Chapter 3
Informal Science Educators and the Nine Dimensions of Reflective Practice

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> Teaching is like creating a work of art; like a work of art, it takes different techniques and mediums to make a masterpiece (Jenn Idema, Informal Science Education student, Texas Tech University, 2014).

People learn science at school, formally and informally, and outside school, formally and informally. However, the experiences people have during an informal learning experience with an informal science educator are likely to spark a curiosity to further explore a science topic. Therefore, informal science educators must understand the ramifications of their beliefs about teaching and how people learn. As informal educators define who they are and their notions about learning, they will shape informal pedagogical and epistemological learning perspectives.

As ISE defines the role of informal science educators within the concept of education, ISE needs to reflect on how it has grown and changed over the last 100 years and how it will evolve within the ever-changing bailiwick of formal education. Will ISE as we know it today survive the changing tide in how learning outside the classroom takes place? Preparing the future leaders of ISE (informal science educators) is an important role and all involved should take it seriously (National Science Teachers Association [NSTA], 2012; National Governors Association, 2012). As the notions of preparing informal science educators develop, university preparatory programs are needed that focus on educational theory and learning and program evaluation within ISE.

This will be difficult until universities appreciate the importance of funding such programs. Developing an education program for informal science educators is not an easy task and the numbers of rigorously trained ISE educators may not happen quickly—but these degrees are an important part of the future of ISE. An advanced degree in informal science education exposes graduate students to learning theory,

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program evaluation, and current issues and research, all of which eventually may build a bridge between formal and informal education. Moreover, as informal science educators are prepared for their roles in ISE, the informal educators should know the guidelines from which they are working. Even though the guidelines informal science educators follow will be different from those used to monitor formal educators, informal science educators should take into consideration one important aspect of formal education, reflective practice. Reflective practice is an important aspect of growth and development for formal educators and now attracts attention from ISE researchers (Allen & Crowley, 2014: Ash & Lombana, 2012; Ash, Lombana, & Alcala, 2012).

Reflective Practice in ISE

"Greater investment in an era of widespread accountability has brought greater scrutiny of whether and how science learning experiences in informal settings reach their goals" (Bell, Lewenstein, Shouse, & Feder, 2009, p. 19). This statement begs the questions: Do we have an understanding of the pedagogical skills that informal science educators need to reach the goals? Do informal science educators teach as they were taught by adopting aspects of the formal classroom in which their ideas of education first developed (Lortie, 1975)? Informal science educators do not always receive training in curriculum/program development; in fact, most likely they have strong content knowledge, but weak pedagogical skills. Pedagogy encapsulates the techniques and methods used to teach and how teachers think about them. While this may not seem an important concept in informal science teaching, research supports a much different viewpoint. For example, guided tours, which may be defined as educational by an informal institution, are viewed by visitors as too formal and boring (Charitonos, Blake, Scanlon, & Jones, 2012).

Informal science educators need to incorporate particular pedagogical practices, but not all, that university training programs teach and formal educators employ. For example, during university training, formal educators develop the skills to create lesson plans, structure lessons, write lesson objectives, differentiate between topics, implement behavior management, engage students, assess learning, and reflect on their teaching practices, which are important aspects of developing pedagogy. Moreover, authors now recommend professional development programs common for formal educators as a crucial aspect in developing the pedagogical skills for informal science educators (Ash & Lombana, 2012; Ash et al., 2012; Bevan & Xanthoudaki, 2008; Castle, 2006; Grenier, 2006, 2008, 2009, 2010; Grenier & Sheckley, 2008). However, to place informal science educators into education programs that focus on building skills that relate specifically to the formal classroom will not work either. Even though the basic skills of teaching mentioned above form a subset of the informal science educators' repertoire of knowledge, the pedagogical knowledge needed to teach in informal settings is distinct.

The best practices of classrooms are not the best practices of museums. Mayhew and Finkelstein (2009), asked university pre-service teachers to design and deliver afterschool programs for middle school children (ages 8–12). The results indicated that the pedagogical teaching skills utilized in a traditional classroom are not the same as the best practices that work in an informal after school program. The afterschool program required more subject knowledge and for the educator to feel comfortable in teaching in an informal setting. By incorporating the subject knowledge of informal science educators and formal learning pedagogies, informal science educators may better interact with their audiences and build a foundation for their teaching. One procedure often used in formal education and now considered an important part of the informal science educator's pedagogical abilities is reflective practice.

Dewey (1933) defines reflective thought as "active, persistent, and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it and the further conclusions to which it tends" (p. 118), and Boud, Keogh, & Walker (1985) as "those intellectual and affective activities in which individuals engage to explore their experiences in order to lead to new understandings and appreciations". Dewey (1915, 1933) suggests reflective thought as a way for formal educators to contemplate the success of their classroom performance and implementation of their lessons. In other words, educators should reflect for the sake of reflecting, but do they?

Reflective thought is a bi-directional process, as it is both a process of imposing previous experiences on the current idea and considering the immediate idea and reflecting back on prior ideas. This a natural process. Once one has a thought about an idea, one's mind builds on that idea and reasons about whether or not that idea is sufficient to answer the posed questions. In other words, one begins to infer about the place that the idea holds in one's beliefs and the inference becomes a process of reflecting on one's beliefs. When one confronts information that appears to be invalid, they reason about its existence, process their thoughts, and decide whether to accept or reject that information as valid. A similar reaction occurs when one expects an outcome that does not transpire or assumes an idea to be present that does not emerge. One then determines which outcome or idea is valid and accepts that as fact (Dewey, 1915, 1933). Even though reflective thought is a common, ordinary process, this does not mean that people reflect in a well-defined, deliberate manner. In fact, cognitive psychologists believe that while people may reflect in efficient ways they also commonly make predictable mistakes in their reflections (Kahneman & Tversky, 1979). Therefore, reflecting for the sake of reflecting is deliberate and requires directed interpretation, which makes the ability to reflect on pedagogical aspects of teaching a reflective practice. Hence, informal science educators require training in reflective practice, because focused thinking about their pedagogical approaches to teaching can provide informal science educators with a way to develop a consciousness of their teaching behaviors, performance, and impact.

