly emphasizes relevant and meaningful student learning and effective decision making, equipping a pre-service teacher with the ability to articulate, "this is what I do and this is why I do it" (CI1, 18). Many of the course assignments focus on effective lesson planning and instruction, such as the learning cycle lesson plan and video analysis. Science subject matter (inquiry, science and technology, nature of science) occupies a significant role in Claire's curriculum, both as a stimulus for reflection and as the content of reflective writing and discussion. The process of video analysis of inquiry instruction provides a retrospective reflection based on questions of relevance to students' lives and the variety of pedagogy and learning activities present.

Also significantly present in Claire's curriculum is the personalistic orientation, emphasizing personal growth and development. Pre-service teachers continually

examine their own personal beliefs about science teaching and learning. She employs a variety of processes, such as a concept map in which they represent their beliefs about the nature of science, related to themes from *Science for All Americans.* Weekly journals are deliberately introspective, serving the needs of the learner rather than satisfying a course requirement for the instructor. The ethnographic study of self exemplifies this orientation in its focus on problematizing and understanding one's own beliefs. She makes this approach and its messiness clear in her instructions for the inquiry lesson plan, where she encourages her pre-service teachers to look at themselves: "We want you to know that it is not always comfortable to do these tasks. We want you to know that we are learning from each other" (CD1, 52-53). Claire's orientations to reflection are represented in Table 4-6.

Figure 4-2 represents Claire's conceptions of and intentions for reflection in her science education courses. The sizes of various elements represent their different emphases in her thinking about reflection, such as the larger impact of subject matter as an external influence on her conceptions. All four components of reflection in Clare's program have relatively equal emphasis, as shown by the explicit course and program experiences described by Claire, They all function to support either the deliberative or personalistic orientation. This mature articulation of reflection by Claire is facilitated by her two decades of experience at her institution and her involvement as department chair in decisions about the curriculum in the science education program. In contrast to Bob's less intense plans, Claire's balanced approach to all four components of reflection supports a more specific focus on the deliberative and personalistic orientations, with each component providing explicit support for both of these complex orientations.

Case Three: Dan

Dan teaches science methods at a regional, comprehensive public university in the northeast. His program offers a Master of Education degree with initial certification in a secondary science content area, and offers different tracks with completion in one to two years. In addition to university-based coursework, pre-service teachers complete a pre-practicum and practicum. Approximately twelve students complete the program each year. The program features a culminating performance assessment using the Teacher Performance Assessment framework, which contributes to the state's teacher certification criteria. Dan has been at this institution for six years, and worked as a secondary science teacher in New York and Brazil. During his time as a teacher in Brazil, he completed the process of National Board Certification.

Dan's Personal Conceptions of Reflection

Dan conceives reflection as a part of the practice of teaching in which the teacher considers their own actions and decisions and their impact on student learning. As noted in Table 4-7, Dan does not restrict reflective practice to an isolated experience involving only the practitioner, but looks for opportunities in which reflection is enabled through collaboration in a learning setting. Connected to this idea of collaborative reflection is his suggestion that reflection on one's own work and the work of others needs to take place in an organized manner, leading to it becoming part of the routine of teaching. Dan also asserts that time is a critical resource that must be provided in order for meaningful reflection to occur, particularly collaborative reflection.

Influences on Dan's Personal Conceptions

The primary influence on Dan's ideas about reflection was his experience going through the process of National Board Certification, as he articulates in Table 4-7. The

certification exercises consisted of a series of portfolio entries, each focused almost entirely on reflection. Different reflective entries addressed planning, instruction, and learning; small group inquiry; whole class discussion; and collaboration and contributions to the professional community. These emphases on reflection as an analytical process contributed significantly to Dan's intentions for the development of reflection by his own learners.

Another influence on Dan's ideas about reflection was the Understanding by Design framework (Wiggins & McTighe, 2001). The framework is a model for organizing curriculum based on three levels: what is *worthwhile knowing;* what is *important to know;* and what results in *enduring understanding.* Dan employs this model to "make the study of teaching longer lasting, more meaningful" (DI1, 63). He intends for his pre-service teachers to apply learning about teaching in situations with their own students, then reflecting on the experience.

External Influences on Dan's Conceptions

The milieu is the only commonplace that represents an external influence on Dan's conceptions of reflection. He discusses the emphasis on reflection contained in the Teacher Performance Assessment pre-service teacher evaluation model that his state has adopted. In preparing for the TPA, pre-service teachers engage in reflection through analysis of planning, videos of lesson delivery, and student learning. As the process becomes more integrated into the teacher education program, reflection will become a larger part of all coursework.

Another influence from the milieu that Dan references enthusiastically in Table 4-7 is the use of technology. He envisions emerging technologies as vehicles for meaningful individual and collaborative reflection. One example he suggests is a video platform that

would allow videos of lesson delivery to be uploaded and shared in a virtual environment.

Components of Reflection in Dan's Curriculum

Three activities serve as stimuli for reflection in Dan's secondary science methods course, as listed in Table 4-8. The first stimulus is a series of videos in which teachers model instructional practices in science teaching, followed by a discussion of effective practices. The other two lesson planning activities Dan uses to generate reflection derive from two of the National Board Certification portfolio entries. One assignment is the planning, preparation, and implementation of a scientific inquiry activity. This mini-lesson is planned and delivered in collaboration with another pre-service teacher, and is videotaped. The second collaborative lesson features learning through whole-class discussion. Specific guidelines are provided in the course syllabus for both of these mini-lessons.

The content of reflection in Dan's methods course is clearly specified but somewhat narrow, focusing primarily on the two mini-lessons described above. The ideas addressed are the same for both mini-lessons. They consider successful and unsuccessful aspects of the lessons, evidence of student learning, pre-service teacher learning about collaboration, and plans for improvement.

Dan's intentions for his pre-service teachers' learning the process of reflection are explicit. With the videos of other teachers, the class specifically looks at what the teachers do and do not do in modeling effective instruction. Discussions of course activities and readings occur both in class meetings and in an online forum. For the videos of the mini-lessons, the partnering pre-service teachers answer five questions directly in a written reflective analysis. Dan conceives the first video analysis of the

inquiry activity as a transformative experience for most of his learners. As a result, their analysis in the second whole-class discussion video is more complex.

Dan aims for his pre-service teachers to be successful in questioning their own instructional decisions, "to see the gray areas and to see missed opportunities, and that teaching is more than just yes or no, up or down, good or bad" (DI1, 73-74). He asserts that reflection can provide a mechanism for revealing the complexity of the science classroom. Dan hopes to give pre-service teachers a good beginning in the process of reflective practice, having developed an appreciation for reflection.

Orientations to Reflection within Dan's Curriculum

The curricular choices Dan makes in his science education program emphasize the technical and deliberative orientations to reflection. Table 4-9 represents how the different components of reflection align with these two orientations.

Reflection in the technical orientation addresses questions of teaching effectiveness, determined by some external authority. Dan uses videos of teachers modeling effective teaching to introduce his pre-service teachers to reflection on instruction. The content of reflection from these exemplary videos consists of evaluation of teaching behaviors.

The other major reflective activities are aligned with the deliberative orientation. Both the inquiry and whole-class discussion mini-lessons allow for decision-making on the part of pre-service teachers, and while the reflective prompts are typical (what went well, what would you do different), the level of reflection is complex, due to the use of evidence to substantiate learning claims. Instructional decisions are analyzed collaboratively based on the interactions of the learning context, not some externally imposed criteria.

The relationship of Dan's conceptions and intentions are represented in Figure 4-3. Dan's professional experiences are the only influence on his personal conceptions, and the milieu of learning is the only external influence. Stimuli and process of reflection are emphasized more explicitly in his curriculum than the content and outcome components.

At first glance, Figure 4-3, representing Dan's conceptions of and intentions for reflection, appears somewhat simple, with only one personal influence and one external influence. This leads to components emphasizing technical orientation and to a larger extent, the deliberative orientation. His ideas, however, are not necessarily simple, but rather explicit in his emphasis on the deliberative aspect of reflection. His design for the curriculum of the science methods course provides experiences in each component, all supporting the deliberative orientation. This is indicative of his foundation ideas about reflection which emanate from his National Board experience, highlighting video-based stimuli and sophisticated collaborative and structured processes of reflection. Even though Dan and Bob have similar levels of science education experience, Dan's intense professional experience with reflection have informed his more clearly purposed approach.

Case Four: Jeff

Jeff is a veteran science educator at a small public university in the northeast. He has been at this institution for twenty-five years. He teaches science methods and supervises science student teachers. He is also the program coordinator for the secondary science program, which is a fifth year program leading to certification with a Master's degree. In addition, Jeff also prepares the accreditation reports for the secondary science teacher education program. He has been an integral part of his

program's successful efforts to achieve NCATE accreditation, and the unit's formal conceptual framework is reflective of his ideas. In contrast to Bob and Dan, whose intentions for reflection are limited to the courses they teach, Jeff's ideas are more pervasive in the institution, and his familiarity with the program is more comprehensive. While Jeff's institution is part of a larger university system, the campus at which he teaches is small, with an enrollment of around four thousand. Most of the students in the professional education program are residents of the state, with a significant proportion of those from the local area. The secondary science education program typically has less than twenty students enrolled. Jeff collaborates with a full-time clinical faculty member in science education. The clinical faculty member's work is divided equally between teaching science education courses in the program and working as a liaison with the secondary school classroom teachers where pre-service teachers are placed.

Jeff's Personal Conceptions of Reflection

In Table 4-10, several references from Jeff exemplify his ideas about reflection. One important aspect of his personal conceptions is the relationship of reflection and lifelong learning. Jeff sees these two ideas as essential attributes of an effective teacher preparation program. The role of the reflective practitioner is clearly stated in the program, with a focus on instructional leadership. Jeff conceives reflective practitioners as agents of innovation and change in their schools and the profession.

Influences on Jeff's Personal Conceptions

Jeff's situation is unique among the participants in the study, in that his personal ideas about reflection are represented in the program without much change due to external influences. This is largely due to his long tenure (twenty-five years) at the university and his extensive involvement in program design, particularly with respect to

175

accreditation and the development of the unit's conceptual framework. That conceptual framework features a strong emphasis on reflective practice connected to lifelong learning.

The value of reflection is embedded in the culture of Jeff's university. He feels this is a function of the deliberately modest size of the institution and teacher education program. This intentionally small enrollment enables pre-service teachers to have a unique level of access to faculty. Jeff considers this an important factor in serving the teacher preparation needs of the region.

External Influences on Jeff's Conceptions

The milieu of learning represents a significant influence on the implementation of Jeff's conceptions of reflection. While the university and its teacher education program's small and manageable size is a potent influence on Jeff's notions of the importance of reflective practice, that small population also presents a constraint. In Table 4-10, Jeff describes the difficulties of developing and maintaining relationships with mentor teachers in the small local school districts. Schools have small numbers of science teachers, limiting the breadth of experiences for student teachers. Due to social, economic, and cultural issues, the concerns of the communities with which Jeff collaborates in the placing of student teachers present unique opportunities for involvement.

Science subject matter is also an important external influence on Jeff's ideas for the development of reflection, connected to the concerns of the communities. Science learning with an emphasis on science-technology-society (STS) is a predominant theme in his program.

Components of Reflection in Jeff's Program

Jeff's science teacher education program includes a seminar on the history and nature of science, a course emphasizing science-technology-society, a science methods course and accompanying field experience, and student teaching. Table 4-11 highlights the variety of stimuli, content, process, and outcome components of reflection in Jeff's program. Since Jeff has a comprehensive understanding of and extensive influence over the secondary science education program, it is appropriate to view his intentions through a wide lens.

Jeff's program provides a large variety of different activities to stimulate reflection. The emphasis on the local community is present in these assignments, including an STS lesson plan involving a local issue. Often these lesson plans feature investigation and evaluation of local environmental concerns such as agriculture and mining. In addition to more traditional 5E lesson plans in science teaching, reflective practice is engaged through the nature of the student teaching placement, frequently occurring in schools of the local Native American nation.

The ideas examined through reflection in Jeff's program focus not on teaching behaviors, but on pre-service teachers' own notions of the meaning of science and their role in doing science. Consistent with the strong connection to the local community, analysis of lesson plans focuses on the relevance of learning approaches and topics.

The structural methods employed as processes for learning how to reflect include common techniques such as student teaching journals and student case studies. An assignment more focused on self-awareness is a self-reflection paper connecting the pre-service teacher's own experience as science learner to the issues examined in the history and nature of science seminar. Autobiography is also used to reveal the

personal beliefs of learners concerning the teaching and learning of science. An explicit

approach present in the field experience and student teaching segments of the program

is the presence of collaboration. University science education faculty and clinical faculty

work together to deliver coursework and supervise field experiences. Clinical faculty are

also charged with developing and maintaining close relationships with local secondary

science teachers. As Jeff recognized when discussing the constraints on the program,

local teachers who are willing and capable of collaborating in the development of

science teachers are a valuable resource in the region. A strong network is present to

enable a team approach throughout the sequence of field experiences.

The outcomes of reflection in the program include emphases on understanding the

complexity of the science classroom and an appreciation of the importance of reflection,

but also an engagement with concerns that extend beyond the classroom, consistent

with the program conceptual framework emphasizing lifelong learning. Due to the

connections of the university with the region it serves, issues of rural poverty, industrial

development, and minority populations are present in the program.

Orientations to Reflection within Jeff's Program

With the emphasis on ideas and concerns that lead beyond traditional examples of

effective teaching, Jeff's curricular choices reveal a complex set of orientations to

reflection. Different components of reflection in the courses and program experiences

for which he is responsible align with the reflection-in and on-action, deliberative,

personalistic, and critical orientations, as shown in Table 4-12.

The approach taken is a process of reflection that involves strong collaboration

between university faculty, clinical faculty, and the mentor teacher and aligns with the

reflection-in and on-action orientation. Aspects of the deliberative orientation are

present in the case study assignment, focusing on the student commonplace as a lens on effective instructional decision-making.

Jeff's program has a significant emphasis on personal development. Activities such as the reflective paper written in the history and nature of science seminar examine the pre-service teacher's own core beliefs about science, and the autobiographical sketch written prior to student teaching connects that identity of science learner further into the role of science teacher. The internalizing of reflection as an essential component of personal development for lifelong learning is an explicit goal of the entire teacher education program.

In Jeff's courses, these ideas of reflection are taken to a higher level of complexity with pre-service teachers' consideration of issues of political liberation and improving the situation of the disadvantaged. The teacher education program has a close partnership with the local Native American nation, and pre-service teachers work with the nation's educational leaders to address their educational goals. Issues of rural poverty and the environment are also central features of many reflective activities, such as the STS lesson. Figure 4-4 illustrates the complexity of reflection present in Jeff's program.

The graphic of Jeff's conceptions of and intentions for reflection reveals not a singularly purposed method aimed at the development of best practices, but rather a mosaic of ideas that interact with the context in which he teaches. These approaches provide pre-service teachers experiences in multiple orientations, with the most significant emphases on the personalistic and critical orientations. The outcome component is featured prominently in Jeff's descriptions of the science education

program, not as an added on characteristic exclusive to a methods course, but rather as a natural consequence of the philosophy of the entire institution.

Case Five: Phil

Phil is the science education faculty member at a mid-sized state university in an urban area of the west. This university, with an enrollment of around twenty thousand students, is one campus of a large state university system. The system prepares approximately sixty percent of the teachers in the state. The secondary science teacher education program is a fifth year, credential only sequence, graduating around fifty teachers each year. Phil has worked in science education for thirty-five years, and has been at this institution for twenty years. Prior to getting his doctorate and moving into higher education, he taught middle school science for fifteen years. He teaches the secondary science methods course, but does not supervise student teachers. He has also written two books for NSTA on the topics of integrating science and mathematics. Since his descriptions of reflective practice was limited to what happens in his science methods course, it is inappropriate to discuss the entire science education program, as was done in Jeff's more comprehensive account.

Phil's Personal Conceptions of Reflection

Phil's ideas about reflection, as shown in table 4-13, are less formalized than some others represented in this study. He takes an approach to the development of reflection that is understated and not necessarily explicit. He asserts a close connection between the practices of science and reflection, in their bases in evidence and being subject to change. Constructivist thinking is aligned with Phil's understanding of reflective practice. A major feature of Phil's beliefs about reflection is that it should be

180

enjoyable; practitioners should not view it as a task to be completed, but as a positive experience leading to a better understanding of themselves.

Influences on Phil's Personal Conceptions

Phil's ideas about reflection have emerged from two sets of experiences: his professional experiences as a middle and high school science teacher and his formal education in completing his doctorate. As a science teacher, he developed a practical approach to reflection based on an approach to teaching that rejected traditional curriculum from textbooks. Reinforcing this method were efforts that promoted inquiry pedagogy in science teaching. While working on his doctorate, he encountered the constructivist philosophies of Piaget and Vygotsky, which caused him to further problematize his thinking about teaching and learning. Dewey and Freire were other formative influences during this time.

External Influences on Phil's Conceptions

Students and the milieu of learning are the two commonplaces that influence Phil's ideas about reflection in his program. The teacher education program at Phil's university focuses on preparing teachers to serve in urban schools. The student population is highly diverse, with a high minority enrollment, greater than fifty percent Hispanic. As he recognizes in his statements in Table 4-13, this population of learners may lack confidence in their own learning, and bring negative ideas about science teaching and learning to the program. Consequently, a major aspect of his intentions for their learning concerns the development of positive attitudes and beliefs about science through reflective practice. Phil also brings recognition of the political realities of teaching to the program, emphasizing awareness of the impact of policy and accountability pressures.

Components of Reflection in Phil's Curriculum

The various methods course activities that serve as stimuli, content, process, and outcomes of reflection in Phil's program are presented in Table 4-14. Stimuli for reflection in the methods course frequently present different curriculum influences to pre-service teachers, such as state and national science frameworks and standards and trade books and journals focusing on science activities. The central teaching activity used as a stimulus for reflection is an inquiry activity presentation and analysis.

Content of reflection in Phil's class emphasizes decision-making about science curriculum. Questions of context are addressed in each occasion of reflection. In evaluating science activities from journals and trade books, pre-service teachers are asked to consider the relevance and feasibility of curriculum for their intended students and context. Phil encourages his pre-service teachers to make connections to the urban learning setting and minority learners. All stimuli, including state and national standards are examined through this lens of relevance and utility.

The processes of reflection are less explicit in Phil's class, where he makes more extensive use of in-class discussion than structured analyses. Phil models reflective practice by problematizing the good and bad in the standards and frameworks. This challenge to authority empowers his pre-service teachers to feel comfortable in raising their own questions about those official curriculum documents. The processes of reflection in Phil's class are meant to provide a comfortable environment for reflection, emphasizing sharing and community.

This emphasis on positive outcomes of reflection relates to Phil's understanding of his students. With a different population of learners, his approach might be different. His recognition of the attitudes and beliefs his pre-service teachers bring to the program

influences his methods course with its focus on development of professional identity and enjoyment of reflection on practice.

