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Exploring Reflective Practices of Beginning Science Teachers in an Online Induction Program

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Induction programs are an important component of teacher education aimed at developing teachers as lifelong learners who can make use of reflective and self-regulatory learning practices. The online induction program in this study uses reflective learning cycles to promote the development of reflective practice. A multiple case study of three beginning science teachers was used to explore their self-regulatory processes in developing reflective practice. The authors contend that beginning teacher education programs must engage beginning teachers in self-regulatory learning in order to become reflective practitioners.

Teacher induction can serve to support the transition of beginning teachers from novice to professional (Tickle, 2000). The existence of teacher induction programs is now widespread, with 90% of beginning teachers in the United States receiving some form of formal induction or mentoring support (Smith & Ingersoll, 2004). While induction programs have been found to lower teacher attrition (Ingersoll 2012), researchers caution that both the type and quality of support dramatically affects the intended impact on teacher retention, classroom practice, and student learning (Ingersoll & Strong, 2011; Luft et al., 2011; Smith & Ingersoll, 2004).

Bickmore and Bickmore (2010) defined effective induction programs as those that meet new teachers' professional and personal needs. Professional needs for successful teaching include knowledge, skills, and strategies in content, pedagogy, and personal reflection (McCann et al., 2005). Equally important are personal needs, such as a sense of self, positive self-esteem, and self-reliance (Bickmore & Bickmore, 2010).

Induction researchers have primarily focused on retention, although some authors have explored the impact of induction of teachers' beliefs, knowledge, and classroom practices (e.g., Crawford, 2007; Luft et al, 2011; Nixon et al., 2017; Roehrig & Luft, 2006; Wong & Luft, 2017). However, the literature on the development of beginning teachers' reflective practice is sparse; therefore, this study focused on examining reflective practice as an important and critical component of beginning teachers' professional growth (Killion & Todnem, 1991; McCann et al., 2005).

In this study, reflective practice was examined through the interactions of beginning secondary science teachers participating in an online teacher induction program. We studied the development of teachers' reflective practice within the professional development activities that comprised the induction program. In addition, we investigated the components of the activities and their role in helping our beginning teachers develop as self-regulated learners. The research questions that guided this study were as follows:

- In what ways do beginning science teachers engage in self-regulatory learning processes and reflective practice through their participation in an online induction program?
- How do beginning science teachers' decisions and motivations lead to different self-regulatory and reflective practices?

Literature Review and Theoretical Framework

In this study, we drew on Schön's reflective practice model adapted by Killion and Todnem (1991) and self-regulated learning (Zimmerman, 2002). An understanding of both domains is critical in the exploration and analysis of beginning teachers' actions as they engaged in an online induction program.

Reflective Practice

Reflective practice is widely recognized as a central component of the teaching and learning process (Brookfield, 1995, 2005). The usefulness of reflective practice has led to the adoption of reflection as a foundation for many teacher education programs (Richert, 1990; Tom, 1985; Valli, 1993). Dewey (1933) and Schön (1983) are considered pioneers in developing the field's understanding of reflective practice, and several researchers have developed conceptions of reflective practice based on their seminal work.

Dewey (1933) suggested, "We do not learn from experience … we learn from reflecting on experience" (p. 78). Similarly, Schön (1983) described reflective practice as a complex cognitive exercise that requires practitioners to revise, modify, and refine their expertise. For Schön, reflection begins in practice, particularly those areas of practice where professionals are confronted with unique and confusing situations – "the swampy lowlands of practice" (p. 42).

Reflective practitioners must engage in "deliberate thinking about action, with a view to its improvement" (Hatton & Smith, 1995, p. 40). Loughran (2002) described reflective practice as "the ability to frame and reframe the practice setting, to develop and respond to this framing through action so that the practitioner's wisdom-in-action is enhanced and articulation of professional knowledge is encouraged" (p. 42). Similarly, Raelin (2002) valued "the practice of periodically stepping back to ponder the meaning of what has recently transpired," which he went on to explain, "privileges the process of inquiry" (p. 66).

The importance of structuring reflection to support educators as they assume new roles has been well substantiated (Perry & Power 2004; Pultorak, 1996, Reiman, 1999; Risko et al., 2002). Teachers should engage in reflective practice as they progress in their field, as intentional or disciplined reflection can lead to reflection becoming a regular feature of a teacher's professional practice. As such, reflective practice serves as a catalyst for continuous learning about educational practice.

Schön (1983) further developed Dewey's ideas and identified two types of reflection: *reflection–on-action* and *reflection-in-action*. In reflection-on-action, teachers review, describe, analyze, and evaluate their past practices, with a view to gaining insight to improve future practice, whereas, during reflection-in-action, teachers examine and respond to events as they occur in real time. In both types of reflection, professionals seek to build new understandings to shape their action in the unfolding situation. Reflective practice is a complex cognitive exercise that requires the practitioner to revise, modify and refine their expertise by

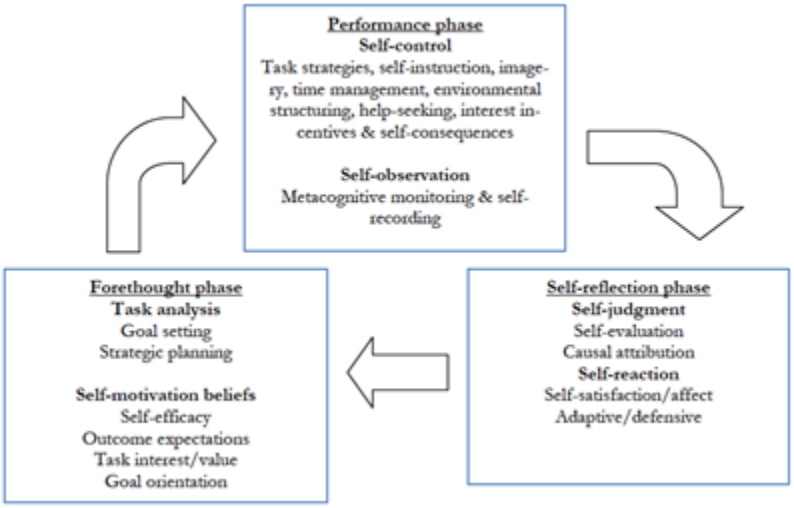
> allow[ing] himself to experience surprise, puzzlement, or confusion in a situation which he finds uncertain or unique. He reflects on the phenomenon before him, and on the prior understandings that have been implicit in his behavior. He carries out an experiment which serves to generate both a new understanding of the phenomenon and a change in the situation (Schön, 1983, p. 68).