Reflective practice must be considered within the context of the educator and the learner. The informal science educator must be cognizant of their place within the

learning and should research how their teaching skills influence the visitors (Ash & Lombana, 2012; Ash et al., 2012). In fact, research supports the idea that training ISI educators to reflect builds a community of practice in which informal science educators have an opportunity to discuss their work with colleagues (Bevan & Xanthoudaki, 2008; Castle, 2006; Horn, 2010). In order to aid informal science educators in developing a self-awareness of their teaching, I suggest the implementation of the Nine Dimensions of Reflective Practice (Zwozdiak-Myers, 2012). I place the Nine Dimensions into three categories, which depict the modes of Theory and Research, Teaching, and Peers. Theory and Research include (1) evaluate teaching using research, (2) link theory with practice by reading the literature, and (3) critically analyze personal learning theories and beliefs. Teaching encompasses: (4) study teaching for personal improvement and reflect often, (5) be innovative by trying out new strategies and ideas, (6) maximize the learning potential of the audience, and (7) be an effective practitioner by enhancing the quality of teaching. Working with peers includes (8) utilize learning conversations with peers to discuss alternative perspectives and possibilities and (9) improve teaching by being involved in professional development and training. The remainder of the chapter describes how informal science educators may attain each of these within an ISI.

Theory and Research

Evaluate Teaching Using Research

Classroom educators believe their students' knowledge is a reflection of the educator's ability to be a successful teacher (Zwozdiak-Myers, 2012). In ISIs, the idea of student knowledge equates to the knowledge of the visitors and the behavior and attitude changes of visitors; therefore, evaluation includes assessing what the audience already knows, does not know, and their interests prior to developing a program (front-end evaluation) and evaluating learning that takes place during a program. Evaluation may take into account the interactions that occur with the guests during the program, visitor participation, level of questioning among visitors and between the visitors and the educator (formative evaluation), and memories visitors have of the experience (summative evaluation) (Friedman, 2008) (for examples of evaluations see Friedman, 2008, Lemke, Lecusay, Cole, & Michalchik, 2012; Westat, 2010). Because "all forms of evaluation play an important role in… enabling 'reflective practice'" (Dierking, 2008, p. 20), informal science educators should evaluate systematically their own teaching by gathering evidence through a diversity of sources and perspectives. Conducting research and considering the results are important aspects of the reflective process and can influence strongly the educator's perspective on teaching. One way to bridge the gap between research and practice "is by meaningfully engaging the [informal science] educators

themselves in their own research pursuits, such as occurs with action research" (DeGregoria Kelly, 2009, p.30).

Visits to ISIs are social experiences and provide sociocultural interactions for visitors (Patrick & Tunnicliffe, 2013). Action research permits reflective informal science practitioners to examine the social interactions of the visitors and the connections between the visitor and the information. Moreover, the reflective behaviors embedded in action research lead to a deep, perceptual insight that progresses the development of a community of practice. When informal science educators take into account the impact of social interactions within their community of practice and with the community of learners, informal science educators will become more aware of their distinct identity in the learning process.

Action research is an important component of informal science teaching evaluation, because the informal science educator has an opportunity to "examine their own educational practice systematically and carefully, using the techniques of research" (Ferrance, 2000, p. 1). Through critical, disciplined examination of their teaching, informal science educators ask a research question, design a methodology to collect data, gather, organize, and synthesize the data, and reflect on the data to improve their daily teaching practice (Ash, 2014; Ash & Lombana, 2013). When the informal science educator identifies questions about their work, examines their performance, and considers various ways of approaching teaching, they must recognize this as a part of their reflective practice and take into account that the research will inform their teaching practice (Watts, 1985). However, educators should not take on action research as a solitary endeavor, because action research is a social process in which colleagues should propose and discuss new actions that improve their work practices. By interacting with other informal science educators within the same institution, the action researcher recognizes their research as subjective and seeks to acquire various perspectives of their teaching and audience learning from peers. Through the process of reflecting on their teaching through action research, informal science educators will "develop a deep understanding of the ways in which a variety of social and environmental forces interact to create complex patterns" (Riel, 2013, Understanding action research) and build an understanding of theory to practice (McNiff & Whitehead, 2010, 2012). Moreover, the results of action research have implications for the educator, the ISI, the visitor, and, if published or shared, for other ISIs.

Link Theory with Practice by Reading the Literature and Critically Analyze Your Personal Theories and Beliefs

Informal science educators should keep abreast of current research, practice, and pedagogy as they relate to informal teaching (Mai & Ash, 2012). Keeping up with current fields of praxis (informal science educators) may occur by reading the research literature that is produced within the field of research (ISE researchers).

However, the role of ISE researchers is to provide investigative results to the praxis field, so that other educators may utilize the findings as they plan, conduct, and evaluate their teaching practice (Folkestad, 2006). One example of how researchers and practitioners are linking their work is through the online journal *Connected Science Learning: Linking In-School and Out-of-School STEM Learning* (http://csl.nsta.org/). The promotional material from the journal states that it intends to bridge the gap between in-school and out-of-school learning settings, promote collaboration between these communities, and publish articles that support practitioners in both settings.

