TEACHER EDUCATION & DEVELOPMENT | RESEARCH ARTICLE

What we see when we look in the mirror: Conceptions of and intentions for reflection by science teacher educators

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Abstract: In this naturalistic study, I examined science teacher educators’ ideas and plans for pre-service teachers’ development of reflection. Participants espoused different ideas about influences, values, and strategies, but consistently emphasized the outcome of effective decision-making by pre-service teachers. Differences were found concerning stimuli, content, processes, and other outcomes such as issues of personal growth and equity. External influences of students, subject matter, and the milieu of learning contributed to how participants framed the value of reflection and designed curriculum for its development. The study provides a meaningful framework for teacher education faculty to examine their own practice. Results suggest further inquiry into (1) reflection in the enacted curriculum, (2) reflective practice of teacher educators and how that is modeled for their pre-service teachers, and (3) changes in components and orientations from accountability influences.

Subjects: Education; Science Education; Teachers & Teacher Education

Keywords: reflection; teacher education; teacher educators; reflective practice; science education

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PUBLIC INTEREST STATEMENT
In this study, I examined the important idea of reflection in science teaching. Using the rationale that science teachers need to reflect on their practice early and often, I looked at how this habit of mind might be developed while they are still learning to be teachers, in their university teacher education courses. I worked with six science teacher educators, analyzing how they think about reflection, including their ideas about why reflection is important, how their ideas developed over their careers in education, and how they plan to engage future teachers in reflective practice. From this research, I developed a model of how teacher educators may conceive reflection and intend to help future teachers learn about reflection in teacher education courses.
1. Introduction

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 et al., 2010). Science education research has used the reflections of pre-service teachers to examine issues such as co-teaching (Eick, Ware, and 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).

In this study, I explored and described the conceptions of and intentions for the teaching of reflection by educators in science teacher education programs. In simpler terms, I examined those ideas about reflection held by educators and their plans for putting those ideas into practice. My larger goal was to capture this variety of interpretations through an examination of educators’ definitions, goals, and plans related to the development of reflection by pre-service teachers. More specifically, the ideas of those teacher educators who articulate some emphasis on reflection were scrutinized to address four 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 toward 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?

The first research question examined how science teacher educators conceive the construct of reflection as an orientation. 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 aligned to those described in the heuristic, other characterizations were not excluded. The most valuable component in addressing this research question was whether the meaning and purpose of reflection is explicitly considered and clearly articulated by science teacher educators.

The second research question examined the origins of science teacher educators’ orientations to reflection. Uncovering the influence of factors such as teachers, family members, or professional experiences provided insights into how teacher educators come to value reflection. The development of an engagement in their own reflective practice by science teacher educators contributed to an understanding of how their intentions for reflection may be realized for pre-service teachers (Russell, 2007; Russell & Martin, 2007).

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

The fourth research question addressed 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, 1995). Insight into particular difficulties may be gained by considering them through the heuristic as corresponding to particular
components. This examination provided another relevant perspective on science teacher educators’ orientations to reflection, particularly with respect to how reflection was 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.

2. Conceptual framework

Research-based approaches to teaching and learning encountered by pre-service teachers in formal coursework were often not realized in the practical world of the classroom (Zeichner, 2011). Schön (1983) identified this disconnect between theory and practice, manifested in the failure 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 to a focus on the reflective practitioner to develop professional artistry.

Even though the development of reflection by pre-service teachers in teacher education programs has been advocated widely, there has been no unified definition of the construct or its outcomes. While scholarly writing on reflection displayed this lack of consensus, three categories of research were evident (Nelson & Sadler, 2013). The first type consisted of studies of 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 type traced 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, 2005; Fox & White, 2010; Nagle, 2009; Sumison, 2000). The final section of the literature was 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).