Killion and Todnem (1991) added a third category of reflection, *reflection-for-action*. Reflection-for-action provides for a deeper focus on lesson planning, which is an important learning space for beginning teachers. The view of reflective practice that we advanced in our online induction program included this third category, as we sought to support beginning teachers' abilities to reflect on past action, in current action, and for future action.

Self-Regulated Learning

Reflective practitioners are described as adaptive experts; similarly, effective learners are often described as adaptive experts in the literature on self-regulated learning (SRL; Winne & Hadwin, 2008; Zimmerman & Schunk, 2001). SRL emphasizes "self" as an agent in establishing learning goals. Each individual's perceptions of self and task influence the quality of learning that ensues. Self-regulation refers to self-generated thoughts, feelings, and behaviors that are oriented to attaining goals (Zimmerman, 2000). The structure of self-regulatory processes is explained in terms of three cyclical phases: forethought, performance, and self-reflection (see Figure 1).

Figure 1
Phases and Processes of Self-Regulation According to Zimmerman and Moylan (2009)



During the forethought phase, which parallels reflection-for-action (Killion & Todnem, 1991), learners perform analysis of the learning task and set specific goals toward completing that task. Both forethought and reflection-for-action provide a learning orientation focused on planning for a learning experience scheduled in the near future. Task analysis involves goal setting and strategic planning. It is the nature of the task and its demands that "guide cognitive processing and the amount of effort" that learners invest in task analysis (Efklides, 2011, p. 21).

Task analysis involves two kinds of processes, automated and analytic. Automated process are often unconscious based on familiarity with the task, whereas an unfamiliar task requires increased cognitive effort and development of new knowledge and strategies (Efklides, 2011). For teachers, task analysis during the forethought phase involves decisions about lesson planning. In the case of beginning teachers, automation is less likely, and determining the appropriate strategies and pathways to complete a task often requires the application of unfamiliar knowledge.

The performance phase encompasses processes that "occur during behavioral implementation" (Zimmerman, 2002, p. 67), parallel to reflection-in-action. Learners employ strategies to make progress on the learning task and monitor the effectiveness of those strategies. According to Zimmerman and Moylan (2009), two main processes take place during the performance of the task: self-control and self-observation. Self-control involves the learner in task strategies to maintain concentration and promote ongoing learning. Motivation is not enough to sustain self-regulatory processes in the performance phase (Randi, 2004).

Learning to teach and improve one's practices is a complex task that requires volitional control (Randi, 2004). Self-observation involves learners in tracking performance through metacognitive monitoring or formal recordkeeping. There are parallels between processes within the performance phase and reflection-in-action (Schön, 1983). For example, engaging in metacognitive monitoring, like reflection-in-action, occurs in real time during as teachers' implementation their planned instruction.

However, other processes within the performance phase include "self-recording personal events or self-experimentation to find out the cause of these events" (Zimmerman, 2002, p. 68), which would represent strategic collection of data for the self-reflection phase (reflection-on-action) rather than reflection-in-action. The use of video to explore reflection-in-action is common in the literature (e.g., Anderson, 2019; Tripp & Rich, 2012; Yanow & Tsoukas, 2009; Xiao & Tobin, 2018). Such research argues that video serves as a proxy for reflection-in-action, as asking teachers to stop and reflect in real time as they make decisions in their classroom is not feasible. However, O'Mara (2016) described reflection-in-action as "ephemeral and difficult to record" (p. 41). While video annotations allow the participants to reflect retrospectively on their in-action decisions and practices, the lines between reflection-in-action and reflection-on-action can become blurred.

In the final self-reflection phase, which parallels reflection-on-action (Schön, 1983), learners evaluate their performance with respect to the effectiveness of the chosen strategies. This phase involves self-judgment and self-reaction. Self-judgment pertains to evaluating whether learning was achieved and determining the reasons for the success or failure of learning. Self-reaction to a learning experience can be satisfying (adaptive) or frustrating (maladaptive) leading learners toward future decisions. Self-reflection helps learners gain control over their own learning and practice by connecting the lessons learnt to decisions for future action. These self-reflections ultimately influence leaners' planning and goals, initiating the cycle to begin again (Figure 1).

SRL theory highlights a cyclic framework, where feedback from previous performance is used to make adjustments in future learning efforts (Zimmerman, 2000). SRL theory has been used extensively to explore student performance (Zimmerman & Schunk, 2001) and has also been used in some studies of teacher education programs (Moos & Ringdal, 2012; Perels et al., 2009). Indeed, there are clear benefits to developing beginning teachers' capacities for SRL, as self-regulated learners are metacognitively, motivationally, and behaviorally engaged in the learning process (Zimmerman, 2002). Thus, these learners are self-aware, goal-oriented, strategic planners, self-monitoring, and self-motivated (Zimmerman & Schunk, 2001).

SRL theory provides the self-regulatory processes for learners to engage in reflection-for-action, reflection-in-action, and reflection-on-action. SRL skills help learners take control of their own learning by being open to inquiry and challenging their ideas to construct new knowledge through continual reflection. The alignment of SRL and reflective practice is summarized in Table 1.

Table 1
Alignment Between SRL Theory and Reflective Practice Model

SRL Theory	Reflective Practices Model	Alignment
Forethought Phase Learner engages in processes of Goal setting and self-motivation beliefs	*Reflection-for-action* Learner engages in planning for the upcoming action in light of previous reflections	Processes of goal setting and self-motivation are prerequisite for learner's planning for a task in future.
Performance Phase Learner focuses on the processes of self-control.	*Reflection-in-action* Learner examines and responds to events in real time.	Processes of self-control, such as meta cognition, support examining and responding to events happening in real time.
Learner focuses on the processes of self-observation.		Processes of self-observation involve the collection of data to support evidence-based reflection in the following SRL phase
Self-reflection Phase Learner uses SRL processes of self-judgment and self-reaction.	*Reflection-on-action* Learner reviews, describes, analyzes, and evaluates past practices with focus on gaining insights to improve future practices.	Processes of self-judgment and self-reaction provide support when a learner is reflecting on action and gaining insights for improving practices for future.