Moreover, informal science educators must understand, define, and question the direct relationship between teaching practice and learning theory. Learning theories vary and even contradict each other; therefore, understanding the distinctions and paradoxes relating to learning theories and how they underscore the process of learning is an imperative component of teaching practice. Most outstanding educators understand these theories and create a personal web of beliefs about learning that rely on several learning theories. Educators accomplish this web of beliefs by studying and understanding learning theories that relate to informal learning. Table 3.1 is an overview of the learning process, the learner, and the role of the educator for four celebrated, longstanding learning theories: Behaviorism, Cognitivism, Constructivism, and Humanism. Even though these learning theories have been used in describing learning in the classroom, they do have application to the informal setting. However, other learning theories exist that may be a better fit for identifying and understanding the learning that takes place in ISIs.

For example, Ash, Rahm, and Melber (2012) cited Activity Theory as a way in which to understand learning in informal settings. In 2014, Ash conceptualized her ideas about identifying and assessing learning and superimposed them over Engeström's (1999), (Ash, 2014) three generations of Activity Theory. In addition to Activity Theory, other contemporary perspectives of learning exist that may be better suited to defining learning in ISIs. As an extension of the conversation about various perspectives on learning within an ISI, Table 3.2 offers a look at Connectivism, Transformative, Biographical, and Experiential theories. A more productive pedagogical approach to identifying learning in ISIs could be to explore how and why visitors learn by applying one of the aforementioned learning theories to practice. Informal science educators may move past the pitfalls of overly simplifying teaching and learning if they take into account the various ways in which people learn. This means creating learning environments based on learning theories and working towards building the necessary pedagogical and epistemological skills that best fit their institution and audience. Moreover, informal science educators should use reflective practice to acknowledge more explicitly and honestly their sensitivity to implementing programs based on learning theory and perspectives. Because no one theory is all-inclusive, as practitioners, informal science educators should be aware of these learning theories and others, so that they may create a personal theory of learning (McDevitt & Ormrod, 2004).

Table 3.1 Long-standing learning theories and their relationship to teaching in informal science education

	Behaviorism (Skinner, 1953, 1974, 1979; Watson, 2009)	Cognitivism (Piaget, 1957; Piaget & Cook, 1952; Vygotsky, 1978; Wadsworth, 1996)	Constructivism (Anderson, 1996; Anderson, Lucas, Ginns, 2003; Anderson, Reder, Simon, 1996; Bruner, 1966, 1996)	Humanism (Maslow 1968, 1969; Maslow & Rogers, 1979)
Learning process	Learning is defined as a change in behavior. Behavior tasks result in a change in behavior by using reinforcement or punishment	Learning occurs through scaffolding of knowledge of experts. The learner builds new knowledge by scaffolding on prior knowledge. Focuses on the internal connections that are made during learning	Learning occurs through real world events that occur in everyday life. The educator is a facilitator and guides learning through problem solving. The learner reflects on past life experiences to construct new knowledge	Learning is guided by intrinsic motivation. Learning will not occur until the learner's basic needs are met
The Learner	The learner responds to a wide variety of stimuli and situations within their environment	The learner is motivated to learn when new information is linked to prior knowledge. The learner processes new information and assimilates, accommodates, or rejects the new knowledge	The learner is vested in the process, which occurs over time. This learning usually takes place outside the formal classroom	The learner chooses what they would like to learn based on the topic's relevance to their lives. The learner must have time to reflect on the information and deem it as important
Role of the Educator	To engage learners through a stimulus-response system	To engage learners to develop cognitively by allowing them to scaffold new information on existing knowledge	To engage the learner in activities that relate to their daily lives. The educator, or facilitator, provides experiences, but does not dictate learning	To engage in self-actualization. The learner is in complete control of what and how they learn, while the educator is seen as a mediator

Informal science educators must be conscious of the learning theories that relate to informal learning, take these into consideration as they design and implement programs, and ask themselves questions about their practice, such as:

- Did I take the time to respond in a meaningful way?
- Did my response foster a desire in the visitor to find out more information?
- Did my response reflect my knowledge of the subject?
- Will my work with visitors aid them in constructing knowledge or am I providing information that I expect them to memorize or remember?

By examining, evaluating, comparing, and contrasting the theoretical principles that act as a foundation for knowledge and learning, informal science educators will

Table 3.2 Contemporary perspectives of learning that may be useful in defining learning in informal science education

	Connectivism (Siemens, 2005, 2007; Tallon & Walker, 2008)	Transformative (Kegan, 2009; Mezirow, 2009)	Biographical (Alheit, 2009)	Experiential (Moon 2004; Usher, 2009)
Learning process	Learning occurs through the use of technology and social networking. Learning is based on the individual's interest. In Connectivism, the individual is a learner and a teacher	Learning occurs through a diversity of experiences and participation in a culture which allows free dialectical, informed discourse. Learners should be allowed to contrast values and ideals. Learners take action on their transformed ideals	Learning occurs when individuals relate new information to their life world	Learning occurs within the continuum of application, expression, autonomy, and adaptation. Learning is based on the experiences and interactions that occur within the continua and how they aid in defining self. Learning is socially and culturally constructed
The Learner	The learner is part of similar interest community that gathers and shares information with others through social networks, such as organizations/clubs, and topic specific social media	The learner has five forms of mind: (1) perceptual impulsive, (2) concrete/opinionated, (3) socialized, (4) self-authoring, (5) self-transforming. These forms of mind allow the learner to understand concepts of knowledge as a system	The learner self-reflects on the social activities around them and basis their decisions on their perceived life course	The focus of learning is on the learner not the educator. The motivation of the leaner informs the learning that will occur. The learner is self-motivated and interested in learning about the topic
Role of the Educator	To engage learners by connecting them to others who have similar interests. The network consists of a variety of learners	To engage learners in meaningful discourse. Provide opportunities for informative conversations between scientists and visitors. Provide examples of how the program fits into the larger picture of the organization and how the visitor might become involved in transforming the local community	To engage learners from their life perspective. Be aware of the learning environment that and how it is perceived by the visitor	To engage learners based on their personal interests and experiences. Provide opportunities to experiment alongside others that have an overlap in interest

be capable of linking their epistemological assumptions about learning to their pedagogical beliefs and practices. Determining these links will allow the informal science educators to question their beliefs about teaching (Zwozdiak-Myers, 2012). Of course, challenging these beliefs may be completed internally without

discussion, but through critical discourse with a peer or mentor informal science educators will find their personal beliefs about teaching and assessment to be challenged.