Nelson and Sadler (2013) constructed a heuristic (Table 1) to consider both the theoretical bases that provided purpose and value to reflection (orientations) and the ways in which it was operationalized and implemented (components). This framework synthesized the writing of van Manen (1977) on levels of reflection, Valli’s (1997) description of the types of reflection in teacher education programs, and Grimmett, Mackinnon, Erickson, and Riecken’s (1990) essential questions for understanding reflective tasks. This comprehensive framework enables understanding of these two dimensions, addressing why reflection is important and how it is reified in teacher education.

2.1. Orientations to reflection

The orientations dimension represents the increasing complexity of reflective thinking. Essential attributes of five different orientations were identified: technical, reflection-in and on-action, deliberative, personalistic, and critical. The technical orientation relies on an external source of authority to be applied to a teaching episode, emphasizing development of observable teaching skill, such as open-ended questioning or lesson closure (Freiberg & Waxman, 1990). Reflection-in and on-action is derived from Schön’s (1983, 1987) reflective practitioner approach, focusing on the development of professional artistry through problem setting and reframing, drawing from the repertoire of a knowledgeable coach to help build a repertoire. The deliberative orientation emphasizes teacher decision-making from the consideration of multiple perspectives; not the what or how of teaching but rather the why (Collier, 2010). Unlike the technical, reflection-in and on-action, and deliberative orientations that focus on professional practice, the personalistic orientation is more concerned with personal growth and relational issues, considering teachers’ own lives as the context for examining critical events and beliefs (Yost, Sentner, & Forlenza-Bailey, 2000). The critical orientation focuses on teachers’ examination of the social, historical, political, and cultural aspects of teaching and problematizing of the relationships between practice and issues of oppression in society (Zeichner & Liston, 1996). While this ordering from technical through critical does indicate increasing complexity
of thought, these orientations should not be considered as stages in a progression, but rather different frames of reference from which to consider different questions of practice.

2.2. Components of reflection
The components dimension represents the different aspects of the specific learning opportunities used by teacher educators to engage pre-service teachers in the development of reflection. These aspects were categorized into stimuli, content, process, and outcome of reflection. The stimuli component includes some event from practice, often a puzzle or problem that needs a solution (Dewey, 1933); addressing the question, “What is causing me to reflect?” Various stimuli could include teaching episodes, readings, assignments, and other personal and professional interactions. Content refers to the ideas being considered through reflective thinking; “On what am I reflecting?” Content of reflection is often represented as text in the form of journal entries or responses to constructed prompts. The process component, “How am I reflecting?” considers the methods or structures employed by a teacher to engage in reflection, such as a solitary journaling, collaborative discussions between a mentor and a mentee, and notation of a video capture of a teaching episode. The final outcome component, “Why am I reflecting?” captures the larger purpose for engaging in reflection. Outcomes can include such goals as directing or controlling, informing, or transforming practice (Grimmet et al., 1990). 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 (LaBoskey, 1993).

2.3. Reflection in science teacher education
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, 2009; Eick & Reed, 2002; Wang & Lin, 2008), and the nature of science (Akerson, Abd-El-Khalick, & Lederman, 2000; Scharmann, Smith, & James, 2005). Very little research considered reflection on the part of the teacher educator; however, the growing area of the self-study of teacher education practices holds promise as an approach (Russell & Martin, 2007; Zeichner, 2007).

While the literature described some science teacher education programs with an explicit approach to reflection in the science methods course, (Abell & Bryan, 1997; Rosenthal, 1991), more often the focus was on the experience of the student teaching internship (Eick & Dias, 2005; MacKinnon & Erickson, 1988; Roychoudhury, Roth, & Ebbing, 1993; Yoon & Kim, 2010). Similarly, a large portion of the research examined the development of reflection in elementary pre-service science teachers (Abell & Bryan, 1997; Britner & Finson, 2005; Rosenthal, 1991; Roychoudhury et al., 1993; Van Zee & Roberts, 2001; Yoon & Kim, 2010). It was therefore worthwhile in this study to examine how science teacher educators in secondary programs conceived reflection and intended it to develop in their pre-service teachers. Acknowledging the call for opportunities and encouragement to reflect earlier rather than later, this inquiry examined conceptions and intentions throughout the teacher preparation sequence, including methods courses, early field experience, and the student teaching internship (Northfield & Gunstone, 1997; Roychoudhury et al., 1993).