Methodology

This study built on previous research (Ellis et al., 2015; McFadden et al., 2014) that explored how online induction program participants reflected on video of their teaching practice using the Learning to Notice Framework (van Es & Sherin, 2008). In this study, a qualitative multiple case study design (Yin, 2013) was used specifically to explore and understand the experiences of three beginning secondary science teachers participating in activities within an online induction program designed to promote reflective practice. These cases were purposefully selected to represent teachers with beginning, developing, and developed reflective practice as identified in our previous work (McFadden et al., 2014).

Context

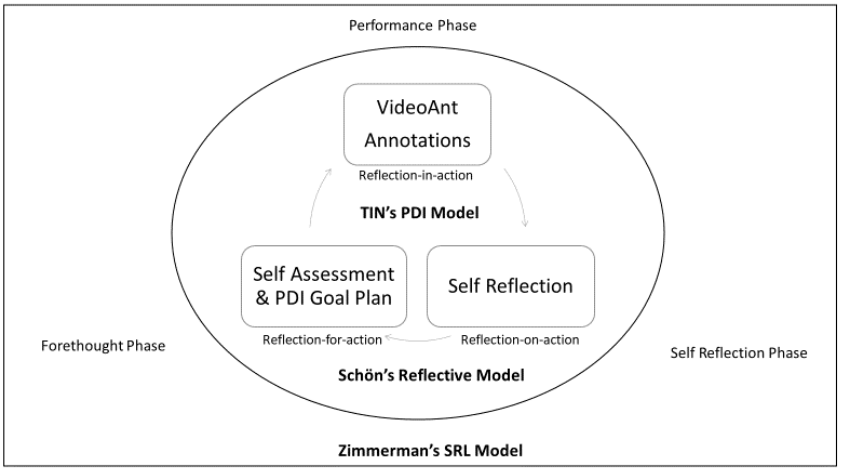
This research was conducted at a large Midwestern university in the United States within an online induction program. The induction program is embedded into the postbaccalaureate secondary science licensure program at the university. This 12-month, cohort-based program includes a three-course science methods sequence, coursework on the nature of science, extensive, supervised practicum, and student teaching experiences. After receiving a teaching license, teachers complete nine additional credits of graduate science education coursework to complete the Master of Education degree while working as new teachers in middle school or high school settings. The induction program is offered as a three-credit online (asynchronous) course as part of the M.Ed. degree requirement.

The induction program is offered online to provide ongoing support to our teachers, regardless of their geographical location. The four primary components of the induction program are Reflective Journals, Topical Response forums, Venture-Vexation discussions, and Professional Development Inquiries (PDIs; Danielson, 2007). These four components are described in detail in Roehrig et al. (2015). Of these four components, the one that most directly supports the development of reflective practice is the PDI.

Professional Development Inquiries

PDIs are completed twice a year (once per semester). Each PDI lasts approximately 8 weeks and follows a reflective learning cycle that maps onto our theoretical framework (Figure 2).

Figure 2
Self-Assessment and PDI Goal Plan



At the start of the PDI, teachers completed a self-assessment using Danielson's (2007) Framework for Teaching. Danielson's framework was used in many schools and, thus, provides a common reference for teachers as they navigate between district language and evaluation and expectations of the induction program. Specifically, teachers were asked to evaluate themselves and identify areas for growth related to the five components of the instructional domain: communicating clearly and accurately, using questioning and discussion techniques; engaging students in learning; providing feedback to students; and demonstrating flexibility and responsiveness.

VideoAnt Annotations

After identifying an area for professional growth, teachers developed lesson plans and assessments to meet their chosen PDI goal. These lessons were video recorded, and teachers were afforded the opportunity to reflect both individually and with their peers using video annotation tools within the PDI to facilitate reflection-on-action. The video annotation tool, called VideoAnt (Hosack, 2010), was designed to provide teachers the ability to pause the video at a point of interest and add a time-marked text annotation (see Figure 3). Each annotation is marked on the timeline on the bottom of the screen, and these annotations are highlighted as the video is played. This feature allows a peer to easily connect annotations with actions in the classroom.

Figure 3
A Beginning Teacher's VideoANT Reflections on Real-World Connections

Participants were directed to upload 20 to 30 minutes of video and use VideoAnt to provide evidence of professional growth based on their specific goals. After restating their one or more goals for the PDI in their first annotation, a minimum of five annotations related to the goal were required with a clear explanation of how the selected moments provided evidence of growth related to the instructional goals. Beginning teachers were also required to add at least five more annotations related to any other aspects of teaching practices noticed.

Reflection Paper

The PDI culminated with a reflection paper looking back at the entire PDI process. The reflection paper included a guiding prompt that asked the beginning teacher to reflect on the entire PDI, beginning with the Self-Assessment and PDI goal and continuing through the PDI lesson reflections made during video annotations to this final reflection paper.

Each of the aforementioned PDI assignments are aligned with our integrated model of SRL and reflective practice (see Table 2). These learning tasks provided beginning teachers the opportunity to gauge their learning by planning, monitoring, and evaluating before the task began, while the task was happening, and once the task ended through reflections. The application of the integrated SRL and reflective practice model used in the induction program gave learners an autonomous role where they implemented the PDI tasks to self-regulate their learning through continuous reflection.

Table 2
Theoretical Model in Action During TIN

Zimmerman's SRL	Schön's Reflective Practices	PDI Assignments	Purpose
Forethought phase	Reflection-for-action	Self-Assessment and PDI goal plan	Plan for a learning task
Performance phase		Video annotations	Self-observation of a learning task
Self-reflection phase	Reflection-on-action	Video annotations Reflection paper	Evaluate learning task

Participants

For this case study, three teachers were purposefully selected from the 16 beginning teachers in our previous study to represent a range of development of beginning science teachers' reflective practice. In our previous study (McFadden et al., 2014), teachers were grouped into three different levels of reflective practice: developed, developing, and beginning. A developed reflective practitioner could look back and not only describe, explain, and evaluate their practices, but also interpret those practices. A developing reflective practitioner could describe, explain, and evaluate their practices, but not interpret. Finally, a beginning reflective practitioner only described and explained their practices and seldom evaluated their practice. The three beginning teachers (Paul, Steve, and Ben) represented the three different categories of reflective practitioners (see Table 3) and allowed for a detailed examination of their use of SRL processes and an evaluation of the possible impact of SRL processes on their level of reflective practice as these three teachers were engaged in the PDI.