Teaching

Study Teaching for Personal Improvement and Reflect Often

Examining teaching methods and reflecting on practice may occur in three ways, reflection-on-action (the past), reflection-in-action (the present), and reflection-for-action (the future) (Schön, 1983, 1987; Zwozdiak-Myers, 2012). Informal educators may capture these three types of reflecting in a narrative form through reflective journaling. Reflective journaling is advantageous, because it "can be used to prompt an awareness of new features of the situation, plan new interventions that can be implemented almost immediately, and observe the effects" (Boud, 2001, p. 13). Moreover, this type of three-way journaling provides an account of the informal science educators' experiences and allows the writer to depict their professional self in practice as well as their journey of self-awareness (Moon, 2004). Once an educator writes the reflective journal, they may self and peer analyze the narratives, and use them in depicting habitual thinking (Harris, 2005), reactions to situations, and feelings. By recording, contemplating, exploring, sharing, and making sense of their actions and using self-assessments, informal science educators will deepen their ability to use the reflective process, gain insights into their practice, and improve their pedagogy (Zwozdiak-Myers, 2012).

Even though reflecting maybe seen as a personal journey, the reflective journal is meant to be shared. By reflecting in privacy, the informal science educator's thoughts might lead to a reinforcement of their perceptions, which may not be accurate. Therefore, sharing the journal or at the least the ideas written in the journal with a partner or group will provide an opportunity to reason through personal thoughts, perceptions, and ideas. This act of reasoning out loud with others will allow informal science educators to challenge their current beliefs and critically cogitate about their patterns of teaching (Boud, 2001). In order to provide examples of ways in which informal science educators might use a reflective journal, I adapted Boud's Models of Reflection into the ISE Reflective Journal Guide, shown in Table 3.3. Specifically, the ISE Reflective Journal Guide addresses the types of interactions informal science educators might consider when writing a reflective journal. Moreover, the ISE Reflective Journal Guide provides specific examples for each element of the journal that address the reflection-on-action (what you did), reflection-in-action (what you are doing), and reflection-for-action (what you plan to do based on previous experiences) mentioned above. Reflection-on-action should take into account the learner, the context, and the skills needed to meet the goals of the project. Reflection-in-action is based on noticing, intervening, and recording

information. During the reflection-for-action period, the journal should focus on the lived experiences and should provide the informal science educator with an opportunity to return to the experience, attend to their feelings, and reevaluate their experiences. By including journaling in reflective practice, informal science educators may develop deliberate, introspective habits of mind that encourage better teaching pedagogies.

Be Innovative by Trying Out New Strategies and Ideas

Teaching strategies are the learning methods informal science educators employ to bring their visitors to the desired learning objective and reflect the educator's teaching methods and educational values. Informal science educators should be encouraged to try out new ideas and teaching strategies and question their teaching style. By implementing new teaching approaches and understanding the complexities inherent in trying new approaches, informal science educators will gain a greater awareness of their pedagogical approaches and their visitors will gain a better understanding of the topic. By refining their teaching through a practice of systematic, self-reflective examination of their ideas and strategies, informal science educators will be more likely to identify those that were successful and discard those that were not effective (Zwozdiak-Myers, 2012). Even though teaching strategies exist for the formal classroom, many of these will not work for informal science education. However, there are some overlaps, such as considering the audience (diversity, disabilities, age, etc.), advanced planning, and behavior management.

Implementing new teaching strategies can be daunting for new and seasoned informal science educators. In order to implement new teaching strategies, one must know their field and their audience and how to create a learning environment. Informal science educators must ask themselves questions, such as:

- When is allowing the audience to discover more important than direct instruction (talking to them)?
- What are your expectations for the program?
- What do you want the audience to know and how can you best communicate that topic to them?

Because these questions and the audience are so diverse, no one teaching strategy will work for all visitors all of the time. However, by trying out new techniques, informal science educators may hone their skills in order to reach a larger portion of their audience.

The following are some ways in which informal science educators might approach designing new teaching practices.

- Take college courses designed for informal science educators. The courses will provide suggestions for designing and evaluating new programs.