Orientations to Reflection within Phil's Curriculum

The major emphasis of reflection in Phil's methods course deals with decisions about curriculum. In Table 4-15, the different components of reflection are aligned with three orientations: reflection-in and on-action, deliberative, and personalistic. The process of reframing curriculum modeled by Phil follows the cycle of problem setting and reframing in Schön's orientation. The focus on development of practical knowledge is also consistent with reflection-in and on-action.

The deliberative orientation is closely matched with the approach taken in the program. Pre-service teachers interactions with various subject matter influences lead to decision-making about curriculum, based not on external criteria but on their understanding of their own learners and learning settings. Phil intends these experiences to enable his learners to develop confidence in their own personal judgment.

The development of a professional identity and positive personal beliefs are aspects of the personalistic orientation. Phil notes that the process of reflective journaling is an introspective one, not a public one. Again, his understanding of the personal characteristics of his pre-service teachers informs these orientations to reflection. These emphases of Phil's conceptions of and intentions for reflection in his curriculum are presented in Figure 5-5.

The graphic illustrates the significance of students' attitudes and beliefs in Phil's intentions for reflection, especially in his emphasis on the need for science teaching and learning to be an enjoyable experience. In a different context, his approach would not

183

necessarily focus so strongly on the identity development outcomes of the personalistic orientation. Phil also highlights the setting and context for learning in the ideas that his pre-service teachers reflect upon, considering the practical aspects of frameworks and standards in terms of usefulness for their own students. He focuses most explicitly on the deliberative orientation, encouraging the growth of decision-making and personal judgment through each component of reflection.

Case Six: Wanda

Wanda is a science educator at a public university in the middle Atlantic region. Her institution has an enrollment of approximately eight thousand students, and the middle and secondary science education program graduates around four teachers each year. In the program, students major in a science content area and select a particular content track in secondary education. The program is a three-semester sequence, with two separate science methods courses followed by student teaching. The two science methods courses are integrated with literacy methods. Wanda has been at her university for fourteen years, and prior to that worked as a science teacher for eleven years.

Wanda's Personal Conceptions of Reflection

Wanda's ideas about the meaning of reflection focus exclusively on decision-making. She was closely involved in the design of the teacher education program's conceptual framework, which echoes this emphasis. She views reflection as the vehicle for a journey of progress in the profession of teaching. Reflection is the way to make better decisions about a practice for which "there aren't answers to every situation they're going to encounter" (WI1, 248). The ultimate purpose she has for the

184

development of reflection by pre-service teachers is the ability to understand the reasons for their instructional decisions, as she articulates in the quotes in Table 4-16.

Influences on Wanda's Personal Conceptions

The major influences on Wanda's notions of reflection come from her professional experiences, both as school science teacher and university science teacher educator. These influences are highlighted in the second section of Table 4-16. Her experience as a school science teacher connects directly to her idea about decision-making. Careful deliberation on instructional decisions, and understanding the reasons behind those decisions, were central to her practice, leading to more effective decision-making in the future. The second major influence came from her involvement in science education professional associations, such as the Association for Science Teacher Education (ASTE). Her interaction with other science educators provided reinforcement and enhancement for her notions of reflection.

External Influences on Wanda's Conceptions

All three commonplaces of students, subject matter, and the milieu of learning have some degree of influence on how Wanda operationalizes her ideas of reflection. Influences from subject matter are captured in her statement in Table 4-16 relating to changes in the national science standards. While she acknowledges that changes in content emphases will occur through new common core standards, she is confident that the approach in place at her institution will manage that transition well.

The milieu provides a significant influence through requirements for teacher education program design and approval from the state. An important state requirement is for secondary teacher education programs to have two methods courses addressing reading in the content area. At Wanda's university, program coordinators decided to

integrate literacy with subject area methods, resulting in the two methods courses. As noted above, the conceptual framework is a relevant authority for the secondary science teacher education program. The emphasis on reflection from that framework is present not only in science methods, but throughout the entire set of programs.

When teacher education students begin the program, their capability for meaningful reflection is limited. Wanda recognizes this disposition, and feels the program of study needs to provide explicit instruction for the development of reflection, addressing student anxiety about honest reflection. Her program provides opportunities to move beyond their typically descriptive reflection in their early teacher education coursework.

Components of Reflection in Wanda's Curriculum

Consistent with the emphasis on reflection in the teacher education unit's conceptual framework, Wanda's science education program features a significant number of experiences explicitly designed for the development of reflective practice by pre-service teachers. These different assignments aligned to the stimuli, content, process, and outcome components of reflection are presented in Table 4-17.

Reflection is stimulated in the science/literacy methods courses through several specific assignments, which have concurrent field experiences. In the first course, pre-service teachers plan and deliver a science lesson in their field assignment, which is also videotaped. This videotaped lesson becomes the impetus for an action research project, in which they formulate a research question, collect and analyze data, and interpret their findings. Reflection is also engaged through the design of a unit science lesson plan. In another assignment, students examine their own beliefs about science by writing a science autobiography.

The content of reflection in these reflective assignments addresses multiple ideas about science teaching and learning. Effectiveness in lesson design and delivery is examined, considering achievement of learning objectives, use of assessment, unanticipated outcomes, and areas for improvement. The action research project includes examination of instructional decisions with a focus on solutions to the problem identified through reflective analysis. In the science autobiography, pre-service teachers problematize their own memories of meaningful science teaching and learning. Events occurring in field experiences are examined throughout the program.

Wanda's methods courses feature a series of explicit processes for the development of reflection, beginning with the videotaped science lesson. Guidelines for this lesson development and analysis are detailed for pre-service teachers, including the use of multiple resources for planning. Pre-service teachers present a ten-minute segment of the lesson to the methods class, including analysis of student work. A particular problem detected in the lesson becomes the question investigated in the action research project, for which explicit procedures are given. An additional authentic reflective experience occurs when pre-service teachers present their action research findings at a regional Professional Development Schools conference. The program includes both online and face-to-face discussions, in which pre-service teachers problematize aspects of course content and field experiences. Development of reflection is explicitly facilitated through the construction of a portfolio, an ongoing process throughout the program experiences. Analysis of portfolio artifacts focuses on three questions: What? So what? Now What? The portfolio serves as a culminating

assessment product demonstrating how pre-service teachers understand their decision-making.

While there are multiple and varied activities in the stimuli, content, and process components, the outcome component has a more singular focus. The outcome of reflection is straightforwardly expressed in Wanda's program. She wants to develop teachers who are independent thinkers who make effective decisions for student learning based on evidence.

Orientations to Reflection within Wanda's Program

The orientations on reflection in Wanda's program represent the reflection-in and on-action, deliberative, and personalistic orientations. Table 4-18 shows the alignment of the representative components with these orientations. Given Wanda's extensive involvement in and familiarity with the entire science education program, it is appropriate to discuss these orientations in the program, not merely the curriculum of her methods course.

Wanda's pre-service teachers make use of a problem they detect in their field experiences, which Schön characterizes as a reflective practicum. They then take this problem through the cycle of problem setting and reframing through the action research process. The result of this cycle of reflection-in and on-action is the development of practical knowledge.

The deliberative orientation is the most strongly manifested orientation in Wanda's program, with its emphasis on decision-making. Pre-service teachers interact with the commonplaces of students, subject matter, and the milieu of learning through their field experiences. They continuously consider their decisions about curriculum and instruction, drawing from multiple sources of evidence. They engage in individual and

collaborative reflection, analyzing decisions retrospectively and in anticipation of future events. The program focuses almost exclusively on the outcome of effective decision-making, consistent with this orientation.

There are some components that align with the personalistic orientation. These include the assignments that examine pre-service teachers' beliefs about science. The science autobiography, which is a more introspective exercise, is personalistic in nature. Certain aspects of the portfolio are personalistic, particularly with the focus on consideration of one's own rationale for selection of evidence to be included.

Figure 4-6 represents the relationships between Wanda's conceptions of and intentions for reflection. The explicit and detailed components of stimuli and process are highlighted in her program, as illustrated by the larger size of those elements in the graphic.

Similar to the graphics presented for Claire and Jeff, Figure 4-6 for Wanda illustrates a mature program, with specific aims for pre-service development in the deliberative orientation. Each component contributes to meaningful decision-making, with the stimuli and process experiences considered most explicitly. The unit's conceptual framework is naturally consistent with Wanda's emphases due to her involvement in its construction.

Case Comparisons

While each participant has a unique approach to reflection within his or her respective science education program, there are some patterns that bear further examination. Comparisons were made between the six science educators based on demographic characteristics in addition to their ideas about reflection.

189

Looking at demographic information on the six science educators, presented in Table 4-19, two broad categories are discerned: years of experience and influence over the science education program. Bob and Dan both have less than ten years of experience in their respective programs, and they also exert less influence over the curriculum in their science methods courses and teacher education programs. The four other faculty members, each with more than twenty years of experience, all consider themselves to have 100% influence over the curriculum in their science methods course, and in all but one case (Phil), they have 100% influence over the design of the science education program. When comparing these demographic patterns with Figure 4-8, which indicates the orientations to reflection emphasized, it is noted that Bob and Dan do not promote the more complex personalistic or critical orientations. The approaches they take in their science methods courses focus more on the technical and deliberative orientations.

This connection of the science educator to the design of the program is an important one. Of the six faculty members examined, three of them are not only highly familiar with the science education program, but control the curriculum for it. Their perspectives on reflection extend beyond the methods course, as in Jeff's case through his careful selection and cultivation of mentor teachers in field experiences. Due to their years of experience, Claire, Jeff, and Wanda participated in the development of the conceptual frameworks of their teacher education units, and have integrated their ideas about reflection into those documents. Bob is an out-of-unit faculty member (chemistry department), and has not participated at that level, so the reach of his ideas about reflection is more limited to the methods course only.

Another pattern worth considering is the set of influences on these participants'

conceptions of reflection, presented in Table 4-20. The most significant personal

influence comes from the experiences they have had as classroom science teachers.

They cited examples of how reflection has impacted their understanding of their own

teaching practice. Dan highlighted his involvement in the process of National Board

Certification as central to his conceptions of reflection. That influence is clearly seen in

his structuring of reflective assignments in the methods course that parallel the

reflective analyses completed by National Board candidates. Wanda also described

how her activities in science education professional associations have affirmed her

emphasis on reflection. Only two participants, Claire and Phil, cited their own formal

education as an influence on how they conceive reflection. They both identified specific

features of their graduate programs that imprinted on their current approaches, such as

Phil's connection of Freire's ideas to his own urban minority learners. By considering

these formative experiences, the meaning, value, and purpose of reflection of these

science educators are made clear, and connections to their own practice are

demonstrated.

Table 4-20 also identifies significant external influences on their conceptions of

reflection. As noted earlier, these influences occur as a function of the interactions of

the science educators with students, subject matter, and the milieu of learning. This is

clearly exhibited in the case of Bob, who referred to the deficit of awareness of his pre-

service teachers with respect to cultural and social diversity. From this student

influence, Bob endeavors to provide experiences that generate reflection on this specific

area. Several participants also acknowledged the influence of science subject matter.

Wanda noted that common-core standards would have an impact on how she approaches reflective assignments in the future. Every participant acknowledged the influence of the milieu of learning on their intentions for reflection, most often with respect to accreditation requirements. While Claire noted that meaningful reflection might be inconsistent with compliance-oriented rubrics, Dan saw opportunities for enhancing collaborative reflection as a result of an explicit process. There is also a connection between experience and how external influences are manifested. Bob and Dan, the least experienced participants, describe accreditation requirements as significant influences on how they approach reflection in their curricular decisions. This can be seen, for example, in Dan's incorporation of the Teacher Performance Assessment requirements into methods course assignments. Wanda, who has more experience than Bob and Dan, also acknowledged the influence of accreditation requirements, but clearly described reflection as a focus in the department that exists independently. She noted, "It's something that we as a department believe in and hold as truth within our whole entire program" (WI1, 35-36). For the educators in this study, experience is a factor that enables more flexibility in how they implement course activities that promote reflection.

These influences do not act in isolation, exclusive to each other, but rather impact approaches to reflection in an interactive way. An example of this interaction is evident in how Jeff's emphasis on a science-technology-society curriculum, a subject matter influence, is related to his recognition of the milieu in which his pre-service teachers operate. Personal and external influences are also not completely absent or present for

any science educator, but are identified in Table 4-20 based on their significance in interview dialogue

In Figure 4-7, I present the emphases of the six participants on the different components of reflection. While each component was present in each case to varying degrees of importance, there were more prominent components for different participants. All six science educators clearly articulated the role of various course and program activities in stimulating reflection with pre-service teachers. Content and process were strongly emphasized by three participants, Bob, Claire, and Phil. Process was strongly emphasized by Claire, Dan, and Wanda. Outcome was a significant feature of four participants' approaches. Claire was the only participant who articulated a significant emphasis in all four components of reflection. In Chapter 1 I made a case that science educators should consider each of these components as a way to understand and frame the reflective tasks in their curricula. Although all six science educators do address each component, there is some risk in ignoring particular components at the expense of others. If content is neglected, the ideas considered in reflection may degenerate into simple teaching behaviors, rather than the more complex ideas of beliefs and relationships and that can be examined with more explicit direction. Likewise, if the process component is neglected, the activities through which pre-service teachers learn how to reflect may consist solely of journaling.

Figure 4-8 illustrates the orientations to reflection within the science teacher education curricula of the six participants. Just as the review of the science education literature revealed approaches in programs and courses that spanned across orientations, no science educator in this study manifested a singular orientation. Unlike

the identification of components, each of which was present to some degree in each intended curriculum, the presence of particular orientations was more distinct, and specific orientations were absent for each participant. The deliberative orientation, focusing on effective decision-making about curriculum and instruction, is the only common orientation of all six science educators' curriculum. The reflection-in and on-action orientation and the personalistic orientation are identified in four programs. The technical orientation, focusing on effective instructional behaviors based on best practices, is present in only two programs, those of Bob and Dan. Bob and Dan are also identified as the science educators with the least years of experience and the least influence over course and program curriculum. Jeff's program, with its connections to regional issues of the Native American nation and rural poverty, is the only program with a critical orientation. Recognizing the orientations to reflection within these programs is critical in order to understand how reflection is conceived and intended by science educators. As Valli (1997) suggests, teacher education programs should endeavor to provide meaningful experiences in reflection across all orientations, addressing questions ranging from teaching effectiveness based on best practices to issues of equity and oppression.

Table 4-1. Bob's conceptions of reflection and influences on those conceptions.

	Quotes from Bob's interviews and documents.	
Personal conceptions of reflection	Fred: How does your own experience influence your perspectives on the development of reflection? Bob: I guess one of the things I feel is that we don't learn very well about teaching in a vacuum. . . if it's [reflective practice] not attached to anything, to no context, I think it makes it very difficult or students to process. I guess what I'm trying to do with them is to provide them with some very specific contexts to illustrate specific points on how teaching is maybe more complicated than they thought (BI1, 139-149). We sort of want to get them to internalize this reflective nature and not have to depend on an external regard. We want that intrinsic motivation in there. We want that to become part of them (BI1, 57-59).	
Influences on personal conceptions	Fred: How do you engage your pre-service science teachers in reflection? Bob: I use a lot of personal examples from when I taught K-12, how I thought I had designed a very good activity and the kind of things that I obviously failed to take into consideration before handing it out, to give them an idea of the kind of thought that is needed before doing an activity, the kind of things that maybe don't occur to you because of your background, because of your preparation (BI1, 4-18). I pull them [personal examples] from my own personal experience, I guess. . . obviously I reflected on them quite a bit after they happened, which is maybe why I then selected them to use as reflection in the methods course; because they had an impact on my teaching (BI1, 152-154). I grew up as a military brat. I lived in Tampa for three-four years. I've been all over the country and I have different perspectives and I realize everything isn't Midwest (BI1, 206-207).	
External influences on conceptions	Subject matter	Often these case studies do involve some interesting ethical issues like the teaching of evolution, the tradeoff of making an assignment authentic vs. violation of privacy (BD1, 19-21). [An experience] I had with my student teacher the other day: they were doing cheek cells under the microscope, with mounts they were making of their own cheek cells. I asked, "Did you check in to any kind of concerns about that?" . . . [The student teacher responded] "Oh, no problem. We did it in college." I look over at his cooperating teacher and he's like, "No, there's no problem with that." So I go to the NSTA website and find out where these are not recommended for use anymore and sent that to them (BI1, 163-169).

Table 4-1. Continued

Students	How do you get students to do things like this reflective journaling? You have to grade them. You have to assign sufficient amount of points to them to make it worth their while to provide that external stimulus (BI1, 54-47).
	They miss the bigger picture. I think that's indicative of teaching in general and that we often think teaching the way we were taught, even if those methods are outdated, is best. Teaching the way we think would work best for us, even if the rest of the world isn't like us (BI1, 181-184).
	The reality is that these students are not aware of life outside of themselves and it's hard for them to become aware. . . There are a lot of our students who have never been out of the state by the time they graduate (BI1, 195-201).
Milieu	[Students complete] a series of reflections after videocase studies/case study readings. Most of these are chosen to specifically address some aspect of the Board of Teaching standards. Our accreditation has become exceedingly tedious and we must show a unique assignment in the syllabus for each standard (BD2, 13-16).
	We're one of these states that is an early adopter for the TPA [Teacher Performance Assessment]. There is a lot of reflection that's built into that and we're currently modifying a lot of the instruction in the ed core to increase the amount of reflection (BI1, 33-35).
	The problem we have here a little bit is we have three reasonably large universities in the one metropolitan area, that there isn't another metropolitan area for over seventy miles, which then means with the amount of early field experience in the classroom, we have placement issues. So getting teachers to take students to teach one lesson when they're already overburdened with all of these others, it's easier for something like this to go into a less formal setting (BI1, 123-128).

Table 4-2. Components of reflection in Bob's science teacher education program.

	Stimuli	Content	Process	Outcome
Methods Course	Case studies	Other people's teaching	Discussion	Accreditation outcomes
	Videocases	Central ideas of science teaching	Written lesson plan analysis	Effective decision making
	Personal examples		Lesson delivery conference	Intrinsic motivation
	Alternative Learning Center lesson delivery			Understanding the complicated nature of teaching
Student Teaching	Lesson planning and delivery	Lesson plans	Weekly prompted journal writing	
	Outreach events	Issues arising from their own unique teaching episode	Student teaching observation conference	
		Changes to instruction from feedback and own perceptions		
		Relationship of activities to standards		

Table 4-3. Orientations to reflection as identified by components in Bob's program.

Component	Stimulus	Content	Process	Outcome
Technical	Lesson delivery		Writing, Supervisory conference	
Reflection-in and on-action	Case studies, Personal examples	Unique situations		Repertoire of knowledge
Deliberative		Multiple perspectives, Instructional decisions		Decision making
Personalistic				
Critical				

Table 4-4. Claire's conceptions of reflection and influences on those conceptions.

