Journal of Elementary Science Education, Vol. 21, No. 4 (Fall 2009), pp. 43-52.

Developmental Perspectives on Reflective Practices of Elementary Science Education Students

Joanne K. Olson, Iowa State University
Kevin D. Finson, Bradley University

Abstract

Instructors of elementary science methods classes have long lamented the significant difficulties their students exhibit when trying to understand the many complexities of teaching science. As noted by some researchers and practicing teachers, preservice teachers often fail to developmentally function at desired levels with respect to constructivism and constructivist practices. Many reasons exist for continuing to consider developmental perspectives when trying to understand student learning, or lack thereof. Developmental learning theories have matured substantially from Piaget's (1969) original four stage model of child development, or the model later proposed by Kohlberg (1984). However, neither is ideal for understanding the development of perspectives in teacher education students. A model proposed by Perry (1970) examined adult development within the context of college students' thinking and its progression throughout the college experience. In this study, Perry's scheme has been applied to the development of constructivist perspectives in a group of preservice elementary education majors. Results revealed 28 of the 38 students held perceptions in the lowest level (dualism) of Perry's scheme. This calls into question the efficacy of science methods instruction premised on the basis of students functioning at stages above that of dualism.

Introduction and Theoretical Framework

Instructors of elementary science methods classes have long lamented the significant difficulties their students exhibit when trying to understand the many complexities of teaching science. Understanding learning theory (Windschitl, 2002), the role of activities (Appleton, 2006), how to "read" a classroom (Bryan & Abell, 1999), knowing how to reflect (Madsen, 2005), and understanding the role of the teacher (Olson, 2006) are just a few examples of elementary education students' conceptual struggles. To understand why these students struggle, a closer look at how people learn is warranted.

As Windschitl (2002) and others have noted, constructivism has taken on an almost exclusive focus in science education. Recent postings on the National Association of Research in Science Teaching (NARST) listserv from researchers echo this perspective. However, postings from a practicing teacher on the same listserv indicate that developmental perspectives are actively used by teachers to better understand their students and why they may fail to learn intended concepts. Many reasons exist for continuing to consider developmental perspectives when trying to understand student learning, or lack thereof. First, developmental learning theories have matured substantially from the original four stage model of child development proposed by Piaget (1969). Models of adult development now exist that take into

account more than conservation tasks or abstract/concrete distinctions. Aspects of emotion, social relations, moral and logical reasoning, and cognition are included in newer models and account for a great deal of what is observed among adults as they mature in their thinking processes. Models recognize the spectrum of thinking and reasoning, rather than defining distinct, mutually exclusive stages as have been criticized in the literature (Metz, 1997). Like their predecessors in the area of child development, current adult developmental models can help us understand student thinking, understand why students may or may not learn intended concepts, and help teachers design ways to better promote the development of students.

Developmental Models

The most well-known developmental model was proposed by Piaget (1969). His original four stage model of child development focuses on the development of abstract thinking as children transition to adulthood. Levels of development were criticized for the lack of generalizability of particular assessment tasks (such as conservation tasks) to other domains. However, even Piaget rejected firm "stages" and viewed them as merely a heuristic device late in his career. Even if people cannot be clearly labeled as "concrete" or "formal" operational, the model has helped teachers, curriculum developers, textbook writers, and parents better understand why children sometimes cannot grasp what seems like a simple concept. Piaget helped us learn to listen to children, to try to understand how they see the world, and to have patience with them when they say or do things that seem illogical to us.

Kohlberg's (1984) model of moral reasoning expands upon Piaget's (1969) work with child development and examines how people make moral and ethical decisions. This stage theory is similar to that of Piaget with regard to a sequence of reasoning that develops as a person ages. Like Piaget, Kohlberg asserts that not all individuals automatically progress to the highest stage but that the environment exerts a heavy influence upon development and can promote or hinder the process.