Data Collection and Analysis

Data sources included all documents and videos related to the spring PDI for these three teachers. These data sources included the self-assessment and PDI goal setting documents, video annotations, and final reflection paper. Analysis was conducted in two phases. The first phase included deductive coding (Miles & Huberman, 1994) of the entire PDI dataset for all three cases. Paul's, Steve's, and Ben's self-assessment and PDI goal setting documents, video annotations, and final reflection papers were coded using the main categories within each phase of SRL (Zimmerman, 2000; Zimmerman & Moylan, 2009; see Table 4).

Table 3
Information for Three Teachers and Details of Their PDI

Name	Reflective Practice Level	Teaching Position	PDI Lesson Topic	Domain of Instruction Explored in PDI
Paul	Beginning	High School Chemistry	Balancing Chemical Equations	3d: Providing Feedback to Students
Steve	Developing	High School Chemistry	Balancing Chemical Equations	3d: Providing Feedback to Students
Ben	Developed	High School Physics	Balloon Engineering Drop	3e: Demonstrating Flexibility and Responsiveness

The second phase was intended to collapse codes to establish broader categories within the data (Corbin & Strauss, 2008). This approach served to provide in-depth description and analysis of the process of a set of activities designed to develop reflective practices of beginning teachers through detailed data sets involving multiple sources of information (Creswell, 2007).

Findings

The key findings are first presented by case, describing each teacher's enactment of reflective practice and self-regulated learning skills throughout the PDI. Each teacher's PDI is unique. Although all three of them participated in the same PDI activity with the same set of expectations and requirements, they responded differently depending on their individual SRL skills.

Paul: A Beginning Reflective Practitioner

Reflection-for-Action and Forethought Phase

During self-assessment and PDI goal planning, Paul indicated that he struggled with the instructional domain of Using Questioning and Discussion Techniques. As a first-year high school chemistry teacher, he identified balancing chemical equations as an upcoming unit to address his PDI focus. Specifically, within his Self-assessment and Goal Setting Document, he identified two issues related to his use of questioning:

> My opening questions are inconsistently timed and require pieces of paper to be used and for me to take time to count up and see how much people understood it after class instead of before.

My think pair share questions are not always high level questions. I want to try and build the level of rigor up as the lesson goes on.

Table 4
Coding Scheme for the Cases Based on SRL Phases and Categories (Zimmerman, 2000; Zimmerman & Moylan, 2009)

SRL Phase	SRL Category	Category Description	Sample Quotes
Forethought	Task Analysis	The process of fragmenting the task and establishing strategies	This class will require flexibility in teaching methods and in what I deem "acceptable work". It will also include a lot of open-ended projects, with a wide range of results from a diverse pool of student talents and abilities.
Forethought	Intrinsic Motivation	Personal motivation guiding PDI decisions	The main reason for this choice is that I have opted to take-on a [chemistry course], which is more concepts- and engineering-based. Just an FYI, this is a big step outside of the box for me…but I need it.
Self-reflection	Self-Judgment	Analysis of performance against some standards or beliefs of success	I think my flexibility has reached new bounds. I am so used to having such well-planned and inflexible lessons, that anything would have improved this goal. Now I've opened a whole new door for myself: the open-ended, student-driven project.
Self-reflection	Self-reaction	Process of emotional and cognitive reactions to self-judgments	I feel as if my lesson has changed the course in a way that will have a lasting effect. My fear is that it will be more 'fun' than the regular courses and will pull kids away from them. My hope is that I will find the time to incorporate these lessons into the regular chemistry classroom as well.

Paul proposed several actions based on his task analysis: the use of clickers, rearranging the classroom so that students could sit in pairs for the think-pair-share activity, and generating think-pair-share cards with different levels of questions. Some details of his task analysis included the following:

> With the use of a timer and clickers I could see immediately whether or not I need to go over the topic immediately or if most understood the question and I can move on and only use a couple minutes at the beginning of class for that.
>
> I will build and use cards for think pair share and the questions will show higher-level questions in their use. I will find some type of timer to use with my opening questions and maybe my think pair share questions as well. Hopefully the clickers have a built in timer I can use to gain data and keep the class on pace. Hopefully I will be able to see my students using logic and discussion with their tablemate.

Reflection-on-Action and Self-Reflection Phase

In his video annotation, Paul first summarized his goals for the lesson and explained that he forgot the camera on the day that he intended to video record. Following these introductory annotations, Paul added only three annotations where he simply described and explained his instructional steps and decisions. For example, in this annotation, Paul explained his decision for organizing his room, stating, "It is kind of hard to see here, but the tables have been moved so that they are all in groups of two, so that they have tablemates with which to discuss these problems and see if they agree."

Paul's video annotations depicted the recall of steps and decision-making process. For example, he annotated,

> I'm going a bit fast here because my first two hours didn't get much time for their skill checks at the end and I wanted to make sure this class did. Turns out I didn't need to; we got even farther in this class.

In the self-reflection paper, Paul reflected on the degree to which he was successful in improving his questioning strategies. In his own self-judgement related to his goals he stated, "This was a moderate success, as it worked for many tables, but I did still have some of them that either refused to participate or didn't want to talk to their tablemate." He went on to say, "There were questions that required them to think at a much higher level, especially on the last page, and it caused most of them to struggle with them."

His self-judgment was limited to student engagement, and he struggled to determine the causes for success or failure, which made it difficult to reflect on how to continue to improve his instructional practice related to questioning. For example, when reflecting on the lack of engagement of some students in the think-pair-share activity, Paul wrote,

> I've been thinking about it, and am still unsure how to get the apathetic ones to participate. This might be able to be done with the clickers and required participation points from the responses, but as I've only just gotten a hold of a set so I haven't been able to test it yet.