Table 3.3 ISE reflective journal guide for informal science educators

	Reflection-on-action (what you did)	Reflection-in-action (what you are doing)	Reflection-for-action (what you plan to do based on previous experiences)
Element of Reflection	**Focus on the Learner:** Expected outcomes of an event, expectations, what the educators brings to the event (strengths and weaknesses), how the educator might be distracted	**Noticing:** Awareness of the external surroundings and events and internal thoughts and feelings	**Return to Experience:** Lived experiences, mentally revisiting and vividly living the experience, the journal writing provides an opportunity to go back and relive the experience with ease
Example in ISE	What were the objectives of the lesson or presentation? Did you meet those? Why, why not? What was the take away of the visitors' experience? What did you expect them to learn? When defining your lesson, what were the ideas that best fit your audience? What curriculum could have been used?	Write about the reaction of the visitors. Videotaping your lesson and the audience is a good way to capture the in-the-moment reactions of the visitors. How do you feel while the activity is occurring? Describe the visitors: ages, families, number of participants	In what way might you change the objectives of the presentation? What would you change about your lesson? Why? How will you use your objectives to meet the expectations of the audience? How will you change the presentation to better engage the audience? If you videotape your presentation, define specific areas of your teaching that you would change and develop a plan to implement the modifications
Element of Reflection	**Focus on Aspects of Context:** Clarify questions about the event, how do others view the event, what is expected of the educator, what are the limitations posed on you by others	**Intervening:** Actions taken to change a situation such as asking a question or listening to a visitor	**Attending to Feelings:** Focus on the feelings that were part of the experience, recognize that the feelings can inhibit or enhance the ability to learn from the experience, feelings may distort ideas and insights, for example positive feelings enhance the desire to participate, while negative feelings detract from participation
Example in ISE	Who were your visitors? What learning limitations might have occurred i.e. learning disabilities, age differences, socioeconomic, families, first time visitors, etc.?	What types of questions are you asking: lower, middle, or higher level questions? How are you interacting with visitors? Are these positive or negative experiences? Are you having problems with a specific visitor?	How did you feel during the last presentation? Did the presentation go well? How will your past experiences and feelings during the presentation support or hinder your ability to present this again?

(continued)

Table 3.3 (continued)

	Reflection-on-action (what you did)	Reflection-in-action (what you are doing)	Reflection-for-action (what you plan to do based on previous experiences)
Element of Reflection	**Focus on Learning Skills/Strategies:** Define the skills needed for the event, what strategies will the educator use during the event, ask what if questions, practice interacting with others who might be there, what will I do if the event does not go as planned	**Recording:** Write down ideas during the moment that may prompt thoughts later	**Reevaluation of Experience:** Relate new information to old ideas, determine the accuracy or validity of feelings and experiences, revisit the journal often, try to find meaning from your writing, add new ideas and extend your vision
Example in ISE	Did you have the skills needed to teach the lesson? How could you have better prepared for the lesson? How could you improve your teaching skills? What did you do that you would do differently next time? What props did you need that you did not have? Should the presentation be moved to a different area?	Write down words (just enough to prompt further thought later), times, weather, visitor reactions, your reaction, feelings, problems	Re-plan the presentation based on your journal reflections. What skills will you need to complete the presentation? What ideas will you address in the presentation? Plan the types of question that will be asked, higher level and lower level questions. Prepare for audience reactions. What is the event type? What props will you need? In what area of the institution will the lesson occur? How comfortable do you feel teaching the lesson?

Adapted from Boud's (2001) Models of Reflection

- Discuss your ideas with science and communication specialists. These interactions will provide positive gains in content knowledge and better ways in which to communicate with the public (Halversen & Tran, 2010).
- Determine if the new teaching strategy is pragmatic and will make learning easier for the audience. Do you have the resources? How long will the implementation of the new strategy take? Does the teaching style fit your epistemological beliefs and pedagogical style? What works for one ISE may not work for another.
- Define how the new teaching strategy fits within the institution's mission statement or logic model. Not all new strategies will accomplish the institution's goals and objectives. Make sure the strategies align with the learning outcomes identified by the education staff.
- Keep the teaching strategy manageable. Do not try to do too many new things at one time.

- List the teaching strategies you would like to implement and discuss them with other educators. Your peers may see immediately apparent constraints.
- Meet with educators from other institutions and brainstorm new teaching strategies. Ask other educators what techniques they use and how they work. Clearly develop and define your techniques and propose them to others.
- Use concept maps to represent a problem to address and add new techniques and ideas to the map as they evolve. Create a focus statement to address and place the statement at the top of the map as a guide (Novak & Cañas, 2006).
- Storyboard the new techniques in a large area so other educators may add suggestions. Have index cards available on which others may write ideas and add to the storyboard.

Excellent educators spend time with colleagues and discuss their ideas about best practices and teaching techniques and how those might look in the ISI. Remember a few important conditions must be meet when realizing if new techniques work, namely the external interactions that informal science educators have with their colleagues, and the internal process of reflective practice. Learning is an extensive, complicated process, which warrants a comprehensive understanding of how to adapt teaching strategies for each program.

Maximize the Learning Potential of the Audience

People visit ISIs for many reasons, such as, taking children, for fun, while on holiday, and during field trips; therefore, informal science educators do not have the pleasure of always knowing their visitors, their capacity to learn, and their commitment to the visit. Zwozdiak-Myers' (2012) nine dimensions of reflective practice encourage educators to know the needs and interests of the students, enhance the quality of the students' learning experiences, and effect behavior change. These may be difficult for informal science educators, because they do not always know the visitor (learner). Even though the ISI has demographic data about the visitors and a general description of the visitors, this does not provide the informal science educator with all they need to be successful. Formal educators are to perform based on imposed standards, which do not exist in ISE. In contrast, informal science educators have more flexibility in designing their public, non-school group programs. When designing programs, informal science educators must take into account that a single audience will have males, females, various ages, cultures, and ethnicities, and special needs learners. Moreover, informal science educators most likely will see their learners one time, which means the informal science educator must get their message across in a matter of minutes.

Another great divide between formal education and informal education is assessing learning and behavior change. The complexity and interrelationship of the visitors' variables mentioned above, which influence visitor learning, make

evaluating visitor learning a very difficult endeavor. Zwozdiak-Myers (2012) suggests analyzing and evaluating what is happening within the environment during the program. By discerning and judging the environments and the interactions that are occurring among visitors and making modifications based on an evaluation of the learning environment, informal science educators will have an opportunity to reflect on the actual and desired outcomes of the program. Reflective practice, which includes taking into consideration the learner, promotes understanding and leads to better teaching approaches and strategies.

