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# REFLECTIONS ON LEARNING PROGRESSIONS

> [The Center on Continuous Instructional Improvement] views learning progressions as potentially important, but as yet unproven tools for improving teaching and learning, and recognizes that developing and utilizing this potential poses some challenges.
>
> Corcoran, Mosher, and Rogat (2009, p. 5)

Learning progressions have captured the imagination and the rhetoric of school reformers and education researchers as one possible elixir for getting K-12 education "on track" (Corcoran et al.'s metaphor, 2009, p. 8). Indeed, the train has left the station and is rapidly gathering speed in the education reform and research communities. As we are concerned about this enthusiasm—and the potential for internecine warfare in a competitive market for ideas— we share the Center on Continuous Instructional Improvement's view of the state-of-learning-progressions as quoted above. Even more, we fear that learning progressions will be adapted to fit various Procrustean beds made by researchers and reformers who seek to fix educational problems. We believe that learning progressions and associated research have the potential to improve teaching and learning; however, we need to be cautious—learning progressions are especially vulnerable to data fitting in the manner depicted in the *Non Sequitur* cartoon (Figure 1). As with any innovation, there are both promises and pitfalls associated with a learning progression reform agenda. Moreover, we fear that the enthusiasm gathering around learning progressions may lead to preferential treatment of one solution when experience shows single solutions to education reform come and go, often without leaving a trace. The best of intentions can go awry.

With this preamble, it is understandable that the LeaPS conference[1] organizers—Alicia Alonzo and Amelia Gotwals—would invite this chapter's first author to keynote the conference as a *friendly curmudgeon* who would raise issues and concerns about the ability of learning progressions to keep the train "on track." As veterans of formative assessment, learning progressions, and cognitive research on learning and memory, we have learned firsthand how tricky it is to attempt to model cognition and the multitude of differences among individuals. For example, in his doctoral dissertation, Jeffrey Steedle (2008; see also Steedle and Shavelson, 2009) revealed how fragmented students' knowledge structures are in explanations of force and motion. Knowledge comes in pieces that seem to be cobbled together in a particular context that calls for a particular explanation; this cobbled-together

*Alicia C. Alonzo, Amelia Wenk Gotwals (eds.), Learning Progressions in Science: Current Challenges and Future Directions, 13–26.*


*Figure 1. Procrustean fitting of data to (learning progression) theory. NON SEQUITUR © 2009 Wiley Miller. Dist.By UNIVERSAL UCLICK. Reprinted with permission. All rights reserved.*

explanation may or may not align neatly with a learning trajectory (e.g., diSessa, 1988). More problematic, imposing a particular learning trajectory on data leads to misinterpretations and mis-prescriptions for teaching. As we discuss in this chapter, there is likely no single linear path within and across students' knowledge structures that has the potential to provide a tidy learning progression and prescriptions for teaching.

We have learned from experience how appealing and (superficially) compelling innovative teaching practices can be, especially when implemented by teachers who have their own conceptions of teaching and learning. Research in the Stanford Education Assessment Laboratory (SEAL) on formative assessment, which incorporated a learning progression for students' learning about sinking and floating, led to the following conclusion that appeared in a special issue of the journal *Applied Measurement in Education*:

> After five years of work, our euphoria devolved into a reality that formative assessment, like so many other education reforms, has a long way to go

> before it can be wielded masterfully by a majority of teachers to positive ends. This is not to discourage the formative assessment practice and research agenda. We do provide evidence that when used as intended, formative assessment might very well be a productive instructional tool. Rather, the special issue is intended to be a sobering call to the task ahead. (Shavelson, 2008, p. 294)

We have also discovered how learning progressions can derail the train by reinforcing naïve conceptions and by prematurely imposing constraints on instruction and cognition that ultimately may not be advantageous. For example, with respect to naïve conceptions, the SEAL research on sinking and floating followed a middle school science inquiry unit (Pottenger & Young, 1992) that was sequenced in a manner consistent with scientists' evolving explanations of sinking and floating: from mass to volume to volume and mass to density to relative density. One major, unintended consequence of the curricular learning progression approach was that the unit reinforced the mass explanation of sinking and floating, complicating subsequent conceptual development and conceptual change.

With respect to the premature imposition of constraints on instruction, SEAL research (discussed below) tested competing models of cognitive progression—a learning progression and a knowledge-as-pieces conception of growth (Steedle & Shavelson, 2009). We found that constraining students' ideas to the learning progression led to clumping incommensurate beliefs about force and motion into a single level. Using the learning progression in teaching, then, might work for some students identified at a given level but not other students with a similar level diagnosis. The evidence, rather, supported the knowledge-as-pieces conception in which students cobble together sets of beliefs into a "model" that they use to explain a phenomenon in a particular situation; the cobbling might lead to a different model of the same phenomenon when surface features of the situation change.

In the remainder of the chapter we first present a simplified view of how the field of learning progression conceptualization and research is evolving along two strands: (a) curriculum and instruction and (b) cognition and instruction. Given the possibility of fragmentation, this view may say more about the perceivers than the perceived; we leave that judgment to the reader. We then discuss each strand, drawing lessons learned and proposing approaches for further research. Finally, we try to put the pieces together in a summary.