Paul continually defaulted to clickers as a potential solution to both participation and technical problems. For example, he believed the clickers would be a better technological solution to pacing questioning activities. He reflected,

> As classroom procedures go this was only a partial success, the students now know the routine of doing opening questions at the beginning of class, but the slide I keep attempting to use with a timer on it stops working most days and says the macros won't load and I'm unsure how to fix it and our tech people have a very slow response time to questions. Hopefully in the future I can also use clickers for that which I believe have a built in timer.

He concluded his reflection paper by considering how engaging in the PDI has helped him as a new teacher:

> The PDI did help me see what areas I need work on and made me attempt to fix them. What it probably helped most with was giving me an outline for the skills. I need to focus on this over the summer for next year, as this experience helped me realize that I have a lot farther to go in some of the areas than I previously thought, such as seeing the quiz scores after giving the packet to my students, most of them missed the connections that were made at the end of it. It showed me that while I thought the packet did a great job of getting them from metaphor to example to concept, it would appear my students' scores and subjective comments to me about it showed me there were gaps in it.

Steve: A Developing Reflective Practitioner

Reflection-for-Action and Forethought Phase

Steve was a first-year teacher at a small, rural high school assigned to teach physical science, physics, and astronomy. During self-assessment and PDI goal planning, Steve identified the instructional domain of Providing Feedback to Students as his area for improvement. Specifically, he stated, "I don't believe that the feedback I provide is prompt enough or detailed enough for each assignment and assessment. I also do not think that I modify the curriculum enough based on the trends I find in student work." Steve's proposed solution was nonspecific. He simply noted evidence for growth, stating, "The primary ways in which I will demonstrate growth in this area is being able to provide a more ready return of student work and document changes in lesson plans based on student performance."

Reflection-on-Action and Self-Reflection Phase

Steve's annotations, while most frequently coded as describe and explain, started to move toward evaluation. For example, Steve annotated and evaluated the quality of his questioning and feedback during his chemical reactions labs, which while related to the topic of feedback, was not aligned with the stated goals in his self-assessment. For example, he noted, "I've been doing good asking questions, but could be asking more through

here," and "I'm doing way too much of the solving of this problem. I should be asking the students to solve this."

Given the nature of the lab activity, students were working in small groups. Steve often reflected on his feedback within small groups:

> Most of the feedback I am able to provide in a lab involves the ability to answer questions students have as they come up. One of the greatest difficulties I have during labs is cycling to each of the groups, especially when the ones with questions are typically the same groups over and over.

He noted toward the end of the lesson that he started to repeat questions to the whole class to improve efficiency with time. Specifically, he stated, "I'm starting to get repeat questions from many students so I'm directing students to the other half of the class where I can address them all simultaneously."

Steve also included several annotations not related to his goal of improving feedback. Many of these annotations addressed classroom management and specifically questioned his students' behavior in lab activities. For example, he stated,

> Trying to get them settled into the lab is a project in itself. Because the copper II sulfate is an eye/skin irritant, I require that they wear goggles for the lab. The next big task is making sure they're working on the right lab. Meaning that they need to be picking up the right materials. Part of me wonders sometimes if the work of keeping them reigned in during a lab is worth the educational/enjoyment benefits they receive from doing the lab.

Steve also shared specific insights into his students that were triggered by watching the video. For example, he noted,

> I have to say, the most advantageous aspect of these videos is being able to observe things occurring in the class, when I wasn't observing. The group in the top right of the screen, the three girls, I find that far too often only the one in the middle, [Kate (pseudonym)], does all the actual thinking involved in any lab.

In his reflection paper, Steve added to his original goal of improving his turnaround time on returning papers to students to include how he provided feedback to students during instruction. Based on his self-judgment, Steve believed that he had only achieved his goals related to feedback during instruction:

> I have found that I have improved in the classroom portion of these goals, but not significantly in the returning graded assignments aspect. For the in-class portion of feedback, I feel I have increased the amount I move around to each group significantly. While it is still the higher achieving students that request my attention more, I feel that I have made it around to the

> rest of the class more evenly to make sure they are progressing and understanding content more thoroughly.

Steve went on to evaluate his progress and reflect on how to continue to improve on feedback for the future. For example, related to his in-class feedback he stated,

> Among the most significant things I found about my teaching during this PDI is that I teach to the student who pays attention. I like the fact that I teach this way because it rewards students for paying attention simply by making them feel like they're important; however, I'm not entirely sold on it because it does leave so many out on any given day.

He also reflected on issues related to providing timely written feedback to all students, as he noticed that the "lower achieving students are not getting the feedback they need." In his reflection paper, Steve explored related policies, such as late work policies, especially with many special education students with Individualized Education Programs (IEPs), allowing them more time to complete their assignments. As he stated,

> The largest problem comes with late work. Students turn in their assignments significantly after the dead line, sometimes even after a test and find that even if I do give them feedback, it now has no bearing on the current content material, or that the bearing it does have is so buried that it is near meaningless to them.

While Steve evaluated and explored issues around improving feedback for all students, he did not resolve a concrete plan for the future.

Ben: A Developed Reflective Practitioner

Reflection-for-Action and Forethought Phase

Ben was a first-year teacher at a large, suburban high school in the Midwest, where he taught sections of physical science and chemistry. At his school, all sophomore students were required to take chemistry, and Ben purposefully planned to conduct his PDI in his Chemistry in the Community class. He stated, "[This course] is more concepts and engineering-based than the regular chemistry course. It also includes a lot less math. Teaching this class will require tons of flexibility in teaching methods and in what I deem acceptable work."

Ben identified the instructional domain of Demonstrating Flexibility and Responsiveness as the focus for his PDI. He connected the identification of this goal to his first-semester experiences and expectation that up-coming academic tasks would meet the needs of all students. He reflected on his strengths and past practices with teacher-centered instruction that were not promoting inquiry and student thinking:

> [Last semester] I chose was "Planning and Preparation," because it seemed like a logical place to start as a first-year teacher. I know

> that my strengths lie in the PowerPoint making, worksheet creation/integration, and planning the class period from start to finish. However, I wasn't so spectacular at organizing student-driven activities, getting students' attention, and planning student-driven activities.