	Quotes from Claire's interviews and documents
Personal conceptions of reflection	Fred: Reflection is the way to the next paradigm? Claire: It's the way to everything. It's the way of what to do tomorrow in the classroom, next year what you're going to do different from last year. Gets you out of this "I'm perfect" mindset, or "If you would just give me the right answer, I would go do it;" instead of looking for you to be creative and critical in your thought processing (CI1, 174-176). We want you to enjoy the idea that you're being asked to think deeply about that same question, "What is happening here?" every time you see this model [5E learning cycle lesson plan] in practice, including when you use the model (CD3, 54-56).
Influences on personal conceptions	Fred: Where did your deliberate emphasis on reflection come from? Claire: Wow—that's a lifetime. I guess even my own undergraduate teacher preparation. . . It was a very unique program because we did a summer set of coursework and then the next year we were in student teaching all day every day for really the whole year. . . So my program started me out with a huge amount [of reflective practice]. . . Then I did my master's and doctoral work . . . and was involved with several grant projects . . . [The grant director] was a huge proponent of reflective practice . . . So nobody ever let up on me on the reflective practice. Then the whole action research movement came along which is really about causing people in the classroom to be reflective (CI1, 115-137). The Max van Manen work on psychological tact . . . that's a great source on what you should be reflecting on, how to reflect on it. That was one of the very early books that I was introduced to in my career (CI1, 154-156).

Table 4-4. Continued

External influences on conceptions	Subject matter	When you think about science teaching, there certainly are standards and thoughts we have about doing science, how we do science, why we do it, and I guess I really do want you to know what the documents say. I want you to have an understanding, content-wise, of what they mean and where they came from (CI1, 26-29).
	Students	Fred: Is there a common source of resistance [to reflecting]? Claire: It's all about control and their fear of losing control and not understanding, even though most of them are very recently adolescents themselves, and some of them may still be adolescents themselves. . . Most of the students that get here have been raised in such an authoritarian, dictatorial manner and they think that's how you do science CI1, 41-59).

Fred: What comes up that gives you trouble? Claire: People [students] don't want to do it (CI1, 139-140). |
| | Milieu | Fred: How would you characterize the role of external forces such as NCATE in your program? Claire: NCATE may have caused us to put more rubrics around it [reflective practice assignments]. Putting rubrics around things means that you have answers you think you should be looking for. I'm not assured that the best of reflections always have answers you should be looking for. In fact, a lot of times you should be looking for a new answer that has a combination or something that hasn't been used before. (CI1, 179-187). |

Table 4-5. Components of reflection in Claire's science education program.

	Stimuli	Content	Process	Outcome
Methods Course	Inquiry lesson plan	Learners	Weekly questions to ponder—journals unseen by Claire	Analysis of instruction for planning
	Videotaped lesson delivery	Inquiry teaching and learning		Learning for all
		Lab experiences		
	Course readings	Collaboration	Video analysis	Understanding of own instructional decisions
		Complexity of teaching	Concept mapping	
	Nature of science paper	Resonance/dissonance of own ideas about teaching	Ethnographic study of self	Understanding the art of teaching
			Inquiry lesson self-evaluation questions	Understanding self in relation to learners
Field Experiences	Practicum experience		Journaling	

Table 4-6. Orientations to reflection as identified by components in Claire's program.

Component	Stimulus	Content	Process	Outcome
Technical				
Reflection-in and on-action				
Deliberative	Subject matter	Instruction, subject matter, learners	Video analysis	Instructional decision making
Personalistic	Teaching performance	Personal beliefs about science teaching & learning	Introspective journaling Concept mapping Ethnographic study of self	Understanding self
Critical				

Table 4-7. Dan's conceptions of reflection and influences on those conceptions.

	Quotes from Dan's interviews and documents
Personal conceptions of reflection	It's all, everything you do, is about reflecting on how your actions and decisions impact or don't impact student learning (DI1, 97-98). I think reflective practice has a bad connotation of always being a singular, isolated, me and the student behind closed doors kind of activity . . . the most productive reflective practice takes place in a learning setting with colleagues (DI1, 153-156). They're [pre-service teachers] always having to examine what they do in light of what they want to do or in light of outcomes and identify and critique themselves. So that, to me, is a reflective process. I think that those are skills people learn to develop. Very often we don't spend enough time thinking about or self-evaluating our work or the work of others in any kind of organized or constructive way and making sure that reflective piece is part of the routine of teaching helps to embed it in what you do (DI1, 207-212).
Influences on personal conceptions	I think I learned about reflective practice when I became a national board candidate. Board certification at that time was a grueling adventure, one that focused almost entirely on reflection. Reflection of planning, reflection of learning, reflection on practice, inquiry, discussion, reflection on collaboration, contributions to the community, the professional community (DI1, 94-97). Fred: Explain to me how the Wiggins and McTighe framework, the enduring understandings relate to this whole process of being a reflective practitioner. Dan: One of the ways to make the study of teaching longer lasting, more meaningful; you learn about it, you discuss it, question it, and then you actually use it. It's in that process of applying the knowledge to a situation with students, that is where the real learning takes place and then the opportunity to then further reflect on that learning in a metacognitive manner adds to the quality of the experience, and because of that entire constellation of activities and learning, the students come away with a more profound understanding of what it means to teach science in today's world (DI2, 61-68).

Table 4-7. Continued

External influences on conceptions	Milieu	We have instituted a more robust teacher performance assessment based on the California model [Teacher Performance Assessment] and a major part of that exercise is to reflect on practice by looking at planning, videotapes of planned instruction, and reflecting on student learning, so reflection is throughout that process and each of those components becomes embedded in the coursework they do (DI1, 10-14). [An important aspect] is the role of emerging technologies in reflection. Both at the individual and at the collaborative level. There are technologies available today that weren't available two-three years ago that make reflection not only more efficient but more seamless with practice. Anything from Twitter to computerized dictation to video cameras in your phone to social networks. It just goes on and on, the potential for reflection to become a more embedded part of practice and more transparent (DI1, 157-162).

Table 4-8. Components of reflection in Dan's science education program.

	Stimuli	Content	Process	Outcome
Methods Course	Videos of other science teachers modeling instruction	Successful & unsuccessful aspects of lessons	Online discussion forum	Question their own instructional decisions
	Videotaped scientific inquiry mini-lesson		Prompted analysis of lesson planning and instruction in two different videos	Understand complexity of the science classroom
	Videotaped whole class discussion mini-lesson			Appreciation of the importance of reflection

Table 4-9. Orientations to reflection as identified by components in Dan's program.

Component	Stimulus	Content	Process	Outcome
Technical	Video of exemplary lesson delivery	Teaching behaviors	Written answers to questions	
Reflection-in and on-action				
Deliberative	Lesson delivery	Decisions in lesson planning and delivery	Retrospective analysis, individual and collaborative	Effective decision making
Personalistic				
Critical				

Table 4-10. Jeff's conceptions of reflection and influences on those conceptions.

	Quotes from Jeff's interviews and documents
Personal conceptions of reflection	We think of [reflection] as a fairly normal thing to be concerned about as far as preparing future teachers; that they be lifelong learners and as part of that process they need to be reflective practitioners (JI1, 25-27). Reflective Practitioner models inquiry, practice, and reflection effectively uses research-based models of curriculum, instruction, and assessment meets the diverse learning needs of students applies knowledge of local, state, and national standards effectively uses instructional and assistive technology promotes inquiry, critical thinking, and problem solving creates positive learning environments for all students uses research, reflection and discourse throughout one's career prepared to become an instructional leader (JD2, 71-80) Reflection provides the foundation for innovation and change (JD2, 176-177).
Influences on personal conceptions	Fred: It's apparent that reflection is valued highly. Where did that come from? Jeff: That concept existed here when I came here and so it seems to be pretty pervasive here. . . It's not just the school of education as I think about this. Even though we're a state university we are somewhat unique in the system. . . We are one of the university colleges where you have BA and Master's degree programs and in the system we are relatively small. . . One of the reasons for that is kind of an emphasis on students having access to faculty . . . so the idea of reflective practice is kind of like part of the environment of not only our college and university and our school of education and out program but it's also an element that's considered important in this particular region where we are (JI1, 291-313).

Table 4-10. Continued

External influences on conceptions	Milieu	The main problem we have is because we are small and the school districts we are working with are small, is being able to sustain a consistency . . . in our arrangements with our mentor teachers and our students. In other words, we can't use the same mentor teacher over and over and over again. . . So the main constraints, for instance, when I mentioned the things that were dear to my heart, working with the [Native American] Reservation, there's only one biology teacher there and one chemistry teacher there, so if I've got twenty students, I can't be putting more than one biology student down there in any given semester. . . In secondary science it's difficult because in small school districts you have a limited number of biology teachers, chemistry teachers, physics teachers to work with (JI1, 316-327).
		Many of the placements that we have in addition to having the [Native American] nation; we also have a number of rural school settings. . . We have one local town that had mines and then the mines are closed. . . In each town there are issues that are significant to the local people and we consider that an important element for our students to become aware of and involved in (JI1, 140-145).
	Subject matter	One of the directions is they need to try and identify a topic which is science-technology-society related that would be of interest to the population of students that they're going to be working with when they do their student teaching. So in our area, for instance, we have [mining]. We have a lot of farming communities. . . You have to identify an issue that is not easily resolved. You can't do global warming where everyone will probably agree on the same outcome (JI1, 113-124).

Table 4-11. Components of reflection in Jeff's science education program.

	Stimuli	Content	Process	Outcome
History and Nature of Science Seminar	History and nature of science course readings	Own conception of science and role in doing science	Self-reflection paper of own experience related to seminar topics	Science as fluid knowledge Understand complexity of the science classroom
Science-Technology-Society Course	STS local interest lesson plan	Relevance of lesson to local community		Appreciation of the importance of reflection
Science Methods Course & Field Experience	Local school activities—science fair projects, website design, local investigations 5E lesson plan		Mentor teacher collaborates with science education faculty throughout field experiences & student teaching	Address Native American nation educational goals Engage in issues related to rural poverty and minority issues
Student Teaching	Student teaching experience	Student learning Management Instructional experiences	Student teaching journal Autobiographical sketch Student case study	

Table 4-12. Orientations to reflection as identified by components in Jeff's program.

Component	Stimulus	Content	Process	Outcome
Technical				
Reflection-in and on-action			Mentor teachers collaborating throughout program	
Deliberative			Student case study	Complexity of science teaching
Personalistic	History and nature of science issues	One's own conceptions of science and role in doing science	Self-reflection writing connecting own experience to curriculum Autobiography	Appreciation of reflection for personal development
Critical	Lesson plans and school activities of interest to the local community	Relevance of lessons to community		Issues of rural poverty Minority educational issues

Table 4-13. Phil's conceptions of reflection and influences on those conceptions.

	Quotes from Phil's interviews and documents
Personal conceptions of reflection	Fred: I get a sense that the real approach you have to reflection is understated rather than structured. Phil: It's definitely understated. It's not structured. I don't know that if you asked my students about a reflective piece of the class, I think they'd have to really think about that. But I like that because I know it's in there. If they're doing it, I'm happy but it's definitely understated (PI1, 75-81). Science is reflective. It's not surprising to me that the math and science people were the constructivists, who really pushed constructivism who really are the reflective practitioners. . . We really have to be [reflective]. It's part of the process of what we teach. It's the nature of science. Nothing's a given and everything's kind of subject to evidence (PI1, 175-179). Who doesn't like to reflect on their practice? I think it's kind of fun for them to see their voice matters as much as mine in the class (PI1, 207-208).
Influences on personal conceptions	I was a middle school teacher for fifteen years before I did this job. It [reflection] was just part of what I did. I've never been a big fan of textbooks. . . I found it just wasn't working. . . It was a grass roots thing here, the whole inquiry direction. You had to reflect to do that (PI1, 127-133). I'm working on my Ph.D. [in the 1980s] . . . and it made me even more reflective. I'm trying to learn new things and maybe put some of it into practice. The whole push of Piagetian and Vygotskyan constructivism was a really huge factor to clarify all that, and of course reflection is a huge bit of that. Paulo Freire and that whole kind of reflective practice and just reading it, doing it, living it, and writing about it (PI1, 137-142).

Table 4-13. Continued

External influences on conceptions	Milieu	Real life is reflective and teaching should be too, but it's hard to make money from textbooks when people are being reflective (PI1, 186-187).
		I pretty much lay it out [the realities of teaching] for them. "Here's what you're going to face." We take a real close look at merit pay and why, at face value, it looks good, and what evaluation means (PI1, 45-47).
	Students	Fred: Is there a field component that goes with this? Phil: Technically they're supposed to do some observations, but they've done so many observations. . . I encourage them to watch other people but so many of our students are parents and returning students and working two jobs. . . It would be nice but it's not so realistic for these guys and I want them to leave this class with a really positive feeling (PI2, 18-25).
		They've had a lot of years of traditional teaching that they've sat through. I think they're not quite prepared. They're young and they haven't really realized they have a voice yet. They don't recognize their own voice and their value (PI1, 213-215).

Table 4-14. Components of reflection in Phil's science education program.

	Stimuli	Content	Process	Outcome
Science methods	Science activity presentation and summary NSTA books State and national standards Review of NSTA journal article	How would activities work with my students in my setting How could standards be implemented or adjusted based on my context What is good and bad in the standards and frameworks Will this be useful to me and my students	Small group discussion Sharing experiences and insights with the whole class Modeling reflective practice; problematizing framework and standards Unprompted journaling	Development of professional identity Positive attitude about science teaching and learning Enjoyment of reflection on practice Practical ideas for use in my classroom

Table 4-15. Orientations to reflection as identified by components in Phil's program.

Component	Stimulus	Content	Process	Outcome
Technical				
Reflection-in and on-action			Reframing curriculum into my own setting	Practical knowledge
Deliberative	Curriculum choices	Decisions about curriculum	Collaborative problematizing of curriculum	Meaningful decisions and personal judgment
Personalistic			Introspective journaling	Professional identity
				Personal development of positive beliefs
Critical				

Table 4-16. Wanda's conceptions of reflection and influences on those conceptions.

	Quotes from Wanda's interviews and documents
Personal conceptions of reflection	We believe in teachers as decision makers. . . who are disposed to question and reflect continuously in pursuit of sound educational judgments (WD3, 150-153).
	We hope as you progress across years of teaching, you move along that continuum and don't stay where you started. . . There aren't answers to every situation they're going to encounter. . . If you teach them to think and teach them to make decisions based on something other than just a hunch then they're more likely to make better decisions (WI1, 243-250).
	When I put those [action research] experiences in I had a very specific goal in mind. I know what I wanted my students to think about and then when we bring it back together, we always talk about that stuff after they do it. We don't just leave it at what they've written on paper. When we come back together, I often start with the question "why do you think I had you do that?" I think it's important for them to know why they do the things they do (WI1, 285-289).
Influences on personal conceptions	One thing I realized when I was a public school teacher is that when I took time to think about why I made decisions, I made better decisions. I think that a lot of times teachers do things and they don't think about why they do them. I think it's really important that when we're sending brand new teachers out in the field . . . to understand that they need to think about what's going to happen with the decisions they make (WI1, 26-29).
	I do a lot of reading of the journals. I have been active in the past in NARST but I'm also active in ASTE now. I have met a lot of people who basically do the same job that I do and we have these wonderful conversations at those meetings about what we do in our methods courses and there's a group of us that really believe you have to teach teachers to think about what it is that they do in terms of practice (WI1, 45-49).

Table 4-16. Continued

External influences on conceptions	Milieu	All of our content methods . . . have an integrated literacy [component] with them because the state requires all secondary teachers to have two content reading methods courses and we decided to put them into our content methods so the students would know how to use the strategies to teach their specific content (WI1, 19-23).
		Our conceptual framework really is the document that we live by. We put a lot of time into writing it and reflection is such an integral part of that document and it runs throughout all the strands of the undergraduate and graduate programs and we really believe that it is one of the keys to success to our students (WI1, 70-73).
	Students	Fred: Students are heavily influenced by the current emphasis on accountability . . . and they tend to be very nervous about really candid reflection. Wanda: The reflective process can be very painful because often times you're admitting things you're not very good at or you need to work on or you need to look at in a different way and that could be whether you're talking about assessment in your classroom or teaching the standards or whatever's happening. That kind of stuff is not very easy to look at yourself honestly and know that you're not doing probably the best job that you can do. I think it's a painful process. It's like when we make them watch the videotapes of themselves. It's a great activity if they'll take it seriously enough and do it but it's not an easy thing for them to do (WI2, 1-11).
		One of the things you have to do is teach your pre-service teachers to be reflective. What they tend to do is just summarize whatever happened instead of giving you any of that deep thought about why they made the decisions they made or why they encountered the problems or concerns they had when they were teaching and I think that's kind of hard to get students to do that (WI1, 54-57).
	Subject matter	Fred: With the changes that are coming with the common core standards and things like that, are you going to realign what goes on with the portfolio? Wanda: We'll have to. . . The new changes that are happening, we will change them once they've been officially adopted as well. Common core will definitely have some influence. We still discuss the draft of what that looks like now. I'm trying to digest that and try to figure out what we're going to do with it (WI1, 208-213).

Table 4-17. Components of reflection in Wanda's science education program.

	Stimuli	Content	Process	Outcome
Science methods and literacy courses	Science lesson taught in field experience and videotaped Action research project Science unit lesson plans Science autobiography	Lesson delivery evaluation Interpretations of action research findings Memories of science learning, characteristics of meaningful science experiences, definition of science Events occurring in field experiences	Analysis of videotaped lesson Action research plan based on videotaped lesson Presentation of action research findings at regional professional development school conference Science autobiography prompts Online discussions Portfolio construction Philosophy of teaching statement Face-to-face discussions in field experience seminar	Teachers who are independent thinkers Make decisions based on student learning Effective decision-making based on evidence

Table 4-18. Orientations to reflection as identified by components in Wanda's program.

Component	Stimulus	Content	Process	Outcome
Technical				
Reflection-in and on-action	Problem present in field experience lesson		Problem setting and reframing in action research	Practical knowledge developed from action research
Deliberative	Interaction with students, subject matter, schools	Decisions about curriculum and instruction	Collaborative discussion	Effective decision making
Personalistic		Own personal beliefs about science	Autobiography Portfolio	
Critical				

Table 4-19. Demographic information on participants.

	Bob	Claire	Dan	Jeff	Phil	Wanda
Years of experience	8	22	10	30	35	25
Years at institution	7	19	6	25	20	14
Methods course influence	50%	100%	75%	100%	100%	100%
Program influence	25%	100%	50%	100%	50%	100%

Table 4-20. Influences on participants' conceptions of reflection.