3. Context and methodology

It was the intent of the inquiry to examine the ideas of those science teacher educators who emphasize reflection explicitly and intensely. It was 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 et al., 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 was 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.

This naturalistic inquiry employed purposive sampling (Erlandson, Harris, Skipper, & Allen, 1993) of faculty, facilitated through a web-based survey of science educators at NCATE accredited and TECSCU member institutions. Questions on the survey focused on (1) familiarity with and control over the design of the science teacher education program, and (2) a clear conception of reflection and explicit intentions for the teaching of reflection. Six faculty who met these two criteria agreed to participate in interviews and provided course syllabi. This number, while small in comparison to large sample sizes in positivistic inquiries, is appropriate for a naturalistic inquiry, where the sample is selected for the development of “information-rich cases whose study will illuminate the questions under study” (Patton, 2002, p. 169).

The orientations to (technical, reflection-in and on-action, deliberative, personalistic, and critical) and components of reflection (stimuli, content, process, and outcome) in Nelson and Sadler’s (2013) heuristic functioning as a provisional coding structure (Miles & Huberman, 1994). Trustworthiness of the inquiry was established using recommendations from Lincoln and Guba (1985) and Erlandson et al. (1993). 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 contributed 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. 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. The institutional review board approved all protocols for the study, and informed consent was obtained from all participants.

At the conclusion of coding for the data constructed from a particular participant, a case analysis (Miles & Huberman, 1994) was prepared. 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 my 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.

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. The tables and figures that characterized individual cases, such as the tables that represent the components of reflection for each science educator, informed these comparisons. 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.

4. Results

The first research question considered the personal ideas held by the science teacher about the meaning, purpose, and value of reflection; their orientations to 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).

The second question explored 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. Originally, I considered the difference between a science educator’s conceptions of reflection and how those conceptions were enacted as due to external constraints and limitations, as addressed in research question four. Through the experience of the study, I reframed these ideas instead as external influences, relevant to the commonplaces of students, subject matter, and the milieu.

It is the intended components, those specific program and course experiences and activities that identify the science educators’ orientations to reflection; the area of inquiry considered in research question three. By examining the components they articulated using the heuristic developed in this study, I identified the orientations represented in the curriculum of science teacher education programs within the influence of the faculty member, typically the science methods course and associated field experiences. All names are pseudonyms.

4.1. 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, such as years of experience, in addition to their ideas about reflection.

Looking at demographic information on the six science educators, presented in Table 2, two broad categories are discerned: years of experience and influence over the science education program. Bob and Dan both have less than 10 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 20 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 1, 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

| Table 2. Demographic factors for each science educator |
|---------------------------------|-------|-------|-------|-------|-------|-------|
| Demographic                    | 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   |
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 3. 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 personal 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 3 also identifies factors that participants identified as significant external influences on their personal 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

| Significant influence              | 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   |
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.” 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 3 based on their significant presence in the data collected from participants.

In Figure 2, 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 was 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. 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 1 illustrates the orientations to reflection within the science teacher education curricula of the six participants. 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, which features 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,

| Component | Bob | Claire | Dan | Jeff | Phil | Wanda |
|-----------|-----|--------|-----|------|------|-------|
| Stimuli   |     |        |     |      |      |       |
| Content   |     |        |     |      |      |       |
| Process   |     |        |     |      |      |       |
| Outcome   |     |        |     |      |      |       |
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.

5. Discussion
The naturalistic methodology of the study facilitated several realizations about participants’ notions of reflection. Initially, I conceived the inquiry as an examination of the direct connection between their orientations to reflection and how they implemented those orientations as components of reflection in course and program curricula. Figure 3 illustrates this simple model, where one specific orientation for an educator is explicitly stated (square), with some general influences identified (dotted arrow), and then translated into course and program components (ellipses), with some modifications (bent arrows) due to external constraints.