Ben described how he tried some small changes in the second trimester that students initially resisted. However, he persisted with the move to more student-centered instruction, noting that "after two or three similar activities over the course of two weeks they are starting to accept this as another method of learning." For the last trimester, Ben planned to integrate a 2- to 3-week engineering design challenge for students to see applications of chemistry. For his PDI, he intended to plan an activity where students would build a small hot air balloon and observe his lessons for flexibility and responsiveness to student ideas.

Reflection-on-Action and Self-Reflection Phase

Ben focused closely on his PDI goals while annotating his video. He described, explained, and evaluated his actions during annotations, connecting his understanding of engineering design lessons with flexibility and responsiveness. When describing the wide range of different balloon designs, Ben noted,

> The only things that I told them they must do are: 1. The balloon must have a ring at the bottom that fits the metal pipe. 2. The balloon must be made of tissue paper. 3. The balloon must have all of its paper connected using rubber cement. Every project I found online relating to balloon building had a set design for students. They did not allow for students to make their own designs. If they made them like that, how could they call their project their "own"?

The open-ended nature of the activity meant that Ben had to let the students guide the lesson. He stated at one point, "It was tough for me not to give them any hints on what they could do to improve their balloon." He went on to explain and evaluate the long-term impact of letting students learn through an iterative design cycle, stating,

> Giving a student a firm answer, I am learning, is not always the most effective way of teaching. Perhaps, that is why Americans will continue to lead the way in the creativity department: We allow for other possibilities and accept failure as a boost toward success.

In the observed lesson, students were testing their balloon designs outside, which presented different testing conditions to their prior indoor tests. The harsher testing conditions led to a series of poor results that required Ben to demonstrate flexibility. For example, in one of his annotations Ben stated,

> The change in conditions caused a balloon with a very long flight time indoors to fail miserably outdoors. The reason, the students

> decide, is the ability for the cold air and hot air to travel through the small holes in the surface of the tissue paper that they made their balloons with. I gave them a score based on their indoor flight, since their balloon was tested and engineered under those conditions.

In his reflection paper, Ben made clear connections between his identified goal and the outcome of implemented lesson. Through his reflection, he demonstrated renewed motivation and commitment to student-centered instruction. For example, he discussed how focusing on flexibility had improved his teaching practices:

> I think my flexibility has reached new bounds. I am so used to having such well-planned and inflexible lessons, that anything would have improved this goal. … As far as improvement of self, I'm more open to this type of project overall, and I'm starting to change my labs in class to be more like this. As long as I have the time in class, I'm going to try these types of labs out in the future.

He also reflected on the benefits of engineering design lessons for his students. He reflected not only on how his students "had a blast" designing hot air balloons, but also that the experience had provided his students with "a new way of thinking" and that "my students are more apt to think outside of the box now; it helped them realize that there's more than one way to make something 'right.'"

As a result of his reflection, Ben suggested various adaptations that would improve his teaching of this lesson in the future. For example, in the following statement, Ben reflected on the need to strengthen his teaching of engineering concepts,

> I think the next piece that I have to include is the structure of the engineering process. I should probably teach that as a concept at some point if I get the go-ahead with redesigning that physics course into an engineering course. Then I can include things like timelines, budgets, materials (with costs), deadlines, product approval, micro-scale product testing, researching material strength and weakness, researching build sites-surveying (if there's a project about building an actual structure), and much more.

Ben also discussed how he would expand his learning from the PDI into other aspects of his teaching. He was given an opportunity to "revitalize a physics course and turn it into an engineering-type course for students that may or may not be struggling with the math piece and want to develop their strengths in engineering." He also reflected on how this engaging hands-on approach would impact students' decisions to choose the regular chemistry course over the Chemistry in the Community option:

> My fear is that it will be more "fun" than the regular courses, and will pull kids away from them. My hope is that I will find the time to incorporate these lessons into the regular chemistry classroom along with all of the standards.

Ben also mentioned his colleague who he worked closely with. This teacher was observed in Ben's teaching video joining the class on his planning period to see how the engineering design challenge was going. In his reflection paper, he commented "We are always giving each other feedback and helping each other improve our lessons."

Cross-Case Analysis and Discussion

A comparison of the findings from these three cases reveals important differences in the use of self-regulatory processes for beginning, developing, and developed reflective practitioners. Each case is representative of a varied use of self-regulatory processes showing different levels of reflection and control over their own learning.

Reflection for Action and Forethought Phase

This assignment was significant within the induction program, and thus, teachers were extrinsically motivated to complete the PDI tasks. However, the PDI structure was designed to activate intrinsic motivation by supporting each teacher in selecting a PDI topic of personal interest. In selecting a topic that addressed teaching strategies aligned with reform-based science teaching, each participant chose to engage in practices that would promote student learning.

All three teachers expressed their desire to develop and reflect on teaching practices that used student ideas to guide instructional decisions. For example, Paul expressed his belief that accessing student ideas at the beginning of each class and building on these ideas with higher order questions throughout the class are important for student learning. Steve stated a belief that evaluation of student understanding should guide future instructional decisions. Ben believed that including student-centered instruction in his pedagogical repertoire was important.

Initial task analysis (i.e., lesson planning) was a critical step in establishing both SRL and reflective practice. Ben was able to act on his goal of engaging students in more student-centered learning through the integration of an engineering design challenge into his classroom. Planning for student-centered engineering design lessons is a complex task, for example, requiring careful consideration of the nature of the engineering design challenge to make sure that it promotes multiple solution pathways and promotes the application of target science concepts (McFadden et al., 2014).

Ben spent significant time during the forethought phase looking at existing engineering lessons, noting that many provided step-by-step directions for building, which he recognized did not match his goals. Ben made significant modifications to relevant, existing engineering design ideas to make sure that his lesson plans aligned with his stated goal of implementing student-centered instruction.