Participant	Bob	Claire	Dan	Jeff	Phil	Wanda
Personal experiences	YES	NO	NO	NO	NO	NO
Professional experiences	YES	NO	YES	YES	YES	YES
Education	NO	YES	NO	NO	YES	NO
Milieu	YES	NO	YES	YES	YES	YES
Subject matter	YES	YES	NO	YES	NO	YES
Students	YES	YES	NO	NO	YES	YES
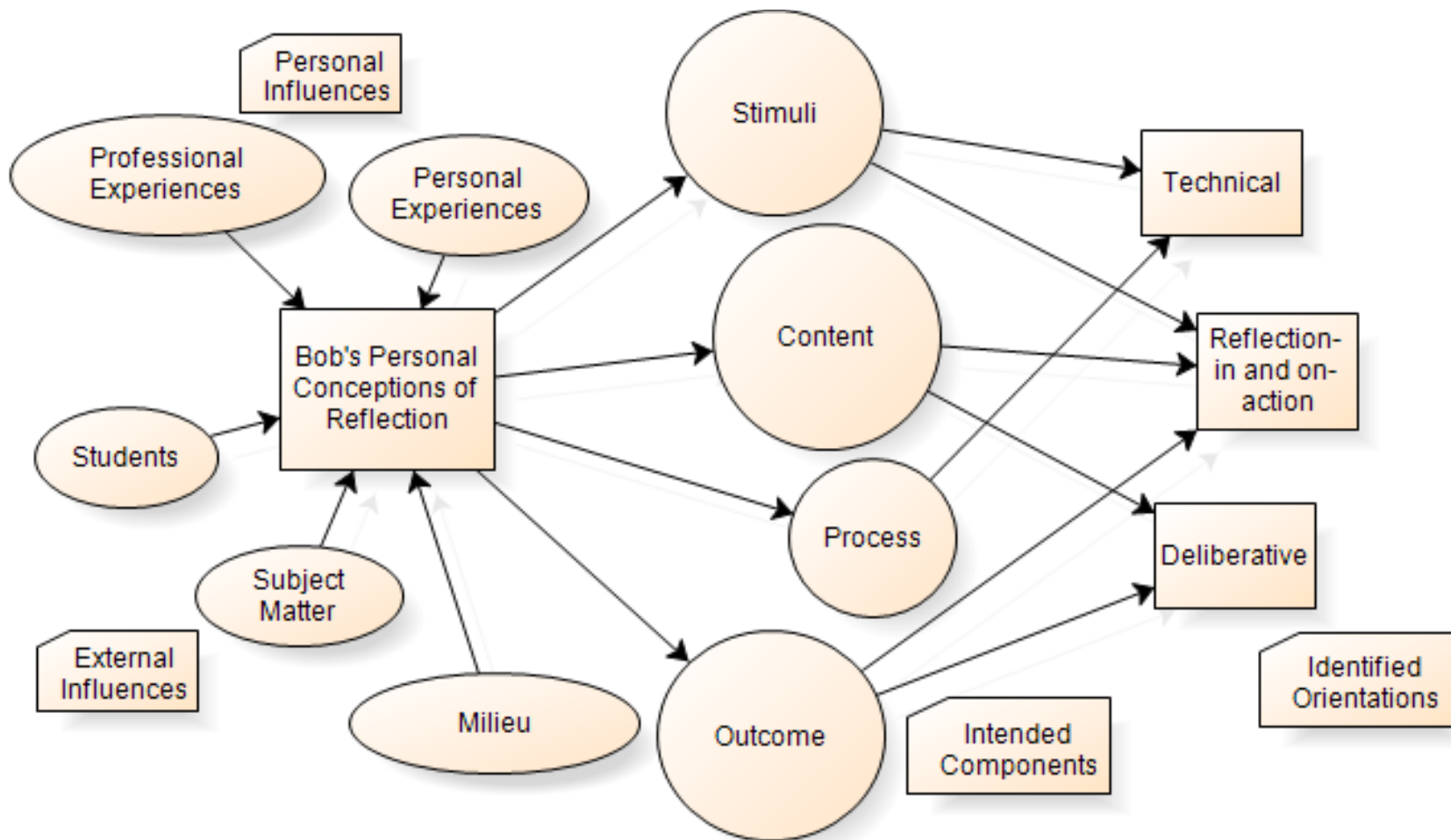
Figure 4-1. Bob's conceptions and intentions for reflection in science teacher education. The relative sizes of different elements indicate their difference in emphasis in Bob's thinking about reflection.
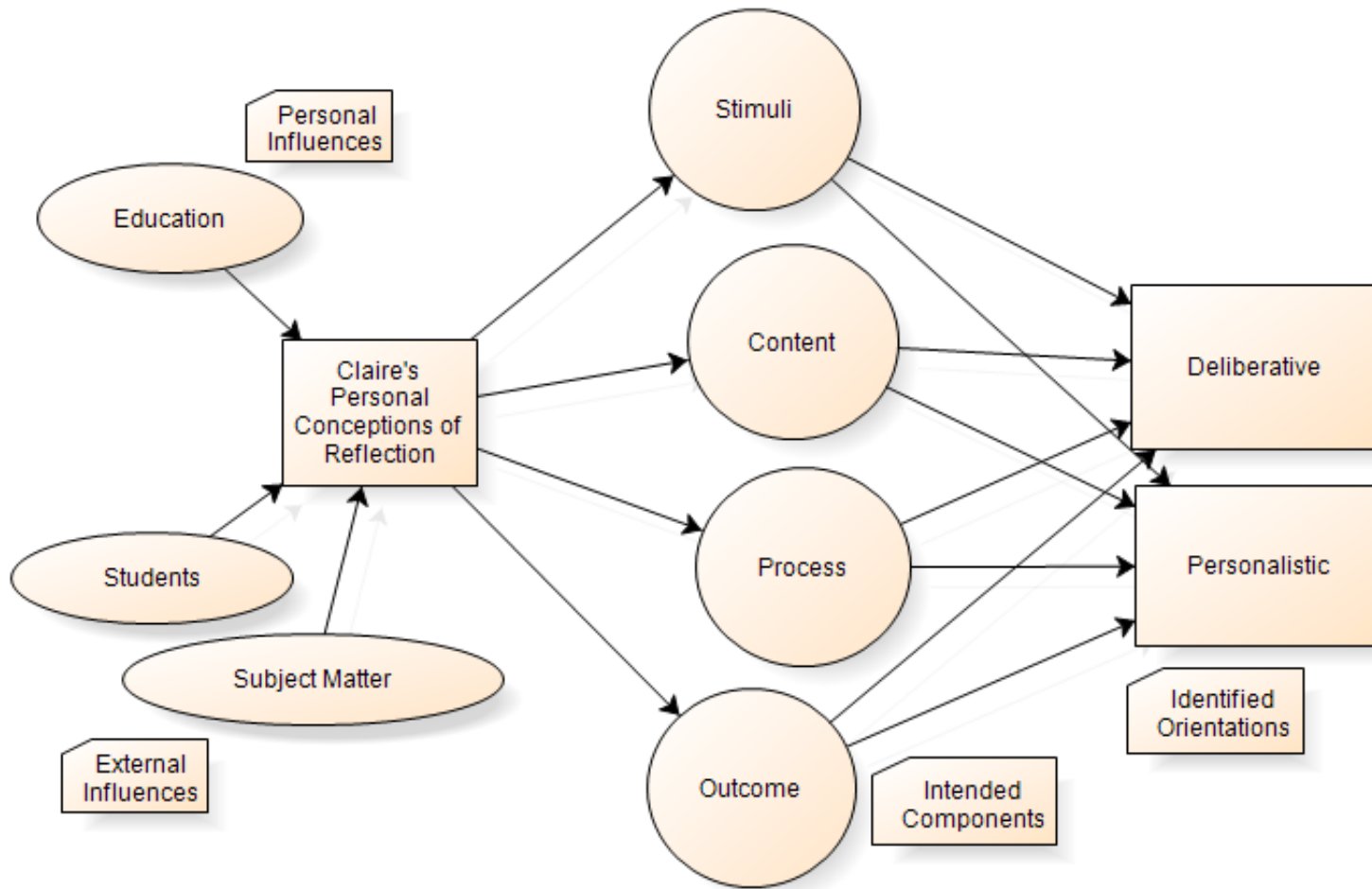
Figure 4-2. Claire's conceptions of and intentions for reflection.
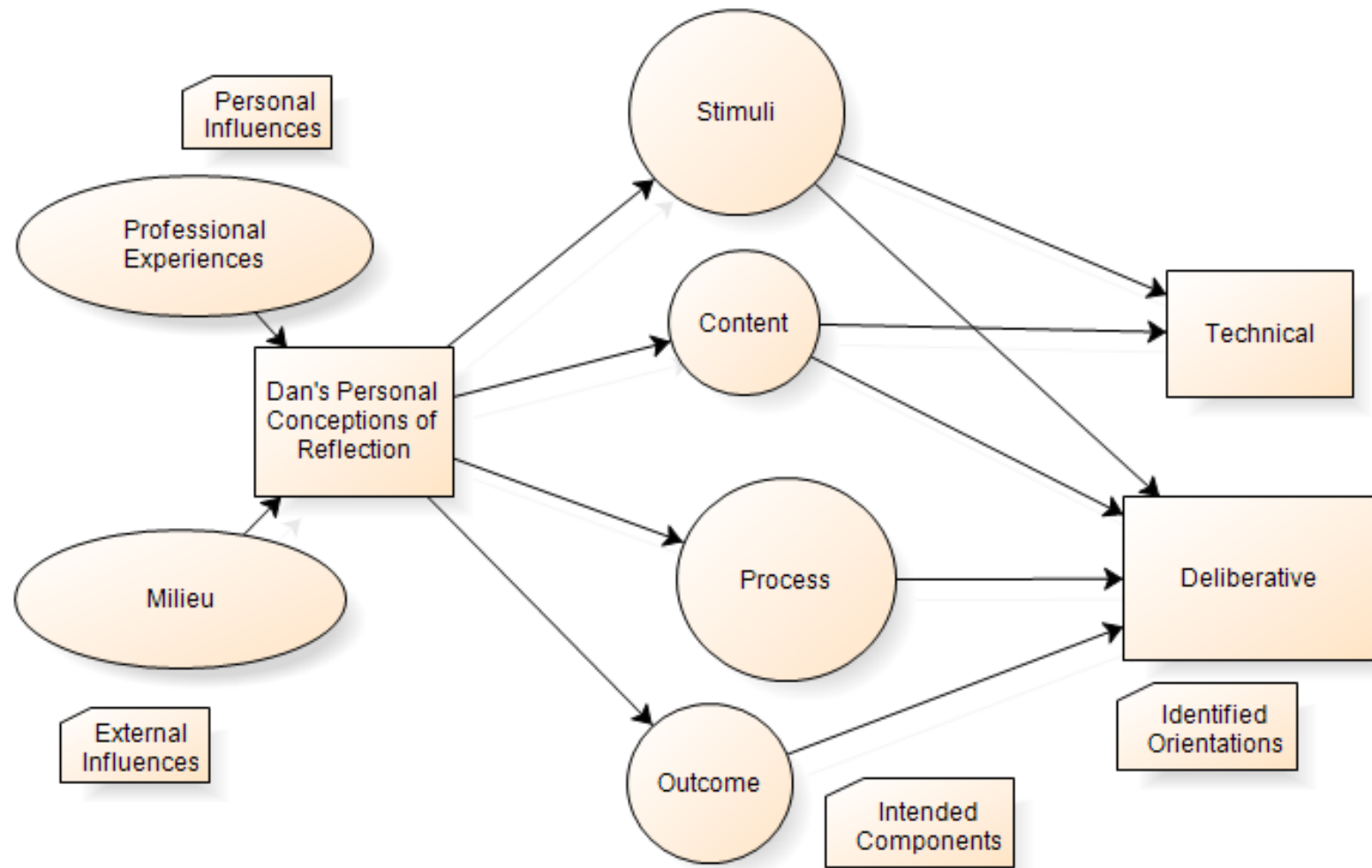
Figure 4-3. Dan's conceptions of and intentions for reflection.
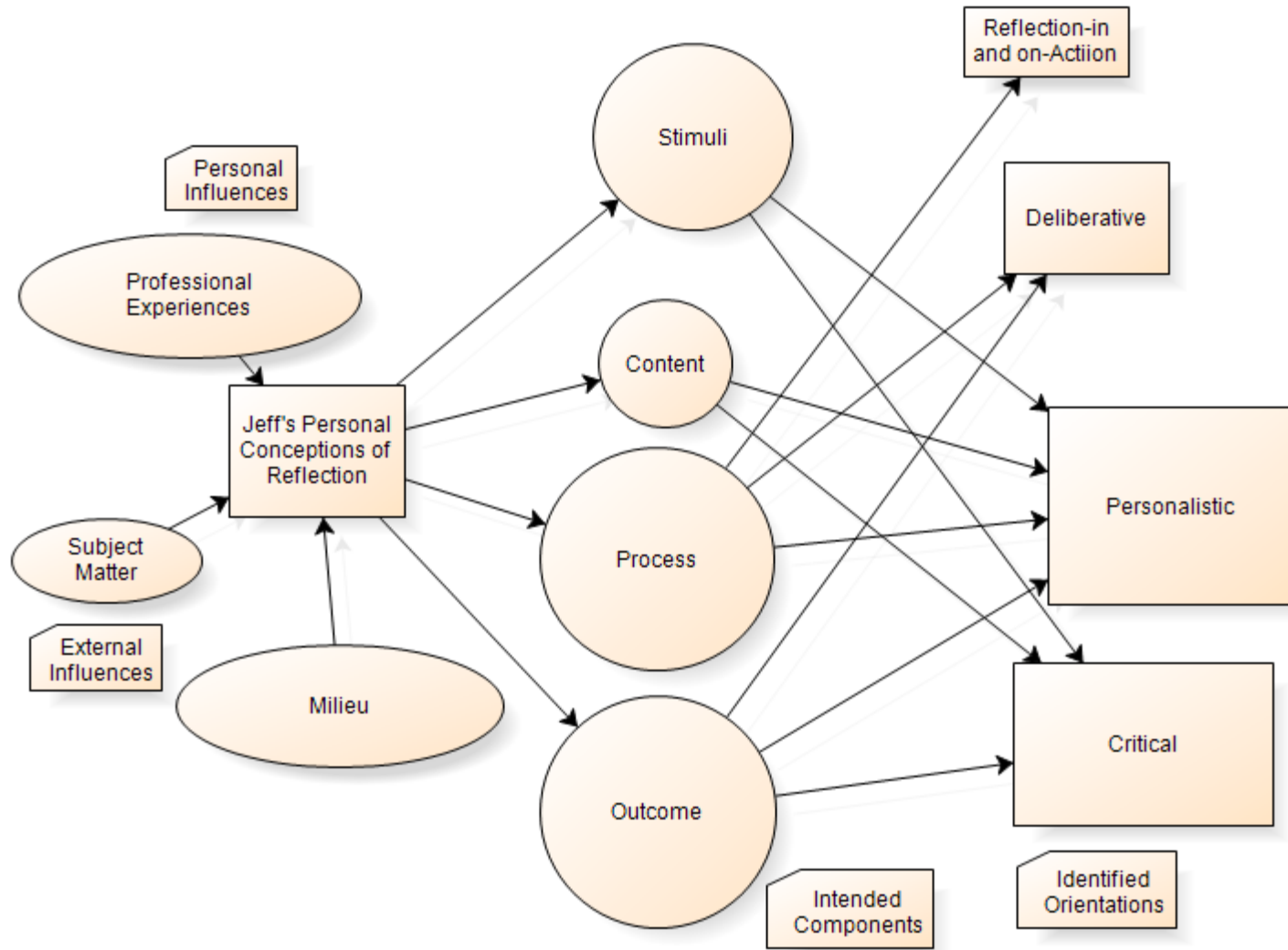
Figure 4-4. Jeff's conceptions of and intentions for reflection.
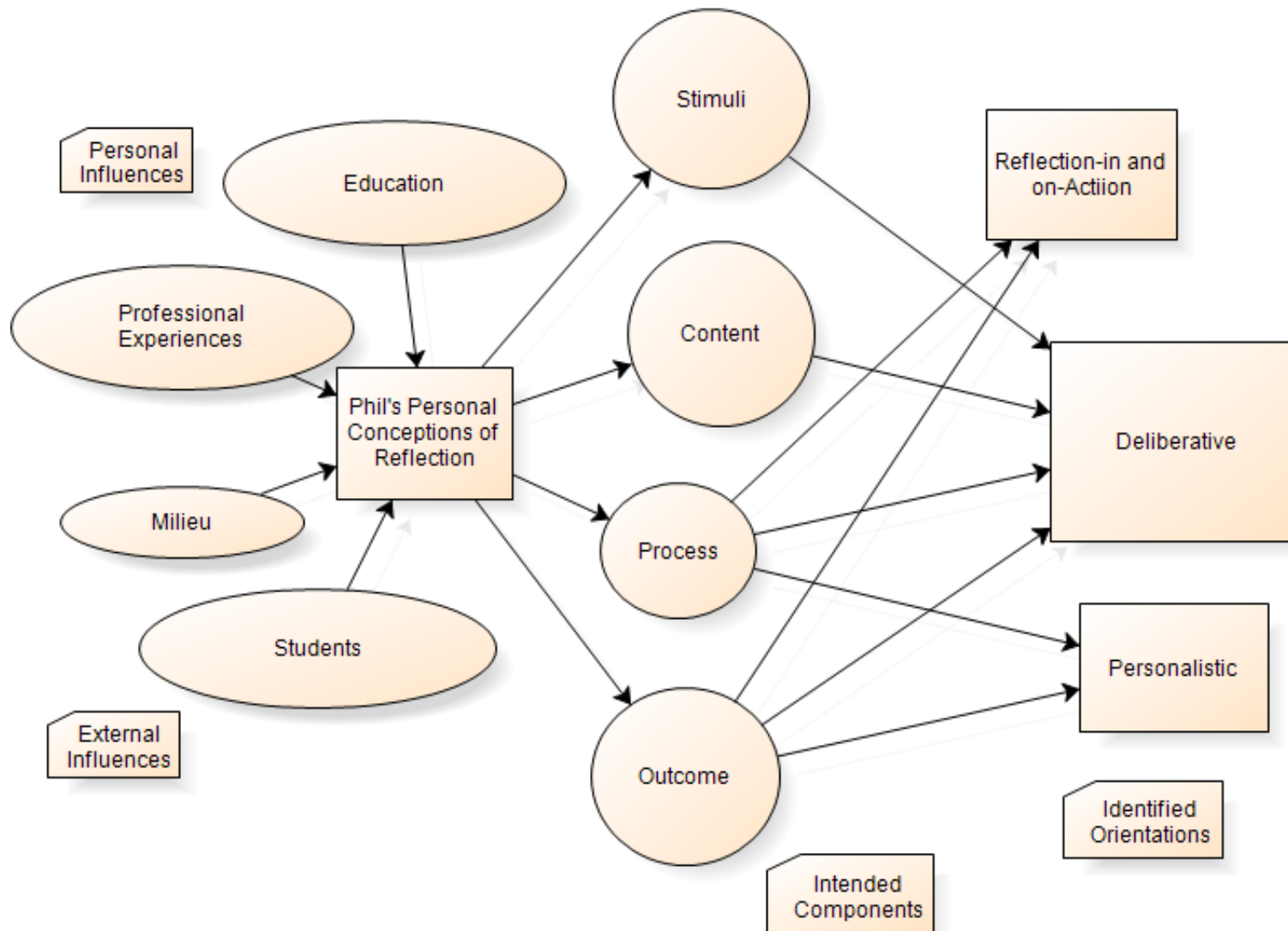
Figure 4-5. Phil's conceptions of and intentions for reflection.
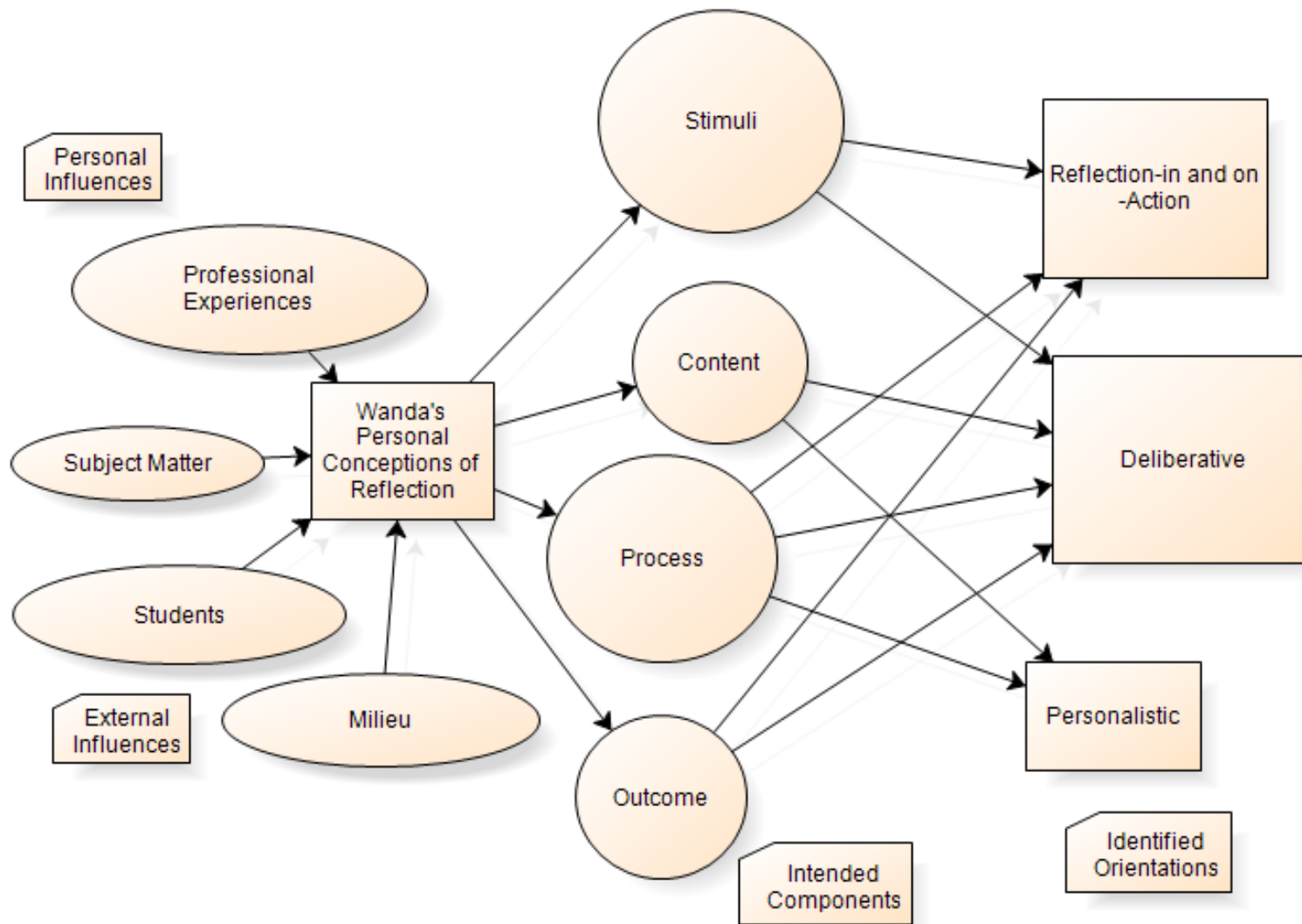
Figure 4-6. Wanda's conceptions of and intentions for reflection.