As I analyzed data, it became clear that the model was not that simple. None of the six participants exhibited a singular orientation, but rather presented multiple ideas about the meaning and importance of reflection, indicating their emphasis on multiple orientations. They also indicated a set of influences on their personal conceptions, including personal, educational, and professional experiences (Sweeney et al., 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 pedagogical and curricular decision-making. In a session of peer debriefing (Lincoln & Guba, 1985), I shared this observation with a colleague, who suggested that these influences could be categorized in the model in a way that provided more meaning. I found the construct of Schwab’s commonplaces of learning (1973) was a meaningful taxonomy for categorizing these external influences as relevant to students, subject matter, and the milieu of learning, with the teacher commonplace relating to personal conceptions.

It was also evident 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 teaching. External influences such as students, subject matter, and the milieu, particular to the context in which they taught, impacted further curricular deliberations. After these considerations, educators made decisions about specific course experiences for 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 4 illustrates these more complex relationships.

Figure 3. Initial simple model of the orientations to and components of reflection in a science education program.
When I generated individual models of the participants (Figures 5 and 6 represent the model applied to educators Jeff and Wanda), and then compared to the general model (Figure 4), it became apparent that they attached more importance to the specific influences on their conceptions than I originally conceived, although not every participant identified every influence. Rather, personal influences were exclusive to that participant's background. External influences were also exclusive to that participant's context of science teacher education. Jeff and Wanda both indicated subject matter as a significant influence on their ideas, but Wanda also valued students highly in her conceptions. While each component of reflection was present in the intended curriculum of each participant,
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 (Figures 1 and 2).

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 educators do provide explicit articulation of their conceptions of reflection and the operationalization of those ideas into methods course curricula.

5.1. 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 through a science autobiography assignment, then apply those core beliefs through action research, a deliberative process. This nonlinear 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 all participants intended 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.
5.2. The role of personal and external influences

Initially, I considered external constraints and limitations on implementing intentions for reflection as deficits. An example of this bias is a view of accreditation requirements as a hindrance to educators’ expression of their reflective orientations. Nagle (2009) suggested that accountability pressures contribute to the reduction of reflection into mere identification and description of the technical aspects of teaching practice. The educators in my study do not necessarily consider such influences as constraints, but rather as opportunities for meaningful reconsideration of the purposes and practices of reflection. For example, Dan viewed the emphasis on reflection provided by the Teacher Performance Assessment as a powerful enhancement of the process component.

The question about influences on participants’ personal ideas about reflection revealed three major categories: personal experiences, professional experiences, and education. Five of the participants identified their experiences as school science teachers as critical influences on their ideas about reflection. Formal education contributed to Claire’s conceptions, through her doctoral work 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, acted on the science educator’s conceptions. As noted previously, in the absence of the influences of these commonplace, 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 personal conceptions and these external influences. By applying the heuristic to descriptions of intended 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.

5.3. Curriculum

Smyth (1989) argued against the notion that complex reflection was only possible for experienced teachers. Roychoudhury et al. (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 examined. Likewise, few participants articulated reflective experiences that spanned their programs. Wanda’s description of the reflective portfolios in her program is an exception.

5.4. 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 noncynical manner. As accountability forces become more prominent in teacher education, reflective practice policy should be framed more in terms of opportunities 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 US 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 (1985) 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 these science educators, but also distinct expressions of reflection on their own practice.

5.5. Professional development
Research on the professional development of teacher educators is scarce. The knowledge base of teacher education has relied on practical experience (Koster, Dengerink, Korthagen, & Lunenberg, 2008). The development of reflective practice by faculty should be prominent in their own professional development.

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 4) 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.