One way in which informal science educators might define the learning environment and the learning interactions that take place during a program is to videotape the program and use a rubric to measure audience engagement. Table 3.4 introduces the Visitor Engagement Rubric (VER), which informal science educators may utilize to determine the level of interactions visitors experience during a program. I based the VER on the 6 Strands of Informal Science Learning (Bell

Table 3.4 Visitor engagement rubric based on the 6 strands of science learning (Bell et al., 2009)

Strand	5 points	3 points	1 point
Strand 1 Experience excitement, interest, and motivation to learn about phenomena in the natural and physical world.	Visitor is excited about the program. Visitor participates in the program and encourages others in their group to participate. Visitor asks thoughtful questions about the topic of the program. Visitor asks for additional sources of information. Visitor is heard discussing the program and program topic in great detail in other areas of the ISI. Visitor's body language demonstrates excitement, understanding, and/or understanding. Visitor expresses interest in the topic after the program by noticeably extending their time at the exhibit, i.e. communicating with staff, spending time in the exhibit, etc	Visitor has some interest in the program. Visitor participation is lackluster with some encouragement for the group to participate. Visitor asks some questions that related to the program. Visitor seems interested in the topic, but not in additional information. Visitor is heard discussing the program topic but not in detail. Visitor's body language demonstrates some interest, but does not express excitement in the topic. Visitor expresses their interest in the topic after the program by spending some extra time at the exhibit, but does not seek more information	Visitor is not interested in the topic and has no interest in learning more. Visitor stops with the group to listen to the program, but is not involved in the group's participation. Visitor is not paying attention to the educator. Visitor does not discuss the program with others. Visitor's body language indicates that they are distracted and are not interested in the topic, i.e. look of repulsion, rolling eyes, walking away. Visitor shows little or no interest in the topic by walking away quickly

(continued)

Table 3.4 (continued)

Strand	5 points	3 points	1 point
Strand 2 Come to generate, understand, remember, and use concepts explanations, arguments, models, and facts related to science	Visitor asks appropriate questions that represent interest outside the program topic. Visitor shares their ideas or asks questions about related topics that are not being discussed in the program, i.e. linking prior knowledge to the current topic. Visitor often uses content specific vocabulary that is introduced during the program	Visitor asks few questions that are vaguely related to the program topic. Visitor shares ideas that linked to the topic, but are a repeat of what has been presented. They do not add anything new to the discussion. Visitor uses some content specific vocabulary that is introduced during the program	Visitor does not ask questions. Visitor does not share ideas. Visitor does not use content specific vocabulary
Strand 3 Manipulate, test, explore, predict, question, observe, and make sense of the natural and physical world	Visitor asks various higher level questions that reflect their prior knowledge. Visitor interacts with available manipulatives at a high level, i.e. touching, smelling, asking questions. Visitor is conversing with their group about the program topic through higher order questioning, predicting, and observing. Visitor becomes immersed in the program through higher level physical and verbal interactions	Visitor asks some lower level questions. Visitor has very little interaction with manipulatives. Visitor is conversing with their group through some lower level questioning, predicting, and observing. Visitor has some interaction with the program through physical and verbal interactions	Visitor does not ask questions. Visitor does not interact with manipulatives. Visitor does not converse with their group. Visitor does not interact with the program
Strand 4 Reflect on science as a way of knowing; on processes, concepts, and institutions of science; and on their own process of learning about phenomena	Visitor clearly articulates their knowledge of the topic when asked questions by the educator. Visitor often discusses the concepts with the educator and/or their group. Visitor relates their previous experiences to the program	Visitor is not sure of the topic and is not able to answer some questions. Visitor has some discussion with the educator and/or their group. Visitor relates a previous experience to the program, but does not articulate how they connect	Visitor is not sure of the topic and is not able to answer questions. Visitor does not engage with the educator and/or their group. Visitor does not connect a previous experience to the program

(continued)

Table 3.4 (continued)

Strand	5 points	3 points	1 point
Strand 5 Participate in scientific activities and learning practices with others, using scientific language and tools	Visitor willingly participates in the program. Visitor participates in the program by correctly applying the program's content language. Visitor communicates with their group using academic/scientific language that relates to the program	Visitor participates, but seems forced to participate by their group. Visitor participates by applying some of the content language, but has difficulty in apply it correctly. Visitor communicates with their group, but rarely uses academic/scientific language that relates to the program	Visitor does not participate in the program. Visitor participates but does not use content related language. Visitor does not communicate with their group using academic/scientific language
Strand 6 Think about themselves as science learners and develop an identity as someone who knows about, uses, and sometimes contributes to science	Visitor articulates several ways in which they might become more active in the topic of the program. Visitor discusses the program topic with their group and describes how the program topic is important to their lives	Visitor articulates a few ways in which they might become more active in the topic. Visitor discusses the program topic with their group, but does not relate the topic to their lives	Visitor does not articulate ways in which they might become more active the topic. Visitor does not discuss the topic with their group

et al., 2009) and offer it to spark conversations about how educators might best analyze the learning potential of the audience. The VER measures the social interactions that take place during a program, because the conversations and actions that occur during a visit are important aspects of engagement. The visitor must see the intellectual, social engagement that occurs in an exhibit as worthy of their attention. Moreover, the engagement, which includes the visitor contributing their own ideas and constructing new knowledge and the educator promoting a positive, relevant learning environment, leads to effective learning experiences (Claxton, 2007; Dunleavy & Milton, 2009; Taylor & Parsons, 2011; Willms, Friesen, & Milton, 2009). The informal science educator and a peer or mentor may use the VER to aid the informal science educator in reflecting on their teaching and extending their pedagogical practice. The rubric presents scores of 1, 3, and 5, but one may assign scores of 2 and 4. The best way to utilize the rubric is to videotape the program and have the informal science educator and a peer or mentor score the video. The mentor should use the rubric results as a catalyst for discourse that analyzes the audience during the program. The discussion should lead to changes in the program and pedagogy.