Component	Bob	Claire	Dan	Jeff	Phil	Wanda
Stimuli						
Content						
Process						
Outcome						

Figure 4-7. Components of reflection with the strongest emphasis within participants' science education programs.

Orientation	Bob	Claire	Dan	Jeff	Phil	Wanda
Technical						
Reflection-in and on-action						
Deliberative						
Personalistic						
Critical						

Figure 4-8. Orientations to reflection within participants' science teacher education programs

CHAPTER 5
DISCUSSION

Overview of the Study

Research-based approaches encountered by pre-service teachers in coursework are often not realized in the classroom (Zeichner, 2011). Schön (1983) recognized this separation of theory and practice as contributing to a "crisis of confidence" (p. 13), characterized by the inadequacy of contemporary professional knowledge to address the complexity, uncertainty, and value conflicts of practice. For progress to occur, Schön advocated moving beyond the step-by-step acquisition of specific skills and focusing on the notion of the *reflective practitioner* as a way to develop professional artistry.

Even though the development of reflection by pre-service teachers in their teacher education programs has been advocated widely, there is no unified definition of the construct or its particular outcomes. While scholarly writing on reflection displays this lack of consensus, three categories of research are evident. The first discusses the explicit teaching of reflection, engaging pre-service teachers in specific activities to foster reflection (Hatton & Smith, 1995; Jay & Johnson, 2002; Pultorak, 1993; Sparks-Langer, Simmons, Pasch, Colton, & Starko, 1990). The second examines pre-service teachers' reflective development, by examining text such as journals, portfolios, or interviews; but without attention to the experiences that facilitate development (Alger, 2006; Sumison, 2000). The final type is comprised of theoretical writing on the historical and philosophical bases of reflection (Dewey 1933; Rodgers, 2002; Russell, 2005; Schön; 1983, 1987; Smyth, 1989; Van Manen, 1977).

I assert what is lacking in existing approaches is a consideration of *both* the theoretical bases that provide purpose and value to reflection and the ways in which it is

operationalized and implemented. What is needed is a more comprehensive model that enables understanding of these two dimensions, addressing *why* reflection is important and *how* it is reified in teacher education programs.

The purpose of this study was to explore and describe science teacher educators' conceptions of and intentions for the teaching of reflection in university-based science teacher education programs. In simpler terms, the inquiry examined the ideas about reflection that science teacher educators hold and their plans for putting those ideas into practice in teaching pre-service secondary science teachers to reflect. The larger goal of this study was to capture this variety of interpretations through an examination of science teacher educators' definitions, goals and plans related to the development of reflection by pre-service teachers.

I began the inquiry with the intention of examining how science teacher educators conceived reflection and intended to operationalize and implement those ideas in teacher education programs. As the study progressed, the data collected portrayed a narrower view of their intentions, focused within the curriculum of the science methods course and associated field experiences. While some of the faculty interviewed did demonstrate awareness of the entire teacher education program (Claire, Jeff, and Wanda), most did not elaborate on how reflection is featured outside of the areas of their direct contact.

Naturalistic Inquiry and a More Complex Model

The naturalistic methodology of the study facilitated several realizations about the notions of reflection held by these science educators. Initially, I conceived the inquiry as an examination of the direct connection between the orientations to reflection and the implementation of these orientations within the components of reflection in course and

program curriculums. Figure 5-1 illustrates this simple model, where orientations are explicitly stated, with some general influences identified. These orientations are translated into course and program components, with some modifications due to constraints. Modifications are indicated in the graphic by an arrow which is bent due to external constraints.

As I examined documents and interview data, it became clear that the model was not that simple. The six science educators in the study did not exhibit a singular orientation, but rather discussed various ideas about the meaning and importance of reflection. They also indicated a set of influences on their personal conceptions, including personal, educational, and professional experiences (Sweeney, Bula, & Cornett, 2001). It was evident that they did not perceive aspects of the context of science teacher education as constraints and limitations, but simply as another set of influences on their curricular decision-making. Through the process of peer debriefing, I applied the construct of Schwab's commonplaces of learning (1973) to categorize these external influences as relevant to students, subject matter, and the milieu of learning.

It was also clear that I needed to work in a different direction to identify how influences, conceptions, components, and orientations were related. Personal influences were formative in nature, shaping the initial conceptions of reflection that these teacher educators brought with them to their positions. External influences such as students, subject matter, and the milieu, particular that of the context in which they taught, impacted further curricular deliberations. After these considerations, decisions were made about specific course experiences that focused on the development of reflection by pre-service science teachers. Using the heuristic, these experiences were

classified into components, and then used to identify the orientations to reflection manifested by the intentions of these science educators. Figure 5-2 illustrates these more complex relationships.

In comparing these two models with those of the individual science educators (Figures 4-1 through 4-6), it is apparent that these six participants attached more importance to the various influences on their conceptions than I originally conceived, although not every participant identified every influence. Rather, personal influences were exclusive to that person's background. External influences were also exclusive to that person's context of science teacher education. While each component of reflection was present in the intended curriculum, the emphasis given to the various components varied (as indicated by the different sizes of component elements), again due to the influences of students, subject matter, and the milieu of learning. These components manifested multiple orientations, some with greater emphasis and some with less, but clearly indicated science educators' intentions for the development of reflection across multiple orientations.

Implications

The results of this study support the notion that there are connections that can be made between teacher educators' conceptions of reflection and their intentions for engaging pre-service teachers in learning how to reflect. Zeichner advocated for the articulation of a "clear and common vision of good teaching and learning" that spreads throughout all aspects of the teacher education program, including coursework and field experiences (2011, p. 9). While my findings do not generalize to all aspects of teacher education programs, these science educators do provide explicit articulation of their

conceptions of reflection and the operationalization of those ideas into methods course curricula.

Developmental Aspects

Hatton and Smith (1995) suggested that the different orientations to reflection represented a developmental sequence, in which students move from the lower technical level to the higher critical one. Examination of the intended curricula of the six teacher educators in this study does not support that argument. There is no particular sequence of increasing complexity present in the participants' organization of course experiences. In Wanda's program, pre-service teachers engage in personalistic reflection early in the program of study through the science autobiography assignment, then apply those core beliefs in the process of action research, a deliberative process. This non-linear approach is more consistent with the recommendations of Danielowich (2007) and Valli (1997), who call for programs to encourage development of reflection across the hierarchy of orientations, rather than toward a goal of the most complex. Although each science educator in the study intends their curriculum to represent multiple orientations, none of their intentions emphasized reflection across all. Only Bob and Dan (the teacher educators with the least years of professional experience) emphasized the technical orientation, and only Jeff's program (taught by the educator with the greatest years of experience at his institution) had a critical focus.

The Role of Personal and External Influences

Research question four considers the perceived constraints and limitations on realization of science educators' conceptions of reflection. Initially I considered these constraints as deficits that attenuated their plans. I perceived external influences such as accreditation as hindrances to the expression of their orientations to reflection. Nagle

231

(2009) suggested that accountability pressures contribute to the reduction of reflection into mere identification and description of the technical aspects of teaching practice. In the course of the inquiry, it became clear that these teacher educators do not necessarily consider such influences as constraints. They instead look on them as opportunities for meaningful reconsideration of the purposes and practices of reflection. For example, Dan clearly looks at the emphasis on reflection provided by the Teacher Performance Assessment as a powerful enhancement of the process component.

The concept of constraints evolved instead into a consideration of external influences on science educators' conceptions of reflection. The framework of Schwab's (1973) commonplaces of teacher, students, subject matter, and the milieu of learning became a useful method of characterizing different influences. As Abell and Bryan (1997) recognized, learning to teach requires pre-service teachers to identify, explain, analyze, and challenge their ideas and beliefs about science teaching and learning. In this study, the external influence of students is significant for four of the six teacher educators. Phil is insistent that his approach to reflective practice enables his students to find their *voice* as science teachers.

The question about influences on science educators' ideas about reflection revealed three major categories: personal experiences, professional experiences, and education. While only Bob acknowledged that his upbringing as a "military brat" contributed to his valuing reflection as a method for understanding social and cultural differences, that personal experience was a powerful influence on how he structures opportunities for his learners. Five of the participants identified their experiences as school science teachers as influential on their ideas about reflection. Formal education

contributed to Claire's conceptions, through her doctoral work in grant programs focused on action research and teacher reflective practice. These influences of the teacher commonplace are formative aspects of the science educator's conceptions of reflection, and occur prior to consideration of how to implement these ideas in course and program elements.

External influences, particular to the students, subject matter, and milieu of learning, act on the science educator's conceptions. As noted previously, in the absence of the influences of these commonplaces, the science educator's conceptions would translate directly into components. That absence is really only theoretical, as the influences of students, subject matter, and milieu are always present in any learning situation. These external influences, therefore, have modified these teacher educators' conceptions into what can be realistically intended for curriculum in their courses. The intended components of reflection emerge from the interaction of the science educator's conceptions and these external influences. By applying the heuristic to descriptions of intended (or enacted, in a different study) components, the orientations to reflection within the curriculum are detected. Orientations are not exclusively a function of the outcomes of reflection. As Valli (1997) suggests, orientations represent considerations of strategy, content, and quality of thinking as well.

Curriculum

Smyth (1989) argued against the notion that complex reflection was only possible for experienced teachers. Roychoudhury, Roth, and Ebbing (1993) also advocated for the development of reflection to begin long before student teaching. While some participants (Wanda and Jeff) describe experiences that occur throughout the program of study, this long-term approach was not a common theme among the programs

233

examined. Likewise, few participants articulated reflective experiences that spanned their programs. Wanda's description of the reflective portfolios in her program is an exception.

Policy

The most obvious policy implication relevant to reflective practice is the inclusion of evidence for its development in systems for the accreditation of teacher education programs. This requirement was acknowledged by the participants in the present study, with varying perceptions. Bob and Dan view accreditation influences as an explicit set of requirements to be satisfied with concrete evidence from specific course assignments. Dan in particular sees these influences as opportunities for enhancing course experiences. Claire characterizes the typical program evidence of pre-service teacher reflective practice, such as rubrics, as contrary to her notions of the purpose of reflection. In Jeff's program, reflection is integrated into the conceptual framework, so course assignments and program experiences are not add-ons, but essential features of teacher education at his institution. Ultimately, clear conceptions of the meaning, purpose, and value of reflection have enabled these science educators to deal with the requirements of accreditation in a non-cynical manner. As accountability forces become more prominent in teacher education, reflective practice policy should be framed more in terms of opportunity rather than requirements.

A second policy implication concerns reflection as a professional qualification of teacher educators. A recent study of teacher educators in the Netherlands found reflection on one's own teaching was a necessary aspect of competence for a teacher educator (Koster, Brekelmans, Korthagen, & Wubbels, 2005). While U.S. teacher education policy documents enthusiastically endorse reflection by pre-service teachers,

reflection by teacher educators is either absent or obscure. Standards for accreditation of teacher education programs emphasize the development of reflection by teacher candidates in explicit detail, identifying stimuli, content, and processes for reflection. Reflection by teacher educators themselves is not addressed in any complexity, but the suggestion is made that qualified faculty "reflect on their own practice" (NCATE, 2008, p. 41).

A study of teacher's preparation programs in the United States found a wide range of professionals making up teacher education faculty, including tenure-track faculty, adjunct faculty, doctoral students, and practicing and retired K-12 teachers. Very little was ascertained about the qualifications of teacher educators, and nothing about their attitudes and beliefs (National Research Council, 2010). Tom (1997) asserts that the ideas about teaching and learning held by faculty are grounded in their personal lives, and these private and frequently tacit conceptions need to be made explicit through reflection. In the present study, these teacher educators articulated clear connections between formative experiences and their ideas about reflection, which were then manifested in their curricular decisions.

The impact of a qualified teacher on K-12 student learning has been established for some time (Darling-Hammond, 1999), but the characteristics of effective teacher educators are less well-defined. Being a good teacher may be an appealing qualification for the role of teacher educator, but it is not entirely sufficient. An articulation of one's conceptions of reflection, including the formative influences on those ideas and one's intentions for operationalizing conceptions into the curriculum, should be considered a critical qualification of a teacher educator. Reflection on the part of teacher educators

should occupy a more conspicuous position in teacher education policy deliberations. The rich descriptions of reflection in the present study portray not only explicit emphasis on reflection by pre-service science teachers, but also distinct expressions of reflection on their own practice.

Professional Development

Just as conceptions of reflection should be considered in qualifications of teacher educators in policy, the development of reflective practice by teacher educators should be prominent in the professional development of teacher education faculty. Research on the professional development of teacher educators is scarce, and specific educational preparation programs for teacher educators are nonexistent. The knowledge base of teacher education has relied on practical experience (Koster, Dengerink, Korthagen, and Lunenberg, 2008).

In their study of teacher education professional development in the Netherlands, Koster et al. (2008) found participants engaged in combinations of activities, frequently with the goal of improving their knowledge and skills, as opposed to experiences that focused on attitudes and beliefs. Experiences that explicitly engaged participants in deep reflection on their work experiences was uncommon. The researchers called for personal modes of reflection such as autobiography, considering their personal experiences as well as their professional ones.

Reflection on one's own practice through the process of self-study of teacher education practices (Clarke & Erickson, 2004) has been put forth as the fifth commonplace. This suggestion emphasizes both practical experience and inquiry into one's own practice. Sharing of learning generated through reflection in this mode is

essential for the development of what Loughran calls, "a pedagogy of teacher education" (2006, p. 23).

Professional development opportunities for teacher educators that promote the development and modeling of reflective practice are needed. The heuristic employed in this study can serve as a framework for exercises in self-awareness by teacher educators. Additionally, the model of relationships between personal conceptions of reflection, personal and external influences, intended components, and identified orientations (Figure 5-2) provides a structure for examining one's own ideas about the meaning, purpose, and value of reflection, and how those notions are operationalized in teacher education curriculums.

Limitations

The findings of this study, in addition to the implications that have emerged, are also a function of the constraints of the research process. The sample of participants is an appropriate example of these limitations. First, these science educators work primarily with pre-service teachers in the secondary certification areas, so the issues related to reflection in elementary science education programs were not considered. Second, these faculty members work in particular institutions: state universities with enrollments ranging from a few thousand to twenty thousand. Faculty in programs at large, research-intensive universities or at private institutions were not included in the sample. In order to have a more comprehensive view of the state of reflection in science education, a larger set of faculty at different categories of universities should be surveyed. Additionally, programs that provide alternative science teacher certification were not considered. Finally, the six participants in this study comprise science

educators who responded to survey, document, and interview requests. It should not be assumed that the only science educators who have strongly held ideas about reflection are those who are willing to talk about them.

The lack of a clear definition for reflection presented another limitation. Some participants suggested that efforts toward the development of reflective practice may be occurring in science teacher education programs, even though that particular label was not attached. Science educators may not always identify course and program activities that result in the development of reflective practice as components of reflection. Providing survey respondents with a primer on the heuristic and its classification of orientations to and components of reflection could provide a common language for identifying their ideas.

The final major limitation relates to the study's examination of the intended curriculum. In order to genuinely understand how reflection develops in pre-service teachers, their perspectives should be considered, in addition to the intentions of their instructors.

Recommendations for Future Research

The most significant area for future research is to apply the heuristic to the enacted curriculum in a science education program. As acknowledged above, the present study does not examine what actually transpires for pre-service teachers. Their perceptions of the alignment of their instructors' conceptions and intentions for reflection are an important contribution to understanding the importance of reflection. Russell called for reflective practice to be taught "explicitly, directly, thoughtfully and patiently" (2005, p. 203). Some participants in this study recognized the lack of explicitness of their approaches to reflection.