However, for Paul and Steve, their stated goal of focusing on student learning was tempered by concerns about classroom management, encompassing student behaviors and efficient use of instructional time to

enable meaningful learning and promote students' growth (Emmer & Sabornie, 2015). Underlying concerns about classroom management and organization influenced the nature of their task analysis and lesson planning. Paul was successful in task analysis to match his goals, his lesson planning incorporated technical solutions such as implementing clickers and developing higher order thinking questions in advance of instruction. Unfortunately, his task analysis was teacher-centered and focused on preplanning, as opposed to planning to be responsive to student ideas during instruction.

Paul, like Ben, was able both to activate prior knowledge from his preservice program and research new approaches and ideas. Paul was able to develop specific lesson strategies to accomplish his goals and move beyond a surface level task analysis to task-specific details (Efklides, 2011). However, Steve's task analysis in the forethought phase remained at a surface level; his analysis did not go beyond a loose plan to monitor turn-around time in returning students' work and documenting changes to his lesson plans. This choice was problematic when entering the performance phase, as the structure of the PDI used video of instruction as a self-observation strategy.

Reflection in Action and Performance Phase

Video annotation allowed the teachers to describe and learn from reflecting on their instructional decisions, a strategy within SRL described as self-recording or self-observation (Zimmerman, 2000). For example, when Steve annotated, "I'm doing way too much of the solving of this problem. I should be asking the students to solve this," he was connecting his performance with his pedagogical knowledge, not only reflecting on action through engaging in video annotation but also reflecting for future action. Similarly, Ben's annotations provided a detailed window into his decision-making process throughout the lesson as he reflected on the degree to which he should support students versus letting them solve problems for themselves.

The three teachers used a variety of strategies during video annotation. While both Paul and Ben created annotations that were focused on their PDI goal, Steve annotated on a variety of topics. As previously noted, Steve did not enter the performance phase, having completed task analysis on his PDI goal. Thus, Steve used video annotation as a mechanism to establish a PDI goal related to his observed lesson. Steve made several annotations on his classroom video related to his small group questioning, noting his behavior patterns with respect to differences in his interactions with students based on their achievement levels in his class. While these annotations were not connected to his initial motivation and PDI focus, they served to generate a new motivation for his PDI to better understand his questioning and group monitoring behaviors during laboratory lessons.

Reflection on Action and Self-Reflection Phase

In addition to supporting self-observation within the performance phase, as described in the previous section, the video annotation task also

engaged the teachers in SRL processes attributed to the self-reflection phase. Self-judgement is closely associated to self-observation, and the teachers with more developed reflective practice used the video annotation task, not only to describe and explain their instructional decisions but also to evaluate and interpret these decisions (McFadden et al., 2014).

Both Steve and Ben engaged in self-judgement through their annotations. While Ben had a mix of positive and negative self-judgements in his annotations, Steve provided only negative self-judgement as he reflected on his teaching. In using the video annotation task to develop his PDI goal, Steve focused on negatives as he sought for a problem of practice to explore in his PDI. This step is important because "people pursue courses of action that result in satisfaction and positive affect, and avoid those courses that produce dissatisfaction and negative affect" (Zimmerman, 2000, p.23).

The PDI culminated in a reflection paper in which teachers were able to extend their self-reflection beyond the video annotation task. Paul's reflections on action were focused on time management and considerations for how to get all students to participate in the activity. While loosely connected to his original PDI focus, he continued to focus on the use of clickers, even though he did not use clickers during his lesson. Within the reflection paper, Paul moved his attention to reflection-for-action in thinking about work he needed to do over the summer to improve his instruction for next year. As such, the SRL cycle started to move back into the forethought phase as Paul reflected on his PDI and initiated some preliminary task analysis statements. He was still wondering if clickers would be the solution to his stated problem, as well as recognizing the need to revisit the structure of the student packet.

Steve started to draw conclusions about his interactions with small groups during the self-reflection phase. He focused on getting to all students during a class period without consideration of the nature of the feedback provided to students, which was his original motivation. His limited reflections were likely related to a lack of clarity in his task analysis during the forethought phase and the spontaneous refinement of his motivation to provide more detailed feedback during the performance phase. Ben, however, was able to draw conclusions related to his PDI focus using evidence from his teaching, not only to reflect on the current teaching episode but also to plan for future instruction, initiating a new SRL cycle.

Through engagement in SRL processes, teachers drew conclusions in their reflection papers about their PDI goals. Zimmerman (2000) referred to these conclusions as adaptive or defensive inferences. Through self-reflection on his PDI, Ben engaged in self-judgement, drawing adaptive inferences that allowed him to reengage in a new SRL cycle with new goals that targeted a further refinement of his implementation of student-centered teaching practices through engineering design. Ben's motivation to implement student-centered instruction was strengthened through his self-regulatory efforts and reflective practice, leading to a continuation of his self-regulatory processes.

On the other hand, Steve drew defensive inferences related to providing timely feedback to students. In placing the blame on the system and school

policies related to late work, Steve protected himself from further dissatisfaction in his own practices. In determining himself helpless to make a difference, Steve disengaged from self-regulatory practices related to student feedback.

Paul also drew some defensive inferences, blaming the lack of technology support for some of his instructional problems. However, he also acknowledged that his packet had not supported student learning in ways he expected, creating a space for continued self-regulatory efforts in future modifications of these lessons.

Conclusions

The cases of Paul, Steve, and Ben provide insight into the components of the PDI and how participating in the PDI process helped them to develop as reflective practitioners. In our previous research (McFadden et al., 2014), we grouped teachers based on the level of their reflective practice (beginning, developing, and developed) by categorizing their video annotations as describing, explaining, evaluating, and interpreting events. This study extended our previous work to consider the full PDI cycle, not just the video annotations (i.e., the performance phase of the PDI). By analyzing the development of reflective practice through the forethought, performance, and self-reflection phases, we were able to better understand the cyclic nature of the PDIs and how they provided ample opportunities for these three teachers to reflect for-action, in-action, and on-action using SRL processes.

This study drew on the theoretical assumption that self-regulatory constructs allow beginning teachers to take charge of their own learning and develop as reflective practitioners. Zimmerman (2000) was clear that, "although it is possible to develop self-regulatory competence by personal discovery, this path is often tedious, frustrating, and limited in its effectiveness" (p. 28). Thus, the induction program was crafted to provide structured tasks to model processes to develop reflective practice and SRL processes, with multiple opportunities to engage in deliberative practice. Through structured opportunities to engage in deliberative practice, learners are able to enhance performance and self-observation (Zimmerman, 2000).