Be an Effective Practitioner by Enhancing the Quality of Teaching

While evaluating the learning or behavior change that takes place among visitors is an important aspect of determining successful teaching, assessing the teaching ability of the informal science educator is also vital. Informal science educators must critically reflect on the quality of their teaching and "act upon insights gained to inform future planning, improvement and development" (Zwozdiak-Myers, 2012, p. 196). Zwozdiak-Myers states that the base of quality teaching is the ability of educators to (1) use reflection of practice to improve teaching and (2) search for cause and effect relationships in the outcomes of their teaching. Moreover, research shows that educators are more effective when they evaluate their teaching, examine their work, and consider various approaches to teaching (Watts, 1985). Because teacher ability ties directly to achievement, informal science educators should evaluate their teaching and ISIs should provide professional development that addresses good teaching techniques.

Reflective practice requires the informal science educator to study and evaluate their teaching, link theory with practice, and critically analyze their teaching. In order to aid informal science educators as they develop the process of reflective practice, I developed an observation technique that incorporates video, self-assessment, and a teaching rubric. Figure 3.1 represents the informal science

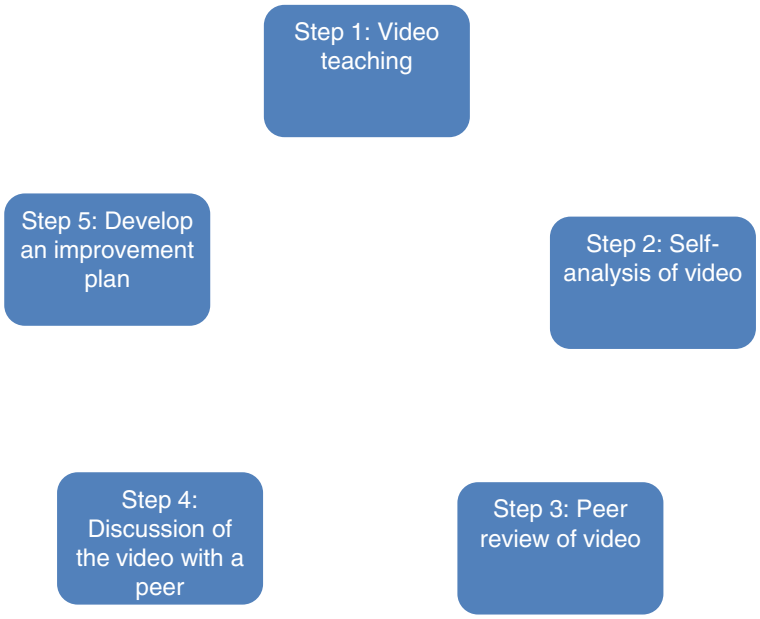

Fig. 3.1 The informal science educator reflective teaching practice cycle

educator reflective teaching practice cycle, which provides a suggestion for how peers could work together to analyze their work. Step 1: Educators video themselves during a program. Step 2: The educator views the video and identifies successful and unsuccessful aspects of their teaching. In what ways could they improve? What are they doing well? Step 3: To increase the ability of the educator to reflect on their teaching, a peer analyzes the educator's teaching and provides feedback. Step 4: The educator and the peer meet to discuss the individual evaluations of the teaching. Step 5: The meeting leads to the development of an improvement plan that focuses on one way in which the educator may improve their teaching. The ensuing conversations promote beneficial exchanges that support reflective practice and aid supervisors in determining areas for professional development, such as, questioning skills.

Peers

Utilize Learning Conversations with Peers or Mentors to Discuss Alternative Perspectives and Possibilities

In her nine dimensions of reflective practice, Zwozdiak-Myers (2012) encourages educators to engage in discourse with others in which they justify their beliefs about learning theories by considering, applying, endorsing, and rejecting the theories. These reflective peer or mentor interactions provide opportunities for informal science educators to reflect on their teaching practice and how their practice relates to learning. This cognitive apprenticeship promotes the joint construction of knowledge through active participation and reflection (Collins, Brown & Newman, 1989; Dickey, 2007; Hockly, 2000; Vasileiou & Paraskeva, 2010; DeGregoria Kelly, 2009). As the community of reflective practice evolves the newcomers may begin on the periphery, but over time move toward the center and become resources for helping new members make progress in becoming members of the community (Abu-Shumays & Leinhardt, 2002; Castle, 2006; Fischer, 2009; Grenier, 2009; Iverson & McPhee, 2008).

In addition to cognitive apprenticeship, informal science educators may be prone to apprenticeship of observation, which Lortie (1975) describes as "the protracted face-to-face and consequential interactions with established teachers" (p. 62). As a result of the interactions that occur between students and formal educators and between new and seasoned formal educators, researchers have shown that formal educators teach as they were taught (Lortie, 1975; Cuban, 1984; Matteson, Ganesh, Coward, & Patrick, 2012). In other words, educators develop their pedagogical beliefs based on the interactions that occurred in previous educational settings (Bevan & Xanthoudaki, 2008; Castle, 2006; Cox-Petersen, Marsh, Kisiel, & Melber, 2003; Grenier, 2010). Formal educators become tied closely to the teachers they perceived as 'good teachers' during their time as a student in the formal

classroom. However, these perceptions are not accurate and do not take into account the everyday issues educators face in the classroom.