Both Russell and Oliver (2007) and Larrivee (2010) question the actual reflective practice that occurs on the part of teacher educators. Larrivee advocates for teacher educators to deliberately examine their own practice, questioning the beliefs, values, and assumptions that inform their pedagogy. They need to serve as transparent models of reflective practice for their pre-service teachers. The heuristic framework used in this study could be applied to examine the stimuli, content, process, and outcomes of reflection by teacher educators. Examination of their own processes would reveal areas of consistency and inconsistency with their espoused orientations, and provide a process for acknowledging limitations and inappropriate expectations in their programs.

As Nagle (2009) and many of the study participants suggested, the external influence of accountability will result in change to approaches to reflection. How those changes occur, whether they are perceived as constraints or opportunities, and how that external influence triggers change in program components and orientations are questions relevant to the value of reflective practice in teacher education.

Summary

In this study, I have sought to further research in science teacher education by examining science educators' ideas about and plans for the development of reflection by their pre-service teachers. The six science educators who participated espouse different ideas about influences, values, and strategies, but all of them articulated a significant emphasis on the outcome of reflection in developing pre-service teachers who are effective decision-makers. Differences were also found related to the various course and program activities employed to stimulate students in reflection, the ideas considered as the content of reflection, processes engaged in to learn how to reflect, and other outcomes such as understanding issues of personal growth and equity. The

role of the external influences of students, subject matter, and the milieu of learning was significant in how participants framed the value of reflection and designed curriculum for its development. To better understand how these conceptions and intentions are manifested in actual pre-service teacher development of reflection, a case study examining student perceptions should be completed. Additionally, the study is limited by the narrow sample of science educators involved. Other types of teacher education programs should be studied, using the heuristic employed here. The study's results suggest several additional areas of study, including the aforementioned enacted curriculum, reflective practice of teacher educators and how that is modeled for their pre-service teachers, and changes in components and orientations due to accountability influences.
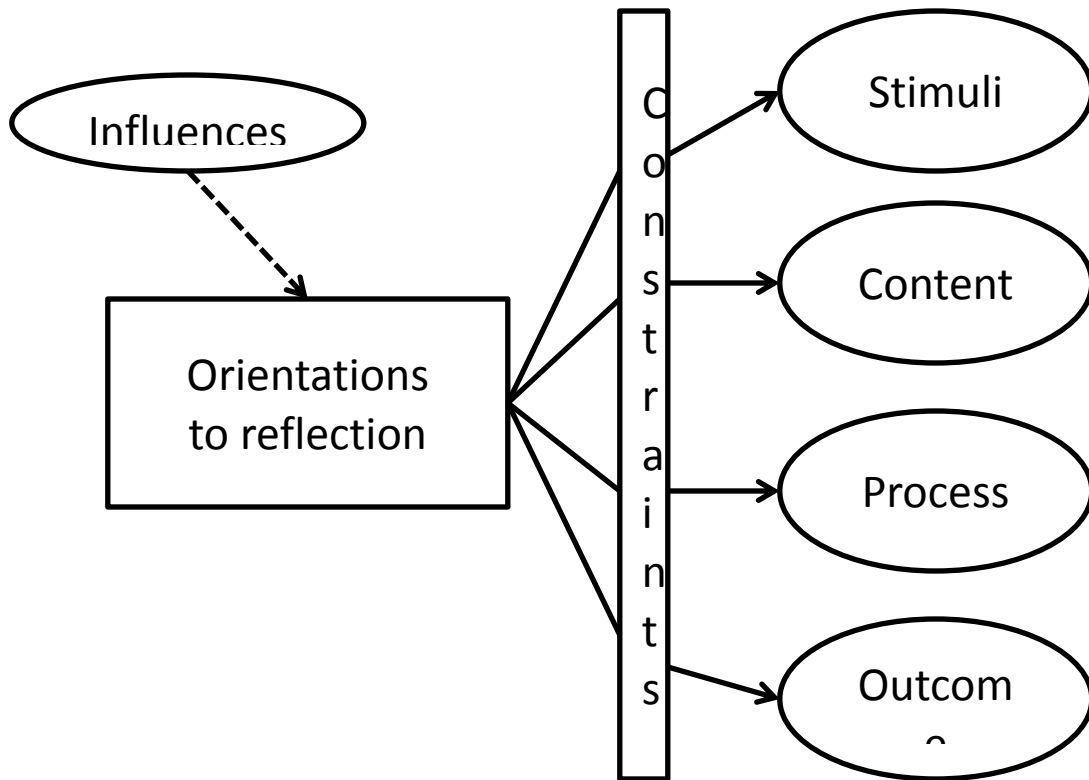
Figure 5-1. Initial simple model of the orientations to and components of reflection in a science education program.
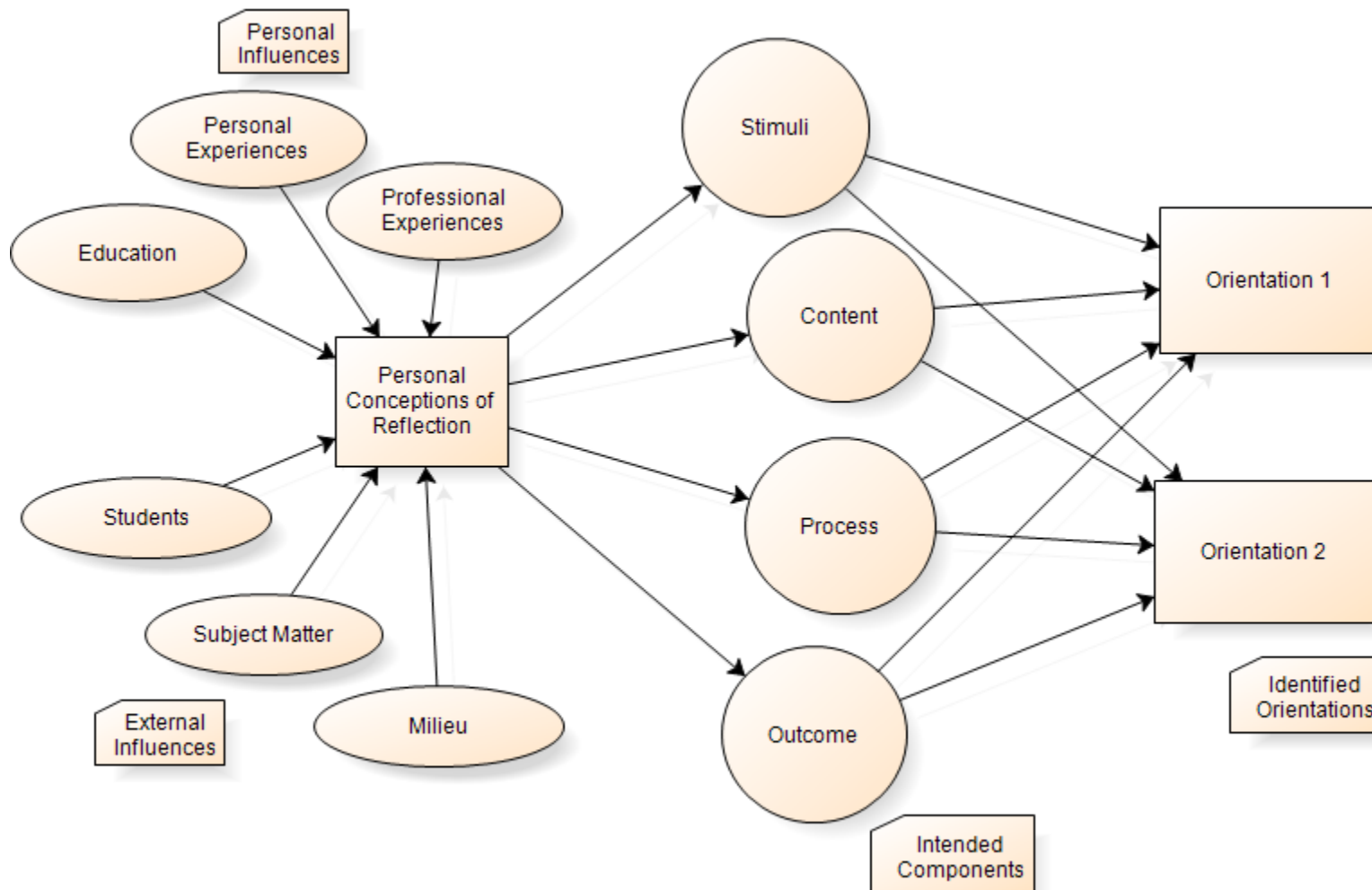
Figure 5-2. General model of the relationships between the study participants' personal conceptions of reflection, personal and external influences on their conceptions, intended components and identified orientations in their science education curricula.

4/28/2011   Conceptions of Reflection in Science Te…

Conceptions of Reflection in Science Teacher Education

This research examines how science teacher educators characterize the teaching of reflection to preservice middle and/or secondary science teachers.

There are no anticipated risks, compensation or other direct benefits to you as a participant in this survey. You are free to withdraw your consent to participate and may discontinue your participation in the survey at any time without consequence.

Participation is voluntary and there is no obligation to participate. You must be at least 18 years of age. Survey results are anonymous.

The survey should take 15-20 minutes to complete.

If you wish to continue with the survey, please select the BEGIN SURVEY button and click NEXT. By selecting the BEGIN SURVEY button you agree that you are at least 18 years of age and are voluntarily participating in completing the survey. If you do not wish to participate in the survey please select the EXIT SURVEY button, click NEXT and close your web browser. Participation may be discontinued at any time by exiting your web browser.

If you have any questions about this research, please contact Frederick Nelson at (904) 483-0365 or f.nelson@unf.edu, or my faculty supervisor, Dr. Troy D. Sadler, at (352) 273-4222. Questions or concerns about your rights as a research participant may be directed to the IRB02 office, University of Florida, Box 112250, Gainesville, FL 32611; (352) 392-0433.

- ◉ BEGIN SURVEY
- ◯ EXIT SURVEY

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[NEXT]

| 20% |

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Conceptions of Reflection in Science Teacher Education

Thank you for participating in this study of reflection in science teacher education.
In answering the survey questions, please consider them in the context of your role as a teacher educator in the secondary science teacher education program (including middle grades science) at your institution. Please answer all questions.

For how many years have you been a faculty member at your institution?

Number of Years   5

For how many years TOTAL have you been involved in science teacher education?

Number of Years   10

Please select the option that *best* describes the secondary science education program at your institution.

- ● Traditional 4-year program with Bachelor's degree in education leading to certification
- ○ Science education minor ONLY
- ○ 5th year program providing Master's degree in education leading to certification
- ○ Alternative certification program
- ○ Other
- ○ My institution does not offer a secondary science teacher education program

If you selected "Other," please briefly describe the characteristics of the secondary science education program at your institution.

To continue with the next section of the survey, please click NEXT.
To exit and return to the survey at a later time, please click SAVE.

NEXT   SAVE

40%

244

Conceptions of Reflection in Science Teacher Education

Are you responsible for NCATE reporting on the secondary science teacher education program at your institution?

○ Yes
◉ No

On average, how many middle or secondary science teachers graduate from your program each year?

Number of teachers graduating [7]

What degree of influence do you have on the design of curriculum for the secondary science teacher education program at your institution?
Move the slider to indicate the percentage range that most closely represents your influence.

Degree of Influence

| N/A | 0% | 25% | **50%** | 75% | 100% |

What degree of influence do you have on the design of curriculum for the secondary science methods course at your institution?
Move the slider to indicate the percentage range that most closely represents your influence.

Degree of Influence

| N/A | 0% | 25% | 50% | **75%** | 100% |
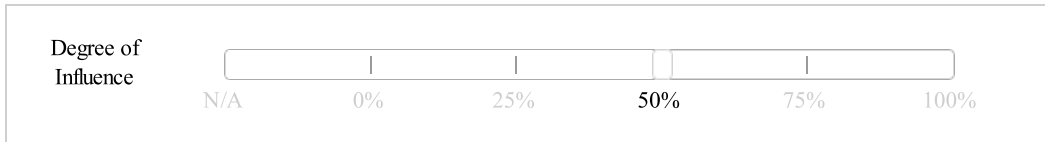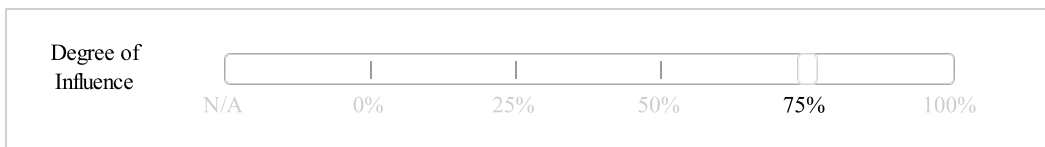
Do you regularly (at least once each year) supervise secondary science student teaching interns?

○ Yes
◉ No

Do you regularly (at least once each year) teach a secondary science methods course at your institution?

◉ Yes
○ No

To continue with the next section of the survey, please click NEXT.
To exit and return to the survey at a later time, please click SAVE.

[NEXT] [SAVE]

Conceptions of Reflection in Science Teacher Education

Please indicate which of these experiences you use to engage your preservice secondary science teachers in reflection and when in the program sequence they occur.
Please select all that apply.

	Science Methods Course	Other Education Courses	Field Experiences Prior to Internship	Student Teaching Internship	Don't Use	Don't Know
Action research	☐	☐	☐	☐	☑	☐
Autobiography of own science education experiences	☑	☐	☐	☐	☐	☐
Classroom observations (context, teaching)	☐	☐	☑	☑	☐	☐
Education philosophy writing	☐	☑	☑	☐	☐	☐
Inquiry investigation	☑	☐	☐	☐	☐	☐
Lesson and/or unit planning	☑	☑	☑	☑	☐	☐
Lesson and/or unit instruction in school setting	☐	☐	☑	☑	☐	☐
Nature of science activities	☐	☐	☐	☐	☑	☐
Microteaching (short lesson, small number of students)	☐	☑	☐	☐	☐	☐
Readings (practitioner journals, research articles, standards, etc.)	☑	☐	☐	☐	☐	☐
Videocase of exemplary science teaching	☐	☐	☐	☐	☐	☑
Videotaping of another's teaching episode (classroom teacher, peer)	☐	☐	☐	☐	☑	☐
Videotaping of one's own teaching episode	☐	☐	☐	☐	☑	☐

Please elaborate on those specific activities and experiences you feel are most important or any others not identified above that you use to engage your preservice secondary science teachers in reflection.

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Which of these topics or ideas are typically considered by your preservice secondary science teachers in their reflections?
Please select YES or NO for each topic or idea.

	YES	NO
Activities and experiences while observing classrooms	●	○
Application of research in science education to the classroom	●	○
Attitudes, beliefs, and ideas about science teaching and learning	●	○
Decisions about science curriculum and instruction	●	○
Evaluation of one's own teaching performance	○	●
Evaluation of another's teaching performance	○	●
Ideas about scientific inquiry	●	○
Learners' thinking in an instructional episode	○	●
Personal experiences in learning science		
Understandings of the nature of science		

Please elaborate on those specific topics and ideas or any others not identified above that are typically considered by your preservice

secondary science teachers in their reflections.

Which of these methods or processes do you employ to help your preservice secondary science teachers learn to reflect? Please select YES or NO for each method or process.

	YES	NO
Autobiography writing	●	○
Case study writing	○	●
Conference related to field experiences	○	●
Conference related to in-class experiences	●	○
Description and analysis of critical incidents or classroom dilemmas	○	●
Entry slip writing for portfolios	●	○
Journal writing--prompted	●	○
Journal writing--unprompted	●	○
Online discussion group	○	●
Prompted analysis and evaluation of own teaching performance	●	○
Repeated viewing and analysis of video of science teaching	○	●
Whole class discussion	●	○

Please elaborate on those specific methods or processes you feel are most important or others not identified above that you employ to help your preservice secondary science teachers learn to reflect.

Which of these forms or modes do your preservice secondary science teachers' reflections typically take? Please select YES or NO for each form or method.

	YES	NO
Electronic	●	○
Written (hard copy)	●	○
In-class discussion	●	○
Individual	●	○
Collaborative	○	●
At specific, prompted times	●	○
Ongoing	●	○

Please elaborate on those specific forms or modes you feel are most important or any others not identified above that your preservice secondary science teachers' reflections typically take.

Which of these goals or outcomes do you have for your preservice secondary science teachers in learning to reflect?

Please select YES or NO for each goal or outcome.

	YES	NO
Efficient instruction and faithful implementation of best practices	○	●
Professional artistry and practical knowledge	●	○
Relevant and meaningful student learning and effective decision making	●	○
Personal growth and development through relationships	○	●
Political liberation and improving the situation of the disadvantaged	○	●

Please elaborate on those specific goals or outcomes you feel are most important or any others not identified above that you intend for your preservice secondary science teachers in learning how to reflect.

To continue with the next section of the survey, please click NEXT.
To exit and return to the survey at a later time, please click SAVE.

NEXT   SAVE

80%

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Conceptions of Reflection in Science Teacher Education

Thank you for completing this survey.

In addition to your survey responses, please consider providing course documents such as course syllabi, assignment descriptions, and blank grading rubrics; and participating in a short Skype (internet video) interview.

Participation in interviews and submission of documents is entirely voluntary, and you are in no way obligated to participate. There are no anticipated risks, compensation or other direct benefits to you as a participant in this survey. You are free to decline to answer any question you do not wish to answer. You are free to withdraw your consent to participate and may discontinue your participation at any time without consequence. You must be at least 18 years of age. Interviews will be digitally recorded and transcribed. Digital recordings will be erased after transcription. Institutional and personal identifiers will be removed from documents. No student assignments will be collected. You will be asked to choose a pseudonym at the beginning of the interview, which will be used throughout the study.

If you agree to be interviewed and provide documents, please enter your name, email address, and telephone number below.

By providing this information, you agree that you are at least 18 years of age and would like to participate in the interview and document submission portion of the study. If you do not wish to participate further, please click on "If you do not wish to be interviewed or submit documents, CLICK HERE and then click SUBMIT SURVEY" and exit your browser.

Enter your name	Frederick Nelson
Enter your email address	fredn56@gmail.com
Enter your phone number, then click Submit Survey	9044830365

◉ If you do not wish to be interviewed or submit documents, CLICK HERE and then click SUBMIT SURVEY.

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SUBMIT SURVEY

100%

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UFIRB 02 – Social & Behavioral Research

Protocol Submission Form

This form must be typed. Send this form and the supporting documents to IRB02, PO Box 112250, Gainesville, FL 32611. Should you have questions about completing this form, call 352-392-0433.