Neither Kohlberg's (1984) model nor Piaget's (1969) model is ideal for understanding teacher education students. In Lawrenz and Lawson's (1986) study of elementary teachers who were given Piagetian tasks, results indicated that not all teachers tested formal operational on conservation tasks. They also found that test scores of students whose teachers taught in an inquiry-based fashion and were concrete operational were higher than those of traditional teachers or formal operational teachers who taught in an inquiry-based manner. What we do not know, however, is the extent to which teacher performance on such Piagetian tasks can translate to an individual's current capacity to understand effective pedagogical decisionmaking. Metz (1997) and others have expressed some concern about the generalizability of such tasks to actual performance.

Two more recent models of adult development have received relatively little attention in science education. Kegan (1995) proposed a model of adult development that is generalizable across domains as diverse as partnering, working, parenting, and other social relationships. He argues that the way humans organize experience is consistent for each individual with regard to subject-object relationships across multiple domains and that this organization changes dramatically from childhood to adolescence and into adulthood. The focus of his model is in the structure of how one frames experience and what is under the person's control (object) and what controls the person (subject).

Perry (1970) also examined adult development but did so in the context of college students' thinking and its progression throughout the college experience. His interest was derived from "the relativism which permeates the intellectual and social atmosphere of a pluralistic university" and "the ways in which students went on to assimilate

that experience" (p. 4). Perry noticed that college students did not necessarily share a relativist worldview and were often confused by the expectations of faculty.

The models of Kegan (1995) and Perry (1970) are particularly useful if we want to understand more about our elementary education students' thinking and design ways to promote their growth. Kegan's model is particularly difficult to use due to the practical concerns involved in determining the subject-object structure of a student's mental organization. His methodology includes extensive subject-object interviews that revolve around conflicts and critical incidents from a variety of domains. Perry, on the other hand, is very useful in a college setting because students' assumptions about "the way things are" is relatively easy to identify within the normal course of a college student's work. Perry's model has been used in science education by Akerson, Morrison, and McDuffie (2006) and Akerson and Donnelly (2008). Akerson and Donnelly (2008) found that "preservice teachers' retention of Nature of Science (NOS) concepts was related to their developmental (Perry's) level" (p. 48). However, no relationship was observed between developmental level (using Perry's model) and NOS views when using a VNOS (Views of Nature of Science) instrument at the beginning of a semester (Akerson & Donnelly, 2008). The authors attribute this result to a small range and low variance in NOS views.

Reflection and the Teacher Education Student

Ever since the work of Schon (1983) about the reflective practitioner, reflection has taken on an important role in teacher education (Sparks-Langer, Simmons, Pasch, Colton, & Starko, 1990). Teacher education students are often asked to reflect on their practicum lessons, develop reflective portfolios, maintain reflective journals, etc. Part of the student teacher supervision process usually entails reflection on action by the student teacher prior to receiving feedback from the supervisor. Unfortunately, research indicates that prospective teachers do not reflect on practice in ways that are meaningful or that will move their practices forward. Stofflett and Stefanon (1996) and Madsen (2005) found at the preservice and inservice levels, respectively, that teachers attribute success or failure of a lesson to inappropriate sources and often do not perceive important aspects of lessons. This is consistent with the findings of Bryan and Abell (1999) who asked preservice teachers to interpret a videotaped lesson and reflect on what occurred. To remedy this problem, several researchers and agencies have proposed models of reflection, training in reflective practices, or simply required reflection to occur (Sparks-Langer et al., 1990). Unfortunately, Madsen (2005) found that a state-mandated reflective portfolio was more often used by teachers as either an annoyance or a scrapbooking activity than a way to think about and modify teaching practices. We assert that such efforts to promote effective reflective practices are likely to fail if those who are asked to reflect are developmentally unable to do so.

Being developmentally unable to do a particular task does not mean that such a task is forever impossible. Developmental theorists assert that progression is possible but that it requires the individual to be carefully taught and supported in the transition. Teaching efforts need to be targeted toward sequentially higher levels rather than to the final state that may be several steps too far for the individual (Kegan, 1995).