Cognitive apprenticeship and apprenticeship of observation explain how the experiences that informal science educators have shape their epistemological and pedagogical beliefs. Moreover, the peer and mentor interactions Lortie (1975) describes are important to reflective practice because those interactions allow informal science educators an opportunity to share their ideas concerning pedagogy and their perceptions of teaching. As informal science educators develop their perspectives of teaching and share those ideas with others, they become part of an evolving community of practice. The interactions that occur between newbie informal science educators and mentor(s) play a role in the educator's pedagogical and professional development (Watts, 1985). The conversations that result from these interactions are important in aiding informal science educators in recognizing their beliefs about teaching.

Improve Your Teaching by Being Involved in Professional Development and Training

In order for informal science educators to build their capacity to work with visitors, educators need empowerment through professional development that involves and supports risk taking. Well-planned professional development increases the understanding educators have of epistemology and pedagogy, aids them in coordinating the instructional outcomes with the mission of the institution, and reinvigorates their reflective conversations with peers (Zwozdiak-Myers, 2012). However, successful professional development should support career long learning, take into account the career stage of the educator, occur regularly and have continuity (Borko, 2004); while connecting to prior teaching and learning within the context of the ISI (Lieberman & Miller, 2008; Muijs & Lindsay, 2008). Three sources of professional development from within formal education may be applied to ISE: (1) *Within the ISI*, e.g., peer reflection groups, peer feedback, collaborative planning, observing and discussing teaching practices, sharing pedagogical practices, and working with scientists in the ISI to improve content knowledge; (2) *Within the ISI network*, e.g., partnering with other ISIs, visiting other ISIs to identify their epistemological and pedagogical practice workshops hosted by ISIs; and (3) *External Relationships*, e.g., university partnerships (i.e., Bevan & Xanthoudaki, 2008; DeGregoria Kelly & Kassing, 2013; Grenier, 2008, 2010; Grenier & Sheckley, 2008; Gupta & Adams, 2012; Halversen & Tran, 2010), non-ISI-hosted workshops, and science education conferences (Training and Development Agency for Schools, 2008).

To address the notion of professional development for science teachers, the NSTA adopted eight guiding principles and four considerations for designing professional development programs (NSTA, 2006). Even though the principles and

considerations are for formal educators, the principles are relevant when developing professional development programs for informal science educators. Below is a list of the NSTA principles adapted for use in ISIs.

- Professional development should align with the mission of the institution and education department, and embed in the curriculum, instruction, program evaluation, and reflective practice.
- Professional development should address science content knowledge, epistemology, and pedagogical content knowledge.
- Professional development should have as a base the evolving needs of educators and should promote collegial, collaborative interactions *Within the ISI*, *Within the ISI network*, and with *External Relationships*.
- Professional development should engage educators in transformative learning experiences that confront deeply held beliefs, knowledge, and habits of practice and promote reflective practice.
- Professional development should focus on a few issues over time and allow for personal and institutional improvement.
- Professional development should involve educators in identifying pertinent research, exemplary teaching practices, and learning theories that relate to learning in ISIs and in applying these to observing and evaluating teaching.
- Professional development should concentrate on visitor evaluation strategies.

In addition to the seven guiding principles, ISIs should take the following considerations into account when designing professional development (NSTA, 2006).

- Planning Professional Development: A range of professional development that relates directly to evaluation, pedagogy and reflective practices is most important in developing excellent educators. The professional development must have a set of benchmarks, goals, and objectives. Embed the learning strategies into the day-to-day activities of the educators. NSTA recommends study groups, professional networks, action research, lesson study, and demonstration lessons.
- Implementing Professional Development: The professional development must fit into the educator's daily schedule. Evaluate the professional development program to determine its effectiveness and implement modifications in the program as needed. Encourage educators to attend science education conferences and share the experiences upon returning.
- Sustaining Professional Development: Educators must have buy-in and full support from the ISI through resources of funding, time, and professional materials, and unfaltering support from administration. Educators must develop partnerships with the community, scientists, universities, and other ISIs that build support for the professional development goals.
- Specific Needs of Professional Development Providers: Consider the next generation of educators. University programs that focus on informal science

learning should prepare future informal science educators and support their pedagogical development. The significance of professional development for informal science educators is a growing research field; therefore, the ISIs involved in professional development should evaluate their professional development programs so they might contribute to the research. ISIs with the resources should take a leadership role in developing and sharing relevant, high-quality professional development materials.

When preparing professional development, consider each topic in terms of its problems, concepts, issues, and emerging trends. Professional development should arouse the interests and cognitive commitment of informal science educators and compel them to further explore their teaching strategies. Consider the entry point of each educator into the processes of observation and pedagogical evolution as the educator begins to examine their personal educational beliefs in detail. Professional development may be powerful, but also may mislead educators; therefore, reflective practice should parallel professional development. Several implications follow from this assertion. First, professional development should spend significant time on the current topic. Second, professional development should portray the topic in a way that encourages communication and interactions among peers (reflective practice). Third, professional development should permeate the educator's self-management checks and balances (reflective practice) and extend the educator's perceptions of learning.

Reflective Practice Is Critical

Reflective practice works through the meanings the informal science educator assigns to it and how the informal science educator applies the practice. Its orientation is towards the cultivation of partnerships both within and outside the ISI that allow for application of new and existing ideas within a community of shared practice. Reflective practice is the application of shared ideas within a culture of self-actualization that promotes cultural transformations within the ISI. It should not be an autonomous vocational practice that isolates educators and separates them from the vision and mission of the ISI. During reflective practice, educators recognize that learning is discursive and circuitous and reflects the interests of the audience, while defining their beliefs about how experiences and knowledge influence their pedagogical practices. As informal science educators contemplate their teaching methods and share those ideas with others, they become self-aware of the relationship between teaching practices and knowledge and become part of a confessional network of educators that share ideas. Learning about one's teaching through reflective practice is a complex topic; therefore, I present the ideas in this chapter as a basic approach to introspection.

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