Title of Protocol:	**Reflection in Science Teacher Education**		
Principal Investigator:	Frederick L. Nelson		**UFID #:**
Degree / Title:	M.S.	**Mailing Address:** (If on campus include PO Box address): 7055 Deer Lodge Circle #106 Jacksonville, FL 32256	**Email:** fredn56@ufl.edu
Department:	School of Teaching and Learning		**Telephone #:**
Co-Investigator(s):		**UFID#:**	**Email:**
Supervisor (If PI is student):	Troy D. Sadler	**UFID#:**	
Degree / Title:	Ph.D. Associate Processor	**Mailing Address:** (If on campus include PO Box address): 2403 Norman Hall PO Box 117048 Gainesville FL 32611	**Email :** tsadler@coe.ufl.edu
Department:			**Telephone #:**
Date of Proposed Research:	**April 1, 2011-March 31, 2012**		
Source of Funding *(A copy of the grant proposal must be submitted with this protocol if funding is involved):*			

Scientific Purpose of the Study: The purpose of the study is to explore and describe science teacher educators' perspectives on how pre-service teachers are taught to reflect, and to examine how those perspectives are implemented in program experiences such as methods courses.

Describe the Research Methodology in Non-Technical Language: *(Explain what will be done with or to the research participant.)* A web-based survey will be administered to participants presenting them with forced-choice questions relevant to the various aspects of reflection implemented in their teacher education programs. Free-response questions will be used to provide clarification and detail. Semi-structured interviews will be conducted to elicit more detailed perspectives of a smaller sample of approximately five teacher educators. Topics such as these will be examined: (a) Describe the specific activities you use to engage students in reflection? (b) What ideas and topics do pre-service teachers reflect upon? (c) What processes and methods are employed to teach pre-service teachers to reflect? (d) What are the goals and purposes of pre-service teacher reflection?
In addition to the semi-structured interviews, documents such as course syllabi and assignment descriptions and rubrics will be requested.

Describe Potential Benefits: The study has the potential to inform and ultimately improve pre-service science teacher education.

Describe Potential Risks: (*If risk of physical, psychological or economic harm may be involved, describe the steps taken to protect participant.)* There are no known risks associated with participating in this study.

Describe How Participant(s) Will Be Recruited: A letter describing the study and soliciting participation will be sent electronically to faculty involved in science teacher education from institutions identified as members of the Teacher Education Council of State Colleges and Universities (http://www.tecscu.org/index.htm) and holding NCATE accreditation. In this letter, the project will be briefly described and a link provided to access the web-based survey.

Maximum Number of Participants (to be approached with consent)	**300**	**Age Range of Participants:**	**18+**	**Amount of Compensation/ course credit:**	**None**

Describe the Informed Consent Process. (Attach a Copy of the Informed Consent Document. See http://irb.ufl.edu/irb02/samples.html for examples of consent.)

Informed consent will be obtained electronically. The first page of the web-based survey will contain the following informed consent information:

This research examines how science teacher educators characterize the teaching of reflection to pre-service secondary science teachers.

There are no anticipated risks, compensation or other direct benefits to you as a participant in this survey. You are free to withdraw your consent to participate and may discontinue your participation in the survey at any time without consequence.

Participation is voluntary and there is no obligation to participate. You must be at least 18 years of age. Survey results are anonymous.

The survey should take 10-15 minutes to complete.

If you wish to continue with the survey, please select the BEGIN SURVEY button and click NEXT. By selecting the BEGIN SURVEY button you agree that you are at least 18 years of age and are voluntarily participating in completing the survey. If you do not wish to participate in the survey please select the EXIT SURVEY button, click NEXT and close your web browser. Participation may be discontinued at any time by exiting your web browser.

If you have any questions about this research, please contact Frederick Nelson at f.nelson@unf.edu, or my faculty supervisor, Dr. Troy D. Sadler, at (352) 273-4222. Questions or concerns about your rights as a research participant may be directed to the IRB02 office, University of Florida, Box 112250, Gainesville, FL 32611; (352) 392-0433.

After the last page of survey questions, participants will be solicited for document submission and interviews, and presented with the following informed consent information:

In addition to your survey responses, please consider providing course documents and participating in a short telephone interview.

Participation in interviews and submission of documents is entirely voluntary, and you are in no way obligated to participate. You are free to decline to answer any question you do not wish to answer. You are free to withdraw your consent to participate and may discontinue your participation at any time without consequence. You must be at least 18 years of age. Interviews will be digitally recorded and transcribed. Digital recordings will be erased after transcription. Institutional and personal identifiers will be removed from documents. You will be asked to choose a pseudonym at the beginning of the interview, which will be used throughout the study.

If you agree to be interviewed and provide documents, please enter your name, email address, and telephone number below.

By providing this information, you agree that you are at least 18 years of age and would like to provide this information. If you do not wish to participate further, please exit your browser.

Provision of this information indicates consent to submit documents and be interviewed. Respondents who do not wish to be interviewed or submit documents will select a button labeled "I do not wish to be interviewed or submit documents" and will then be taken to the ending page of the survey.

(SIGNATURE SECTION)		
Principal Investigator(s) Signature:		**Date:**
Co-Investigator(s) Signature(s):		**Date:**
Supervisor's Signature (if PI is a student):		**Date:**
Department Chair Signature:		**Date:**

APPENDIX C
DOCUMENT PROTOCOL

1. Course Syllabus—How are components of reflection specified or instantiated in the syllabus?
    a. Stimuli
    b. Content
    c. Process
    d. Outcome
2. Assignment guidelines/descriptions
    a. Are assignments explicitly stated as engaging the pre-service teacher in reflection?
    b. Does the instructor explicitly determine the content of reflection?
    c. Is a process of reflecting detailed?
    d. What modes of reflection (written, electronic, individual, collaborative, etc.) are specified?
3. Grading rubrics
    a. Is reflection included as an evaluation criterion?
    b. What levels of performance are considered for reflective practice/writing?
    c. What descriptors are used to characterize levels of performance for reflection?
    d. How significant is reflection in the overall grading scheme?

APPENDIX D
SEMI-STRUCTURED INTERVIEW PROTOCOL

Science Teacher Educators' Conceptions of Reflection

Introduction

My name is Fred Nelson, and I am a doctoral candidate at the University of Florida. My dissertation research explores science teacher educators' ideas about reflection, and I would like you to share your ideas. This interview should take no more than 45 minutes. I would like to digitally record this interview. After the interview, I will personally transcribe the interview. After the study, the digital recordings will be deleted. Do I have your permission to record this interview? I would like you to choose a pseudonym, to which you will be referred throughout the study.

Questions of this type

In your survey response, you indicated _____ as a significant experience you use to engage your pre-service science teachers in reflection. Please share some details about how this works.

Where did you get this idea from?

In the course syllabus you sent, you describe _____ assignment. What ideas do students focus on in their reflections from this activity?

Describe how your use _____ as a process or method to help your pre-service science teachers learn to reflect?

What experiences have influenced how you view reflection?
Important people, events, work?

Your course syllabus includes _____ as a course objective. Could you elaborate on how this objective is representative of your orientation to reflection?

What should I have asked you that I didn't think to ask?

Summary

Let's review the major ideas you have shared with me today._____
Have I missed any important ideas?

Thank you for your participation. I would like to conduct a follow-up interview at a later time and share my interpretations to make sure they are correct.

APPENDIX E
TENTATIVE DOCUMENT MEMO

Date received:

Participant:

Name of document:

Brief summary of contents:

Significance or importance of document:

Other impressions:

Components of Reflection

Stimuli—any experiences, assignments, activities in the program or course that are used to engage in the pre-service teacher in an act of reflection.

Content—the ideas, beliefs, thoughts, or themes that are considered in reflective writing, discussion, or analysis.

Process—the methods, structures, exercises, guidelines, or procedures that are used to enact reflective practice.

Outcome—the goals, objectives, desires, and purposes for which pre-service teaches engage in reflection.

Influences on Personal Conceptions of Reflection

Education—experiences, ideas, learning, mentors, philosophies, or theories that result from formal education on the part of the teacher educator. These could include courses, teachers in higher education, or readings that occurred prior to beginning the present position in science teacher education.

Personal Experiences—experiences, memories, attitudes, or beliefs that contribute to ideas about reflection that occurred prior to beginning the present position in science teacher education. These could include influence of family, previous jobs, or upbringing.

Professional Experiences—experiences, attitudes, beliefs, curricula, or theories that result from experiences as a teacher, either as a K-12 science teacher or faculty member in science education prior to beginning the present position in science teacher education.

External Influences

Milieu—any influence from the setting in which science teacher education occurs, including ideas from colleagues, school partnerships, accreditation procedures, state curricula, or department organization.

Students—any influence based on the nature, attitudes, beliefs, or thinking of the population of pre-service science teachers in the program.

Subject Matter—any influence from the subject matter of science education, including content knowledge, pedagogy, or pedagogical content knowledge.

Orientations

Technical—aimed at the development of proficiency in specific pedagogical skills such as questioning or time management. The criteria for evaluating proficiency are established by an external higher authority. Problematization of the effectiveness of instructional practice is often limited to questions of what went well or not in a teaching episode.

Reflection-in and on-action—aimed at the development of practical knowledge and professional artistry. Situates development of reflection within the reflective practicum, a setting that approaches the real world of practice but in which some of the complexity is reduced. Role of a mentor or coach is important. Reflection emerges from some puzzling event in the reflective practicum.

Deliberative—aimed at the development of effective curricular and instructional decision-making based on consideration of multiple perspectives on any of the commonplaces of teachers, students, subject matter, or the milieu of learning.

Personalistic—aimed at personal growth and development, using introspective methods that analyze the pre-service teacher's own personal ideas about teaching, learning, thinking, and relationships.

Critical—aimed at recognition and improvement of issues of injustice in society, using analysis of oppression, empowerment, and questions about assumptions of roles in society.

LIST OF REFERENCES

Abell, S. K., & Bryan, L. A. (1997). Reconceptualizing the elementary science methods course using a reflection orientation. *Journal of Science Teacher Education, 8*(3), 153-166.

Abell, S. K., Bryan, L. A., & Anderson, M. A. (1998). Investigating pre-service elementary science teacher reflective thinking using integrated media case-based instruction in elementary science teacher preparation. *Science Education, 82*, 491-510.

Abell, S. K., George, M., & Martini, M. (2002). The moon investigation: Instructional strategies for elementary science methods. *Journal of Science Teacher Education, 13*(2), 85-100.

Akerson, V. L., Abd-El-Khalick, F., & Lederman, N. G. (2000). Influence of a reflective explicit activity-based approach on elementary teachers' conceptions of nature of science. *Journal of Research in Science Teaching, 37*(4), 295-317.

Alger, C. (2006). 'What went well, what didn't go so well': Growth of reflection in pre-service teachers. *Reflective Practice, 7*(3), 287-301.

Altheide, D. L. (1987). Ethnographic content analysis. *Qualitative Sociology, 10*(1), 65.

Altheide, D. L. (1996). *Qualitative media analysis.* Thousand Oaks, CA: Sage Publications.

Anderson, R. D., & Mitchener, C. P. (1994). Research on science teacher education. In D. Gabel (Ed.), *Handbook of research on science teaching and learning* (pp. 3-44). New York: Macmillan.

Association of Teacher Educators (2010). *The purposes, practices, and professionalism of teacher reflectivity: Insights for twenty-first-century teachers and students.* E. G. Pultorak (Ed.). Lanham, MD: Rowman & Littlefield.

Barnett, M. (2008). Using authentic cases through a web-based professional development system to support pre-service teachers in examining classroom practice. *Action in Teacher Education, 29*(4), 3-14.

Black, P., & Atkin, J. A. (1996). *Changing the subject: Innovations in science, mathematics and technology education.* London: Routledge.

Blanchard, M. R., Southerland, S. A., & Granger, E. M. (2009). No silver bullet for inquiry: Making sense of teacher change following an inquiry-based research experience for teachers. *Science Education, 93*(2), 322-360.

Britner, S. L., & Finson, K. D. (2005). Pre-service teachers' reflections on their growth in an inquiry-oriented science pedagogy course. *Journal of Elementary Science Education, 17*(1), 39-54.

Brown, D. (1999). Promoting reflective thinking: Pre-service teachers' literacy autobiographies as a common text. *Journal of Adolescent & Adult Literacy, 42*(5), 402-410.

Calderhead, J. (1989). Reflective teaching and teacher education. *Teaching and Teacher Education, 5*(1), 43-51.

Carter, K., & Doyle, W. (1996). Personal narrative and life history in learning to teach. In J. Sikula (Ed.), *Handbook of research on teacher education* (pp. 120-142). New York, NY: Macmillan.

Chambers, D. W. (1983). Stereotypic images of the scientist: The draw-a-scientist test. *Science Education, 67,* 255-265.

Clarke, A., & Erickson, G. (2004). Self-study: The fifth commonplace. *Australian Journal of Education, 48*(2), 199-211.

Collier, S. T. (2010). Reflection as a social problem-solving process. In E. G. Pultorak (Ed.), *The purposes, practices, and professionalism of teacher reflectivity: Insights for twenty-first-century teachers and students* (pp. 25-44). Lanham, MD: Rowman & Littlefield.

Colton, A. B., & Sparks-Langer, G. M. (1993). A conceptual framework to guide the development of teacher reflection and decision making. *Journal of Teacher Education, 44*(1), 45-54.

Converse, P. D., Wolfe, E. W., Huang, X., & Osward, F. L. (2008). Response rates for mixed-mode surveys using mail and e-mail/web. *American Journal of Evaluation, 29*, 99-107.

Cook, C., Heath, F., & Thompson, R. L. (2000). A meta-analysis of response rates in web- or internet-based surveys. *Educational and Psychological Measurement,60*(6), 821-836.

Council of Chief State School Officers. (2010). *Interstate teacher assessment and support consortium (InTASC) model core teaching standards: A resource for state dialogue (draft for public comment).* Washington, DC: Author.

Cruickshank, D. R., & Applegate, J. H. (1981). Reflective teaching as a strategy for teacher growth. *Educational Leadership, 38*(7), 553-554.

Cruickshank, D. R., Kennedy, J. J., Williams, E. J., Holton, J., & Fay, D. E. (1981). Evaluation of reflective teaching outcomes. *Journal of Educational Research, 75*(1), 26-32.

Danielowich, R. (2007). Negotiating the conflicts: Reexamining the structure and function of reflection in science teacher learning. *Science Education, 91*(4), 629-663.

Darling-Hammond, L. (1999). *Teacher quality and student achievement: A review of state policy evidence.* Center for the Study of Teaching and Policy.

Dewey, J. (1933). *How we think; a restatement of the relation of reflective thinking to the educative process.* Boston, London: Heath.

Dietz, C. M., & Davis, E. A. (2009). Pre-service elementary teachers' reflection on narrative images of inquiry. *Journal of Science Teacher Education, 20*(3), 219-243.

Dillman, D. A. (2007). *Mail and internet surveys: The tailored design method* (2nd ed.). Hoboken, NJ: Wiley.

Dinkelman, T. (2000). An inquiry into the development of critical reflection in secondary student teachers. *Teaching and Teacher Education, 16*(2), 195-222.

Dome, N., Prado-Olmos, P., & Ulanoff, S. H. (2005). "I don't like not knowing how the world works": Examining pre-service teachers' narrative reflections. *Teacher Education Quarterly, 32*(2), 63-83.

Eick, C. J., & Dias, M. (2005). Building the authority of experience in communities of practice: The development of pre-service teachers' practical knowledge through co-teaching in inquiry classrooms. *Science Education, 89*(3), 470-491.

Eick, C. J., & Reed, C. J. (2002). What makes an inquiry-oriented science teacher? the influence of learning histories on teacher role identity and practice. *Science Education, 86*(3), 401-416.

Eick, C. J., Ware, F. N., & Jones, M. T. (2004). Co-teaching in a secondary science methods course: Learning through a co-teaching model that supports early teacher practice. *Journal of Science Teacher Education, 15*(3), 197-209.

Erlandson, D. A., Harris, E. L., Skipper, B. L., & Allen, S. D. (1993). *Doing naturalistic inquiry: A guide to methods.* Newbury Park, CA: Sage Publications.

Feiman-Nemser, S., McDiarmid, G. W., Melnick, S. L., & Parker, M. (1989). *Changing beginning teachers' conceptions: A description of an introductory teacher education course* (Research Report 89-1). East Lansing: Michigan State University, National Center for Research on Teacher Education.

Fendler, L. (2003). Teacher reflection in a hall of mirrors: Historical influences and political reverberations. *Educational Researcher, 32*(3), 16-25.

Freiberg, H. J., & Waxman, H. C. (1990). Reflection and the acquisition of technical teaching skills. In R. T. Clift, W. R. Houston, & M. C. Pugach (Eds.), *Encouraging reflective practice in education: An analysis of issues and programs* (pp. 119-138). New York, NY: Teachers College Press.

Gado, I., Ferguson, R., & Van 't Hooft, M. (2006). Using handheld-computers and probeware in a science methods course: Pre-service teachers' attitudes and self-efficacy. *Journal of Technology and Teacher Education, 14*(3), 501-529.

Genor, M. (2005). A social reconstructionist framework for reflection: The "problematizing" of teaching. *Issues in Teacher Education, 14*(2), 45-62.

Gilbert, S., Pedersen, J. E., & Mason, C. Survey of changes in science teacher preparation programs responding to performance-based science standards. *Electronic Journal of Science Education, 9*(3).

Glaser, B. G., & Strauss, A. L. (1967). *The discovery of grounded theory: Strategies for qualitative research*. Chicago, IL: Aldine Publishing Company.

Goodman, J. (1984). Reflection and teacher education. *Interchange, 15*(3), 9-26.

Gore, J. M. (1987). Reflecting on reflective teaching. *Journal of Teacher Education, 38*(2), 33-39.

Greenlaw, C., & Brown-Welty, S. (2009). A comparison of web-based and paper-based survey methods: Testing assumptions of survey mode and response cost. *Evaluation Review, 33*(5), 464-480.

Griffin, M. L. (2003). Using critical incidents to promote and assess reflective thinking in pre-service teachers. *Reflective Practice, 4* (2), 207-220.

Grimmett, O. O., MacKinnon, A. M., Erickson, G. L., & Riecken, T. J. (1990). Reflective practice in teacher education. In R. T. Clift, W. R. Houston, & M. C. Pugach (Eds.), *Encouraging reflective practice in education: An analysis of issues and programs* (pp. 20-38). New York, NY: Teachers College Press.

Hallam, R. A., Buell, M. J., & Ridgley, R. (2003). Preparing early childhood educators to serve children and families living in poverty: A national survey of undergraduate programs. *Journal of Research in Childhood Education, 18*(2), 115-124.

Hatton, N., & Smith, D. (1995). Reflection in teacher education: Towards definition and implementation. *Teaching and Teacher Education, 11*(1), 33-49.

Hauhart, R. C., & Grahe, J. E. (2010). The undergraduate capstone course in the social sciences: Results from a regional survey. *Teaching Sociology, 38*(1), 4-17.

Hirsch, E. D., Kett, J. F., & Trefil, J. S. (1987). *Cultural literacy: What every American needs to know*. Boston: Houghton Mifflin.

Houston, W. R., & Clift, R. T. (1990). The potential for research contributions to reflective practice. In R. T. Clift, W. R. Houston, & M. C. Pugach (Eds.), *Encouraging reflective practice in education: An analysis of issues and programs* (pp. 208-224). New York, NY: Teachers College Press.

Hullfish, H. G. (1963). Reflective thinking as educational method. *Educational Theory, 13*, 235-44.