The study we describe here seeks to understand our elementary education students' level of development using Perry's (1970) model of college student development and to compare these findings to our current expectation that teachers be *reflective practitioners*. We seek to know if our expectation is currently too high for these students and suggest what might be done to help our students better understand effective practice and reflect upon it in ways that help them improve.

Methodology

Thirty-eight students from a private Midwestern university who had completed an elementary science methods course participated in this study. Their end-of-semester reflective essays served as a data source, which were coded by a second researcher using Perry's (1970) framework (described in Figure 1 below). The reflective essay was assigned as part of a course portfolio, and students were asked to reflect on their learning throughout the semester and the implications for their teaching practice. Students typically take the course during the one or two semesters immediately prior to student teaching.

Figure 1. Perry's (1970) Model of Intellectual Development

Stage Name	Description
Dualism	Division of meaning into two realms—good vs. bad, right vs. wrong. All that is not success is failure. Right answers are to be memorized by hard work. Knowledge is quantitative. Agency is experienced as external, residing in authority, test scores, the right job.
Multiplicity	Diversity of opinion and values is recognized as legitimate in areas where right answers are not yet known. Opinions remain atomistic without pattern or system. No judgments are made among them, so "everyone has a right to his own opinion; none can be called wrong."
Relativism	Diversity of opinion, values, and judgment derived from coherent sources, evidence, logic, systems, and patterns allowing for analysis and comparison. Some opinions may be found worthless, while there will remain matters about which reasonable people will reasonably disagree. Knowledge is qualitative, dependent on context.
Commitment	An affirmation, choice, or decision (career, values, politics, personal relationships) made in the awareness of relativism (distinct from commitments never questioned). Agency is experienced as within the individual with a fully internalized and coherent value structure.

From Miller (2006).

Statements were coded if they corresponded to any of the above stages using a more specific coding scheme composed of nine levels (see Appendix A). For example, transitional phases exist between these stages, resulting in two types of dualism and a mixed dualism/multiplicity phase. Each of these "positions" was coded and a final "position" was identified that represented the highest and most consistent pattern of thinking evident in the essay. Important to note is that students did not have multiple "positions" that skipped levels in the essays. No student expressed ideas at Positions 2 and 4, for example. The greatest variance in a single essay was a student who expressed ideas at Positions 1, 2, and 3. The student was given the benefit of the doubt and coded as a "3."

Findings

Of the 38 essays coded, one could not be coded due to a lack of information contained in the essay. The rest ranged between Position 1, Dualism, and Position 6, Relativism. Findings are displayed in Table 1.

Table 1. Stages of Elementary Education Students

Stage	Position	Number of Students
Dualism	1	17
	2	11
Dualism/Multiplicity	3	2
Multiplicity	4a	1
	4b	2
Multiplicity/Relativism	5	3
Relativism	6	1
Relativism/Commitment	7	0
Commitment	8	0
	9	0

Discussion and Implications

Twenty-eight of the 38 students in the study exhibited dualistic thinking in their reflective essay. Dualists perceive that correct answers exist out there, and their job is to learn those answers. This accounts for Appleton's (2006) finding that prospective teachers seek "activities that work" as if activities by themselves have an enduring characteristic of "working" regardless of the classroom context or the teacher. More complex views of the reality of science teaching may be rejected by dualists. This calls into question the efficacy of science methods instruction premised on the basis of students functioning at stages above that of dualism. Dualists have the expectation that the teacher will tell them the *right* way to teach, the *best* practice, and should be able to answer all of their questions. Teachers who do not do so are perceived as fraudulent or not knowledgeable. Dualistic thinking is evident in the findings of Olson (2006) who noted that 78% of her students believed that multiple strategies are important so that "if one doesn't work, you have something else to try." Teacher education becomes a matter of learning *the* way to teach—an expectation that is likely shattered when dualists encounter methods professors who advocate multiple ways to write lesson plans (some contradictory to one another), multiple approaches to classroom management, and multiple expectations on assignments.