Ultimately, effective self-regulation is dependent on both the quality and quantity of individuals' self-regulatory processes (Zimmerman, 2000) and their ability to apply these skills independently (van Eekelen et al., 2005). All participants were successful in engaging in SRL processes through their engagement in the three phases of the PDI, although the depth of their reflections and use of SRL processes differed. It is also important to note that the scope of this study did not inform us about the teachers' development of a self-controlled level of self-regulatory skill and use of SRL process after their induction experience, but the development and use of SRL processes within the induction program is a critical step. By integrating reflective practice and the SRL framework into the induction program, we prepare beginning teachers to engage in reflective practice and SRL processes in the future.

Zimmerman (1998, 2000) argued that dysfunction in self-regulation is primarily due to ineffective forethought and performance control processes. Given the inherent difficulties in accessing the nature of teachers' reflection-in-action during the performance phase, we focus here on the forethought phase. Within the forethought phase, the PDI purposefully provides autonomy of learning for beginning teachers. Like others who have extended SRL to teachers' perspectives (Randi, 2004), we argue that teacher choice is an important characteristic of a learning environment that supports the development of teachers' SRL processes.

Autonomy relates to motivation, which is an important driver for engagement in SRL (Randi, 2004; Zimmerman, 2002). All three teachers expressed motivation for engaging in learning through the PDI activities and completed some level of task analysis, lesson planning in the cases of Ben and Paul, in preparation for the performance phase. The structure of the induction program provided extrinsic motivation to, at least minimally, stay the course and work toward learning related to the PDI goals. The hope is that through structured, deliberative practice with SRL processes within a course or induction program, educators will instill these processes in teachers for future use. It is important to note that both Ben and Paul proposed continued learning over the summer related to their goals in the reflection phase.

However, focus on the chosen PDI goal was difficult to maintain, as the teachers struggled with the realities of becoming a teacher. While the goal of the induction program was to promote reform-based science teaching, beginning teachers often struggle with classroom management and resort to more teacher-centered practices (e.g., Luft et al, 2011). In the case of Steve and Paul, their need to control the class environment became more important than their initial goals related to student-focused instruction. Induction programs should not focus solely on classroom management, but instead support teachers in developing classroom management skills alongside a focus on students and student learning (Langdon, 2011). Using an SRL approach to induction provides a space for teachers to act on their desire to engage in student-centered instruction through tasks designed to support reflective practice. However, a carefully structured task, such as the PDI, aligned with SRL processes is clearly not sufficient. A more direct approach from the induction facilitator is needed to maintain focus on reform-based teaching.

Implications

These findings can be of benefit to science teacher educators wishing to promote self-regulatory learning processes and reflective practice among beginning science teachers. While induction programs and professional development opportunities often focus on supporting teachers' pedagogy and content knowledge, supporting the development of SRL practices in these spaces may promote autonomous skills that will far outlive the induction program or PD workshop.

Even though the greatest benefits from these efforts may not arrive until later in the teacher's career, our work demonstrates that beginning science teachers are capable of making decisions related to SRL and reflective practices, even in the relatively short time span of an induction course or

professional development workshop. We encourage science teacher educators to consider the value of incorporating educational activities that promote these important, career-shaping skills.

Taking charge of one's own learning using self-regulatory processes can support the development of reflective practice – a critical skill for a teacher. The ability to provide virtual spaces for teachers to develop and reflect upon their practice is a critical step in supporting beginning teachers. Parallel to the findings of Kong (2010), this study shows that a carefully structured PDI can increase the depth of reflective thought related to classroom management and professional knowledge of teaching.

As with previous research (Randi, 2004), this study suggests that supporting the development of SRL practices in formal education settings can support beginning teachers to habituate reflective practice and, ultimately, to use SRL skills to become automatized reflective practitioners. However, our findings show that beginning teachers need supports in their development of self-regulated learning. Our data suggest that more detailed feedback from the instructor and peers within the small groups in the induction program are needed to push for a clear and detailed task analysis resulting in stronger lesson plans. Similarly, during video annotation the instructor and small group members need to push for annotations focused on the PDI focus and for depth of reflection within the annotation. Unfortunately, our previous work shows that peers are reluctant to push each other's thinking (Ellis et al., 2015), so the instructor needs to model how to provide feedback to support reflective practice.

Finally, while the goal of the induction program was to promote reform-based science teaching, beginning teachers often struggle with classroom management and resort to more teacher-centered practices (e.g., Luft et al, 2011). This struggle was evident in the case of Steve and Paul. Their need to control the class environment tempered their desire to implement student-focused instruction. Induction programs should not focus solely on classroom management, but instead support teachers in developing classroom management skills alongside a focus on students and student learning (Langdon, 2011). Using an SRL approach to induction provides a space for teachers to work on goals for student-centered instruction with the support of mentors and tasks designed to support reflective practice.

Limitations

While the body of research related to SRL is extensive, the vast majority of studies are focused on understanding SRL of students, not teachers. Only a few studies report on teacher learning from an SRL perspective (e.g., Bakkenes et al., 2010; Randi, 2004; Tillema & Kremer-Hayon, 2002; Van Eeklen et al, 2005), thus the present work is exploratory in nature. The ultimate goal is for teachers to develop as reflective practitioners and engage in SRL processes throughout their careers in a way that is automatized and personally directed. Thus, researching teachers' use of SRL is difficult, as it is expected that the research process itself will elicit teacher learning. Indeed, Van Eeklen and colleagues (2005) reported that all of their participants reported that the study itself influenced their learning.

This study purposefully engaged beginning teachers in a structured task (i.e., the PDI) to explore their reflective practice and SRL processes as they engaged in learning around a problem of practice. Thus, it is not possible to generalize to how these teachers might engage in SRL in the future without the support of the induction program. Additionally, as participants were receiving graduate credit for their participation in the induction program, engagement in reflective practices and SRL were required, and the reported reflections and SRL processes of teachers cannot be attributed entirely to their spontaneous reflective practices. However, understanding how teacher educators can support the development of SRL processes is important, as these skills must be taught and are rarely acquired spontaneously.

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