I'Anson, J., Rodrigues, S., & Wilson, G. (2003). Mirrors, reflections and refractions: The contribution of microteaching to reflective practice. *European Journal of Teacher Education, 26*(2), 189-199.

Jay, J. K., & Johnson, K. L. (2002). Capturing complexity: A typology of reflective practice for teacher education. *Teaching and Teacher Education, 18*(1), 73-85.

Kang, S., Scharmann, L. C., Noh, T., & Koh, H. (2005). The influence of students' cognitive and motivational variables in respect of cognitive conflict and conceptual change. *International Journal of Science Education, 27*(9), 1037-1058.

Koster, B., Brekelmans, M., Korthagen, F., & Wubbels, T. (2005). Quality requirements for teacher educators. *Teaching and Teacher Education, 21*, 157-176.

Koster, B., Dengerink, J., Korthagen, F., & Lunenberg, M. (2008). Teacher educators working on their own professional development: Goals, activities and outcomes of a project for the professional development of teacher educators. *Teachers and Teaching: theory and practice, 14*(5-6), 567-587.

Korthagen, F. A. J. (1985). Reflective teaching and pre-service teacher education in the Netherlands. *Journal of Teacher Education, 36*, 11-15.

Korthagen, F. A. J., & Kessels, J. P. A. M. (1999). Linking theory and practice: Changing the pedagogy of teacher education. *Educational Researcher, 28*(4), 4-17.

Krippendorff, K. (2004). *Content analysis: An introduction to its methodology* (2nd ed.). Thousand Oaks, CA: Sage Publications.

Kuhn, T. S. (1996). *The structure of scientific revolutions* (3rd ed.). Chicago, IL: University of Chicago Press.

Kvale, S., & Brinkmann, S. (2009). *InterViews: Learning the craft of qualitative research interviewing* (2nd ed.). Los Angeles, CA: Sage Publications.

LaBoskey, V. K. (1993). A conceptual framework for reflection in pre-service teacher education. In J. Calderhead & P. Gates (Eds.), *Conceptualizing reflection in teacher development* (pp. 23-38). Bristol, PA: The Falmer Press*.*

LaBoskey, V. K. (1994). *Development of reflective practice: A study of pre-service teachers.* New York, NY: Teachers College Press.

Larrivee, B. (2000). Transforming teaching practice: Becoming the critically reflective teacher. *Reflective Practice, 1*(3), 293-307.Larrivee, B. (2010). What we know and don't know about teacher reflection. In E. G. Pultorak (Ed.), *The purposes, practices, and professionalism of teacher reflectivity: Insights for twenty-first-century teachers and students* (pp. 137-162). Lanham, MD: Rowman & Littlefield.

Lee, S. K. F., & Loughran, J. J. (2000). Facilitating pre-service teachers' reflection through a school-based teaching programme*. Reflective Practice, 1*(1), 69-89.

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry.* Beverly Hills, CA: Sage Publications.

Lortie, D. (1975). *Schoolteacher: A sociological study.* Chicago: University of Chicago Press.

Loughran, J.J. (1996) *Developing reflective practice: Learning about teaching and learning through modeling.* New York, NY: Routledge Falmer.

Loughran, J. J., & Gunstone, R. F. (1997). Professional development in residence: Developing reflection on science teaching and learning. *Journal of Education for Teaching, 23*(2), 159-178.

Loughran, J. J. (2002). Effective reflective practice: In search of meaning in learning about teaching. *Journal of Teacher Education, 53*(1), 33-43.

Loughran, J. J. (2006). *Developing a pedagogy of teacher education: Understanding teaching and learning about teaching.* New York, NY: Routledge Falmer.

Lyons, N. (1998). Reflection in teaching: Can it be developmental? A portfolio perspective. *Teacher Education Quarterly, 25*, 115-127.

MacKinnon, A. M. (1987). Detecting reflection-in-action among pre-service elementary science teachers. *Teaching and Teacher Education, 3*(2), 135-145.

MacKinnon, A. M., & Erickson, G. L. (1988). Taking Schön's ideas to a science teaching practicum. In P. P. Grimmett, & G. L. Erickson (Eds.), *Reflection in teacher education* (pp. 113-137). New York, NY: Teachers College Press.

Makinster, J. G., Barab, S. A., Harwood, W., & Andersen, H. O. (2006). The effect of social context on the reflective practice of pre-service science teachers: Incorporating a web-supported community of teachers. *Journal of Technology and Teacher Education, 14*(3), 543-579.

Markham, M. (1999). Through the looking glass: Reflective teaching through a Lacanian lens. *Curriculum Inquiry, 29*(1), 55-76.

Melville, W., Fazio, X., Bartley, A., & Jones, D. (2008). Experience and reflection: Pre-service science teachers' capacity for teaching inquiry. *Journal of Science Teacher Education, 19*(5), 477-494.

Mead, M., & Metraux, R. (1957). The image of the scientist among high school students: A pilot study. *Science, 126,* 384-390.

Metcalf, L. E. (1962). Reflective teacher. *Phi Delta Kappan, 44*, 17-21.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis* (2nd ed.). Thousand Oaks, CA: Sage.

Millbrandt, M. K., & Klein, S. R. (2008). Survey of art educators: Qualifications, identity, and practice. *Studies in Art Education, 49*(4), 343-357.

Minstrell, J. (1992). Facets of students' knowledge and relevant instruction. In R. Duit, F. Goldberg, & H. Niedderer (Eds.), *Research in physics learning: Theoretical issues and empirical studies* (pp. 110-128). Kiel, Germany: Institute for Science Education.

Nagle, J. F. (2009). Becoming a reflective practitioner in the age of accountability. *The Educational Forum, 73,* 76-86.

National Board for Professional Teaching Standards. (2002). *What teachers should know and be able to do.* Arlington, VA: Author.

National Council for Accreditation of Teacher Education. (2008). *Professional standards for the accreditation of teacher preparation institutions.* Washington, DC: Author.

National Research Council. (1996). *National science education standards.* Washington, DC: The National Academies Press.

National Research Council. (2010). *Preparing teachers: Building evidence for sound policy.* Committee on the Study of Teacher Preparation Programs in the United States, Center for Education. Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

National Science Teachers Association. (2004). *Standards for science teacher preparation.* Arlington, VA: Author.

Noddings, N. (1984). *Caring: A feminine approach to ethics and moral education.* Berkeley, CA: University of California Press.

Northfield, J., & Gunstone, R. (1997). Teacher education as a process of developing teacher knowledge. In J. Loughran & T. Russell (Eds.), *Teaching about teaching: Purpose, passion and pedagogy in teacher education* (pp. 48-56). London: Falmer.

Parsons, E. R. C., & Summer, G. (2004). Use of images as reflective discrepant events: Pathways for elementary teachers to reconsider practice in relation to their views of science teaching and learning. *Electronic Journal of Science Education, 9*(1).

Patton, M. Q. (2002). *Qualitative research & evaluation methods* (3rd ed.). Thousand Oaks, CA: Sage Publications.

Peshkin, A. (1988). In search of subjectivity: One's own. *Educational Researcher, 17*(7), pp. 17-21.

Posner, G. J. (2005). *Field experience: A guide to reflective teaching* (6th ed.). Boston, MA: Pearson/Allyn and Bacon.

Pultorak, E. G. (1993). Facilitating reflective thought in novice teachers. *Journal of Teacher Education, 44*(4), 288-295.

Rezba, R. J., Sprague, C., McDonough, J. T., & Matkins, J. J. (2008). *Learning and assessing science process skills* (5th ed.) Kendall/Hunt.

Richardson, V. (1990). The evolution of reflective teacher in and teacher education. In R. T. Clift, W. R. Houston, & M. C. Pugach (Eds.), *Encouraging reflective practice in education: An analysis of issues and programs* (pp. 3-19). New York, NY: Teachers College Press.

Richardson, V. (1996). The role of attitudes and beliefs in learning to teach. In J. Sikula (Ed.), *Handbook of research on teacher education* (pp. 102–119). New York, NY: Macmillan.

Rodgers, C. R. (2002). Defining reflection: Another look at John Dewey and reflective thinking. *Teachers College Record, 104*(4), 842-866.

Rosenthal, D. (1991). A reflective approach to science methods courses for pre-service elementary teachers. *Journal of Science Teacher Education, 2*(1), 1-6.

Ross, D. D. (1990). Programmatic structures for the preparation of reflective teachers. In R. T. Clift, W. R. Houston, & M. C. Pugach (Eds.), *Encouraging reflective practice in education: An analysis of issues and programs* (pp. 97-119). New York, NY: Teachers College Press.

Roychoudhury, A., Roth, W., & Ebbing, J. (1993). Becoming a reflective science teacher: An exemplary endeavor by a pre-service elementary teacher. In P. A. Rubba, L. M. Campbell & T. M. Dana (Eds.), *Excellence in educating teachers of science* (pp. 91-110). Columbus, Ohio: ERIC.

Russell, T. L. (2005). Can reflective practice be taught? *Reflective Practice, 6*(2), 199-204.

Russell, T. L. (2007). How experience changes my values as a teacher educator. In T. L. Russell & J. Loughran (Eds.), *Enacting a pedagogy of teacher education: Values, relationships and practice* (pp. 182-191). London: Routledge.

Russell, T. L., & Martin, A. K. (2007). Learning to teach science. In S. K. Abell, & N. G. Lederman (Eds.), *Handbook of research on science education* (pp. 1151-1178). Marwah, NJ: Lawrence Erlbaum Associates.

Russell, T. L., & Munby, H. (1991). Reframing: The role of experience in developing teachers' professional knowledge. In D. A. Schön (Ed.), *The reflective turn: Case studies in and on educational practice* (pp. 164-187). New York, NY: Teachers College Press.

Saldana, J. (2009). *The coding manual for qualitative researchers.* London: Sage.

Scharmann, L. C., Smith, M. U., & James, M. C. (2005). Explicit reflective nature of science instruction: Evolution, intelligent design, and umbrellaology. *Journal of Science Teacher Education, 16*(1), 27-41.

Schön, D. A. (1983). *The reflective practitioner: How professionals think in action.* New York, NY: Basic Books.

Schön, D. A. (1987). *Educating the reflective practitioner: Toward a new design for teaching and learning in the professions* (1st ed.). San Francisco, CA: Jossey-Bass.

Schön, D. A. (1991). *The reflective turn: Case studies in and on educational practice.* New York: Teachers College, Columbia University.

Schwab, J. J. (1973). The practical 3: Translation into curriculum. *The School Review, 81*(4), 501-522.

Smith, J. J., Yendol-Hoppey, D., & Milam, R. S. (2010). Reflectivity with the teacher research cycle: Promoting prospective teachers' progress toward an inquiry stance. In E. G. Pultorak (Ed.), *The purposes, practices, and professionalism of teacher reflectivity: Insights for twenty-first-century teachers and students* (pp. 3-24). Lanham, MD: Rowman & Littlefield.

Smith, J. P., diSessa, A., & Roschelle, J. (1993/1994). Misconceptions reconceived: A constructivist analysis of knowledge in transition. *The Journal of the Learning Sciences, 3,* 115-163.

Smyth, J. (1989). Developing and sustaining critical reflection in teacher education. *Journal of Teacher Education, 40*(2), 2-9.

Spalding, E., & Wilson, A. (2002). Demystifying reflection: A study of pedagogical strategies that encourage reflective journal writing. *Teachers College Record,104*(7), 1393.

Sparks-Langer, G. M., Simmons, J. M., Pasch, M., Colton, A. B., & Starko, A. (1990). Reflective pedagogical thinking: How can we promote and measure it? *Journal of Teacher Education, 41*(4), 23-32.

Sparks-Langer, G., & Colton, A. B. (1991). Synthesis of research on teachers' reflective thinking. *Educational Leadership, 48*(6), 37.

Sumison, J. (2000). Facilitating reflection: A cautionary account. *Reflective Practice, 1*(2), 199-214.

Sweeney, A. E., Bula, O. A., & Cornett, J. W. (2001). The role of personal practice theories in the professional development of a beginning high school chemistry teacher. *Journal of Research in Science Teaching, 38*(4), 408-441.

Tabachnick, B. R., & Zeichner, K. M. (1984). The impact of the student teaching experience on the development of teacher perspectives. *Journal of Teacher Education, 35,* 28-42.

Tann, S. (1993). Eliciting student teachers' personal theories. In J. Calderhead, & P. Gates (Eds.), *Conceptualizing reflection in teacher development* (pp. 53-69). Bristol, PA: The Falmer Press.

Tom, A. R. (1985). Inquiring into inquiry-oriented teacher education. *Journal of Teacher Education, 36*, 35-44.

Tom, A. R. (1992). Foreword. In L. Valli (Ed.). *Reflective teacher education: Cases and critiques* (pp. vii-x). Albany, NY: State University of New York Press. Tom, A. R. (1997). *Redesigning teacher education.* Albany, NY: State University of New York Press.

Trezise, R. L. (1964). Reflective teaching. *Michigan Education Journal and Moderator-Topics, 41*, 18-19.

United States National Commission on Excellence in Education, & United States Dept. of Education. (1983). *A nation at risk: The imperative for educational reform : A report to the nation and the Secretary of Education, United States Department of Education.* Washington, D.C.; The Commission; Supt. of Docs., U.S. G.P.O: distributor.

Valli, L. (1990). Moral approaches to reflective practice. In R. T. Clift, W. R. Houston, & M. C. Pugach (Eds.), *Encouraging reflective practice in education: An analysis of issues and programs* (pp. 39-56). New York, NY: Teachers College Press.

Valli, L. (1993). Reflective teacher education programs: An analysis of case studies. In J. Calderhead & P. Gates (Eds.), *Conceptualizing reflection in teacher development* (pp 11-22). Bristol, PA: The Falmer Press*.*

Valli, L. (1997). Listening to other voices: A description of teacher reflection in the United States. *Peabody Journal of Education, 72*, 67-88.

Van Manen, M. (1977). Linking ways of knowing with ways of being practical. *Curriculum Inquiry, 6*(3), 205-228.

Van Zee, E. H., & Roberts, D. (2001). Using pedagogical inquiries as a basis for learning to teach: Prospective teachers' reflections upon positive science learning experiences. *Science Education, 85*(6), 733-757.

von Glasersfeld, E. (1995). A constructivist approach to teaching. In L. Steffe, & J. Gale (Eds.), *Constructivism in education* (pp. 3-15). Hillsdale, NJ: Lawrence Erlbaum Associates.

Wallace, C. S., & Oliver, J. S. (2003). Journaling during a school-based secondary methods course: Exploring a route to teaching reflection. *Journal of Science Teacher Education, 14*(3), 161-187.

Wang, J., & Lin, S. (2008). Examining reflective thinking: A study of changes in methods students' conceptions and understandings of inquiry teaching. *International Journal of Science and Mathematics Education, 6*(3), 459-479.

Watts, M., & Lawson, M. (2009). Using a meta-analysis activity to make critical reflection explicit in teacher education. *Teaching and Teacher Education, 25*, 609-616.

Wellington, B., & Austin, P. (1996). Orientations to reflective practice. *Educational Research, 38*, 307-316.

Wildman, T. M., Niles, J. A., Magliaro, S. G., & McLaughlin, R. A. (1990). Promoting reflective practice among beginning and experienced teachers. In R. T. Clift, W. R. Houston, & M. C. Pugach (Eds.), *Encouraging reflective practice in education: An analysis of issues and programs* (pp. 139-162). New York, NY: Teachers College Press.

Wilson, G., & I'Anson, J. (2006). Reframing the practicum: Constructing performative space in initial teacher education. *Teaching and Teacher Education, 22*(3), 353-361.

Wood, P. O. (1991). The cooperating teacher's role in nurturing reflective teaching. In B. R. Tabachnick, & K. M. Zeichner (Eds.), *Issues and practices in inquiry-oriented teacher education* (pp. 202-210). Bristol, PA: The Falmer Press.

Yerrick, R. K., & Hoving, T. J. (2003). One foot on the dock and one foot on the boat: Differences among pre-service science teachers' interpretations of field-based science methods in culturally diverse contexts. *Science Education, 87*(3), 390-418.

Yerrick, R. K., Ross, D., & Molebash, P. (2005). Too close for comfort: Real-time science teaching reflections via digital video editing. *Journal of Science Teacher Education, 16*(4), 351-375.

Yinger, R. J. (1990). The conversation of practice. In R. T. Clift, W. R. Houston, & M. C. Pugach (Eds.), *Encouraging reflective practice in education: An analysis of issues and programs* (pp. 73-96). New York, NY: Teachers College Press.

Yoon, H., & Kim, M. (2010). Collaborative reflection through dilemma cases of science practical work during practicum. *International Journal of Science Education,32*(3), 283-301.

Yost, D. S., Sentner, S. M., & Forlenza-Bailey, A. (2000). An examination of the construct of critical reflection: Implications for teacher education programming in the 21st century. *Journal of Teacher Education, 51*(1), 39-49.

Yung, B. W. W., Wong, S. L., Cheng, M. W., Hui, C. S., & Hodson, D. (2007). Tracking pre-service teachers' changing conceptions of good science teaching: The role of progressive reflection with the same video. *Research in Science Education, 37*, 239-259.

Zechiel, A. N., & McCutchen, S. P. (1938). Reflective thinking in social studies and in science. *Progressive Education, 15*, 284-290.

Zeichner, K. M. (2005). A research agenda for teacher education. In M. Cochran Smith & K. M. Zeichner (Eds.), *Studying teacher education: The report of the AERA panel on research and teacher education* (pp. 737-759). Mahwah, NJ: Lawrence Erlbaum Associates.

Zeichner, K. M., & Liston, D. P. (1987). Teaching student teachers to reflect. *Harvard Educational Review, 57*(1), 23-48.

Zeichner, K. M., & Liston, D. P. (1996). *Reflective teaching: An introduction.* Mahwah, NJ: Lawrence Erlbaum Associates.

Zeichner, K. M., & Tabachnick, B. R. (1982). The belief systems of university supervisors in an elementary student teaching program. *Journal of Education for Teaching, 8,* 34-54.

BIOGRAPHICAL SKETCH

Frederick Nelson became a science teacher later in life, after twenty years in the field of retail management. When he returned to school, he knew immediately he wanted to be a teacher. Teaching science was a natural fit for him, since he grew up on a farm surrounded by natural phenomena, with a curiosity that was constantly encouraged by his parents. He was fortunate to enter science teaching at a time of reform based on models of inquiry and conceptual learning, and became committed to a constructivist approach to teaching and learning.

This approach was validated by his success as a science teacher with the achievement of National Board Certification. After teaching high school science for nine years, Frederick felt he had a story to tell to a different audience, so he found a position as a science education instructor at the University of North Florida in Jacksonville. Soon after beginning that work in higher education, he enrolled in the science education doctoral program at the University of Florida.

While deliberating on ideas for his dissertation research, he came across a line in the Handbook of Research on Science Education (2007) that suggested that the teaching of reflection was not occurring in science teacher education programs. Recalling his own immersion in reflection during National Board Certification, he found that this particular topic was the one that spoke most clearly to him. After six years in higher education, he is happy to report that he will be able to continue to tell his story to a new audience, this time as Assistant Professor of Science Education at California State University, Fresno in the fall of 2012.