As noted by Grossman (n.d.), when dualists are asked to reflect, they cannot do it. Instead, they will provide a play by play of events, stated matter-of-factly, that shows no insight. They see no need to explain or support their views with evidence or description. This is because they see the world as black and white and believe there is one truth. Controversies do not exist for dualists because answers are simply right or wrong. Authorities that present a more complex view of reality are often rejected by dualists as being inadequate or untrustworthy.

This dualistic thinking is epitomized in the following quotations from students' reflective essays:

- I thought I knew how to do APA citing but it turns out there were a few things I did wrong. (Sandy)
- With the experimental study, I learned what was necessary in an experiment. . . . Next, the experimental study was used to develop the lesson plan. Modifying lessons and activities is exactly what I will be doing as a teacher in the future, so this assignment is valuable. Following the experimental study and lesson plan was the assessment activity. (Marcie)

- Looking through this portfolio, I think that I have grown a lot. Looking at the grades and how they went from the beginning to the end, I started out with a lower grade and by the end of the semester, achieved higher grades. (Juan)
- I learned how to accurately conduct my own experiment. I learned how to create a lesson plan for my students that would cover the entire basis. I learned how to create my own rubric. (Felicia)
- I can see also my mistakes [were] mostly errors in punctuation. . . . We learn from the assessment what we did right, or wrong, and what we may need to reteach. (Gwen)

When we understand the dualistic nature of students' thinking, statements such as the following start to make more sense:

> I'm really frustrated that they taught us how to write lesson plans in 245 [general methods] and then we get to math methods and they say that's wrong and write it this other way. Don't they know how to teach? (Student comment from one of our methods classes)

Rapaport (2003) notes that dualists panic when confronted with multiple solutions, compare and contrast tasks, and reflection tasks. Since one way is the right way in their minds, they feel we are wasting time when presenting other ways that must be wrong. They struggle to know which of the multiple ways presented is the "right" way and expect that competent professors will make clear what is correct.

Many science educators, recent research reports, and standards promulgate the importance of helping preservice teachers become more articulate with constructivist-based and inquiry practices. By their nature, these typically entail multiple avenues through which a given topic can be addressed. However, dualists have expectations that the science methods professor will tell them the one right way to teach, what is the best practice, and what the "right" answers are to student questions. Given the current emphasis on constructivism and inquiry-oriented science instruction, the dualist's thinking can be problematic. Often, inquiry itself entails ambiguity. How to best plan for, initiate, and effectively deliver such instruction becomes almost insurmountable to the dualist. Imposing students at this stage of thinking into such instructional contexts and then requiring them to adequately reflect on those experiences for instructional improvement may be inappropriate.

Science education faculty may assume their students are relativists (Grossman, n.d.). Giving reflective assignments requires that students be capable of presenting arguments that are grounded in evidence while remaining open to the possibility that their conclusions may need revisions or reevaluation. These characteristics of relativistic thinking stem from an understanding that right and wrong answers exist, but they are usually dependent upon the context. They also understand that some answers are inherently better than others, but convincing someone else of this requires providing a solid, well-supported argument. Unfortunately, only 1 to 2% of undergraduates achieve thinking at the level of relativism during college (Baxter Magolda, 2001; King & Kitchener, 1994).

This substantial mismatch between students' present abilities and our expectations demands that we either modify our expectations or actively teach students to move toward higher levels of thinking. Strategies to do so are no different than strategies we advocate for K-12 students to promote their development. We need to work within their zone of proximal development, helping them to first understand that multiple ways exist to solve a given problem. We can role model

how to accept multiple points of view and how to challenge authority. We can ask students to explain and defend their statements. We can teach them how to compare and contrast points of view and how to use evidence to justify ideas. We can require that they look at two alternative perspectives and provide a valid argument for each. Once they attain a multiplist perspective, a danger exists that they will adopt the notion that all ideas are equally valid, so teacher education is just another opinion that is equal to their own. Moving them toward a more sophisticated understanding requires that we provide examples and practice distinguishing well-supported and weakly supported ideas. They need to generate multiple courses of action and play out the consequences of each scenario. They need to defend opinions and be given examples of how to rethink positions based on changing evidence or new information (Felder & Brent, 2005).