5.6. Limitations
The findings of this study, in addition to the implications that have emerged, are also a function of the limitations of the research process. The sample of participants is an example of these limitations. First, these science educators work primarily with pre-service secondary teachers, so the issues
related to reflection in elementary programs were not considered. Second, these faculty members work in particular institutions: comprehensive state universities with enrollments ranging from a few thousand to twenty thousand. Faculties in programs at large, research-intensive universities or at private institutions were not included, nor were programs that provide alternative science teacher certification. Finally, the six participants in this study comprise those 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 were willing to talk about them.

6. Conclusions
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 aspects of reflection in teacher education programs should be studied, using the heuristic employed here.

The most significant opportunity for future research involves applying the heuristic to the enacted curriculum in a science education program. The present study does not examine what actually transpires for pre-service teachers. Their perceptions of the alignment of their instructors’ conceptions of and intentions for reflection would provide an important lens for understanding reflective practice.

Both Russell and Martin (2007) and Larrivee (2010) question the actual reflective practice that occurs on the part of teacher educators. Larrivee advocates that teacher educators need to deliberately examine their own practice, questioning the beliefs, values, and assumptions that inform their pedagogy. Teacher educators could apply the heuristic to examine the stimuli, content, process, and outcomes of their own reflection.

As Nagle (2009) and many of the study participants suggested, the external influence of accountability will cause changes to approaches to reflection. How those changes occur, whether they are perceived as constraints or opportunities, and how that influence triggers changes in program components and orientations are questions relevant to the value of reflective practice in teacher education.

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References
Abell, S. K., & Bryan, L. A. (1997). Reconceptualizing the elementary science methods course using a reflection orientation. Journal of Science Teacher Education, 8, 153–166.
Abell, S. K., George, M., & Martini, M. (2002). The moon investigation: Instructional strategies for elementary science methods. Journal of Science Teacher Education, 13, 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, 295–317.
Alger, C. (2006). “What went well, what didn’t go so well” Growth of reflection in pre-service teachers. Reflective Practice, 7, 287–301.
http://dx.doi.org/10.1080/14623940600837327
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.

Pajares, M. F. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. Review of Educational Research, 62, 307–332.

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), 1–22.

Pultorak, E. G. (1993). Facilitating reflective thought in novice teachers. Journal of Teacher Education, 44, 288–295.

Pultorak, E. G. (1993). Facilitating reflective thought in novice teachers. Journal of Teacher Education, 44, 288–295.

Rodgers, C. R. (2002). Defining reflection: Another look at John Dewey and reflective thinking. Teachers College Record, 104, 842–866. http://dx.doi.org/10.1111/tcre.2002.104.issue-4

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.

Roth, W., & Ebbing, J. (1993). Becoming a reflective science teacher: An exemplary endeavor by a preservice elementary teacher. In P. A. Rubba, L. M. Campbell, & T. M. Dano (Eds.), Excellence in educating teachers of science (pp. 91–110). Columbus, OH: ERIC.

Russell, T. L. (2005). Can reflective practice be taught? Reflective Practice, 6, 199–204. http://dx.doi.org/10.1080/14623940500105833

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.

Roth, W., & Ebbing, J. (1993). Becoming a reflective science teacher: An exemplary endeavor by a preservice elementary teacher. In P. A. Rubba, L. M. Campbell, & T. M. Dano (Eds.), Excellence in educating teachers of science (pp. 91–110). Columbus, OH: ERIC.

Russell, T. L. (2005). Can reflective practice be taught? Reflective Practice, 6, 199–204. http://dx.doi.org/10.1080/14623940500105833

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. (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.

Roberts, D. (1991). A reflective approach to science methods courses for pre-service elementary teachers. Journal of Science Teacher Education, 2(1), 1–6.

Roychoudhury, A., Roth, W., & Ebbing, J. (1993). Becoming a reflective science teacher: An exemplary endeavor by a preservice elementary teacher. In P. A. Rubba, L. M. Campbell, & T. M. Dano (Eds.), Excellence in educating teachers of science (pp. 91–110). Columbus, OH: ERIC.

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. (1983). The reflective practitioner: How professionals think in action. New York, NY: Basic Books.