Given the limitations of a single-semester science methods course, these issues should likely be raised to the entire teacher education program and a deliberate sequencing of strategies put in place to help students better comprehend the pluralistic nature of the teacher education program that is neither a single "best practice" nor "anything goes." At the very least, we need to help students be aware that we understand their thinking and enable them to see why we do things that are different than what they expect of us. Just as we expect elementary teachers to "know thy learner" and use their students' understanding as a starting point for instruction, so too must teacher educators know our learners and use this information.

This study illustrates that our learners, for the most part, do not entertain the possibility that multiple effective ways of teaching might exist, and they are largely unable to reflect in ways that promote improved teaching practices. How we use this information to improve our practices says much about our capacity to practice what we preach and underscores just how complex teaching is. One potential consequence of not addressing this issue may be classroom teachers who revert to teaching via approaches viewed as less acceptable to the current science education enterprise.

References

Akerson, V. L., & Donnelly, L. A. (2008). Relationships among learner characteristics and preservice elementary teachers' views of nature of science. *Journal of Elementary Science Education, 20*(1), 45-58.

Akerson, V. L., Morrison, J. A., & McDuffie, A. (2006). One course is not enough: Preservice elementary teachers' retention of improved views of nature of science. *Journal of Research in Science Teaching, 43*, 194-213.

Appleton, K. (2006). Science pedagogical content knowledge and elementary school teachers. In K. Appleton (Ed.), *Elementary science teacher education: International perspectives on contemporary issues and practice* (pp. 31-54). Mahwah, NJ: Lawrence Erlbaum in association with Association for Science Teacher Education.

Baxter Magolda, M. B. (2001). *Making their own way*. Herndon, VA: Stylus Publishing, LLC.

Bryan, L. A., & Abell, S. K. (1999). Development of professional knowledge in learning to teach elementary science. *Journal of Research in Science Teaching, 36*, 121-139.

Felder, R. M., & Brent, R. (2005). Understanding student differences. *Journal of Engineering Education*, *94*, 57-72.

Grossman, R. W. (n.d.). *Using Perry's epistemological development scheme to structure student reflective practices*. Retrieved September 18, 2009, from www.kzoo.edu/psych/EnglandReflection.pdf.

Kegan, R. (1995). *In over our heads: The mental demands of modern life*. Boston: Harvard University Press.
King, P. M., & Kitchener, K. S. (1994). *Developing reflective judgment*. San Francisco: Jossey-Bass.
Kohlberg, L. (1984). *The psychology of moral development*. New York: Harper and Row.
Lawrenz, F., & Lawson, A. E. (1986). Student gain in reasoning ability as a function of teacher reasoning level and teaching style preference. *Journal of Research in Science Teaching, 23,* 523-531.
Madsen, A. J. (2005). *Where is the "self" in teacher self-assessment? An examination of teachers' reflection and assessment practices in relation to their teaching practices*. Unpublished doctoral dissertation, Iowa State University.
Metz, K. (1997). On the complex relation between cognitive developmental research and children's science curricula. *Review of Educational Research, 67*, 151-163.
Miller, K. (2006). *The stages of intellectual development according to Perry*. Unpublished manuscript, University of Missouri–Columbia.
Olson, J. K. (2006, April). Preservice teachers' thinking within a research-based framework: What informs decisions? Published online in the *International Journal of Science & Mathematics Education*.
Perry, W. G. (1970). *Forms of intellectual and ethical development in the college years: A scheme.* New York: Holt, Rinehart, and Winston.
Piaget, J. (1969). *Science of education and the psychology of the child*. New York: The Viking Press.
Rapaport, W. J. (2003). *William Perry's scheme of intellectual development*. Retrieved September 18, 2009, from www.cse.buffalo.edu/~rapaport/perry.positions.html.
Scale of intellectual development. (1995). Retrieved October 22, 2009, from http://admin.vmi.edu/ir/sid.htm.
Schon, D. A. (1983). *The reflective practitioner: How professionals think in action*. New York: Basic Books.
Sparks-Langer, G., Simmons, J. M., Pasch, M., Colton, A., & Starko, A. (1990). Reflective pedagogical thinking: How can we promote it and measure it? *Journal of Teacher Education, 41*, 23-32.
Stofflett, R. T., & Stefanon, L. (1996). Elementary teacher candidates' conceptions of successful conceptual change teaching. *Journal of Elementary Science Education, 8*, 1-20.
Windschitl, M. (2002). Framing constructivism in practice as the negotiation of dilemmas: An analysis of the conceptual, pedagogical, cultural, and political challenges facing teachers. *Review of Educational Research, 72*, 131-175.

Correspondence regarding this article should be directed to

Joanne K. Olson
Iowa State University
Center for Excellence in Science and Mathematics
N157 Lagomarcino Hall
Ames, IA 50011-3190
Office: (515) 294-3315
Fax: (515) 294-6206
jkolson@iastate.edu

Manuscript accepted October 17, 2008.

Appendix A. Perry's Stages of Intellectual Development

Stage Name	Position	Transition
Dualism	*Position 1* This position is pure, closed structure. Uncertainty is not adequately perceived. *Truth* is out there and accepted. Authorities know, and if we work hard, read every word, and learn the *right answers*, all will be well.	But what about those others I hear about? And different opinions? And *authorities* disagree with each other or don't seem to know, and some give us problems instead of *answers*.
Dualism	*Position 2* Here there is the recognition of limited diversity. True *authorities* must be right; the others are frauds. We remain *right*. Others must be different and wrong. Good *authorities* give us problems, so we can learn to find the right answers by our own independent thought.	But even *good authorities* admit they don't know all the answers yet.
Dualism--> Multiplicity	*Position 3* Here we see the realization that *some* truth remains unknown even to the true *authorities*. Then some uncertainties and different opinions are real and legitimate *temporarily*, even for *authorities*. They're working on them to get to the *truth*.	But there are so many things they don't know *answers* to! And they won't for a long time.
Multiplicity	*Position 4a* This position represents the beginning of the shift from certainty to uncertainty. Where *authorities* don't know the *right answers*, everyone has a right to his own opinion; no one is wrong.	But some of my friends ask me to support my opinions with facts and reasons. But what right do *they* have to grade us? About what?
Multiplicity	*Position 4b* In certain courses, *authorities* are not asking for the right answer. They want us to *think* about things in a certain way, *supporting* opinion with data. That's what they grade us on.	But this way seems to work in most courses and even outside them.
Multiplicity--> Relativism	*Position 5* Knowledge is now viewed as relative and contextual. Then all thinking must be like this, even for *them*. Everything is relative but not equally valid. You have to understand how each context works. *Theories* are not *truth* but metaphors with which to interpret data. You have to think about your thinking.	But if everything is relative, am I relative too? How can I know I'm making the *right* choice?

Stage Name	Position	Transition
Relativism	*Position 6* Here we see the acceptance of a truly relativistic world in which infinite contexts exist and that choosing is essential to avoid disorientation. I see I'm going to have to make my own decisions in an uncertain world with no one to tell me whether or not I am *right*.	I'm lost if I don't make my own *decisions*. When I decide on my career or marriage or values, everything will straighten out.
Relativism--> Commitment	*Position 7* This position marks the point of initial commitment in some important aspect of life such as values or career. Well, I've made my first *commitment*.	Why didn't that settle everything?
Commitment	*Position 8* Here we see the emergence of additional choices regarding the implementation of initial commitments. I've made several commitments. I've got to balance them; how many, how deep? How certain, how tentative?	Things are becoming contradictory. I can't make logical sense out of life's dilemmas.
Commitment	*Position 9* Here we see the integration of commitments, and commitments are seen as ongoing activities. This is how life will be. I must be wholehearted while tentative, fight for my values yet respect others, and believe my deepest values to be right yet be ready to learn. I see that I shall be retracing this whole journey again and again, but, I hope, more wisely.	Back to square one.

Source: Scale of Intellectual Development (1995)