Before proceeding, it seems appropriate to attend to definitional matters. Along with a number of others who also attended the LeaPS conference, we had the good fortune to serve on the Planning Committee for the Science Framework for the 2009 National Assessment of Educational Progress (NAEP). We described a learning progression as "a sequence of successively more complex ways of reasoning about a set of ideas" and stated that learners move from novice to expert after extensive experience and practice. We added that "learning progressions are not developmentally inevitable but depend on instruction interacting with students' prior knowledge and construction of new knowledge." Moreover, we recognized that there was no one "correct order" of progression. We also noted that learning evolves in a “succession with changes taking place simultaneously in multiple interconnected ways.” Finally we warned that learning progressions are “partly hypothetical and inferential since long-term longitudinal accounts of learning by individual students do not exist” (National Assessment Governing Board [NAGB], 2008, p. 90). We believe that this description constituted a reasonably accurate characterization of learning progressions and what was known in 2006 when the framework was being written.

Corcoran et al. (2009), reporting for a committee of researchers engaged in work on learning progressions, provided a more recent yet consistent definition of learning progressions based on a National Research Council (2007) report: “empirically grounded and testable hypotheses about how students’ understanding of, and ability to use, core scientific concepts and explanations and related scientific practices grow and become more sophisticated over time, with appropriate instruction” (p. 8). Corcoran et al. (2009) also noted that the hypotheses describe pathways students are likely to follow as learning progresses, with the number and nature of such pathways empirically testable and influenced by instruction. These learning progressions are based on “research… as opposed to selecting sequences of topics and learning experiences based only on logical analysis” (p. 8).

There seems to be considerable overlap in the two definitions. Both characterize learning progressions as the sequence or growth of successively more complex ways of reasoning about a set of ideas. They both recognize the centrality of instruction in the evolution of the progressions. They both recognize that such growth is not simple but may take complex forms as learners move from novice to expert. And both definitions recognize the hypothetical character of learning progressions and the need for a strong research base on which to justify policy recommendations for widespread use of such progressions.

It is the hypothetical and under-researched nature of learning progressions that frightens us. It is premature to move learning progressions into prime time, as seems to be happening; significant empirical research is required to establish these progressions. When we think of each set of core ideas that might be the focus of learning progression research and subsequently incorporated into teaching and learning, the amount of research required is staggering. Moreover, by the time this research is completed, the policy and reform circus will have long ago taken down its tents and headed for another apparently greener pasture. Just what are we embarking on and recommending? Might it be premature? Or might we recognize the hypothetical nature of learning progressions, call for more research, but push ahead with the empirically-based revision of progressions in the meantime? That is a question we pose to our community as we move forward.

## TWO ROADS TO LEARNING PROGRESSIONS

Robert Frost’s (1916) well-known poem “The Road Not Taken” describes the choice a traveler faces when meeting a fork in a wood:

Two roads diverged in a yellow wood,
And sorry I could not travel both
And be one traveler, long I stood
And looked down one as far as I could
To where it bent in the undergrowth.
Then took the other, as just as fair,
And having perhaps the better claim,
Because it was grassy and wanted wear;
Though as for that the passing there
Had worn them really about the same.
. . .
Somewhere ages and ages hence:
Two roads diverged in a wood, and I—
I took the one less traveled by,
And that has made all the difference.

Like the traveler in the poem—although more simply—we face a choice between two roads: interrelated roads traveled by learning progression reformers and researchers. One appears more worn, but like the roads in Frost's poem, both are really worn about the same. It is the choice that makes all the difference.

We call the first road the curriculum and instruction road and the second road the cognition and instruction road. Fortunately, we are more than one traveler and do not have to choose (or should not choose) at a glance. President Obama's stimulus package (e.g., see http://www2.ed.gov/programs/racetothetop-assessment/index.html accessed November 3, 2010) has the potential to allow researchers and reformers the pursuit of both in order to see if, in fact, one of the two roads makes all the difference, whether both do, or whether neither does.

### *The Curriculum and Instruction Road*

The curriculum and instruction road may be characterized by the development of instructional units on, say, living organisms (Lehrer & Schauble, 2000) or sinking and floating (Shavelson, Yin, et al., 2008); K-8 curricular specifications for, say, atomic structure (Smith, Wiser, Anderson, & Krajcik, 2006); or even content specifications spanning K-12 science (e.g., Valverde & Schmidt, 1997).

To be sure, cognition is not omitted from the curriculum and instruction road. Yet we believe that curriculum and instruction progressions are based largely on logical analysis of content structure—perhaps a kind of spiral curriculum as envisaged by Jerome Bruner (1960) in *The Process of Education*. This logical content analysis is combined with what we call "psychologizing" as to how students might develop ideas cognitively.[2] Yet such psychologizing is always limited to the person engaged in this process. When concrete data are brought to bear on the cognitive processes students employ, complication and surprises arise. This is evident as students "think aloud" when they wrestle with solving a problem or explaining why things sink and float.

Perhaps an example of a learning progression that follows the curriculum and instruction road would be helpful. In SEAL research on the use of formative assessment in teaching about sinking and floating (e.g., Shavelson, Young, et al., 2008), we posited a learning progression that followed the series of investigations described in *Foundational Approaches in Science Teaching* (Pottenger & Young, 1992; see Figure 2). The dependency of the learning progression on teaching and learning is evident in the performance of two students, one from a "successful" guided-inquiry teacher (Gail) and another from an "unsuccessful" open-ended discovery teacher (Ken). Gail's student appears to follow the learning progression; Ken's student does not. Rather, Ken's student is mired in the conception that heavy things sink and light things float. That is, Gail's guided-inquiry teaching provided empirical support for the learning progression, but Ken's open-ended discovery teaching did not.

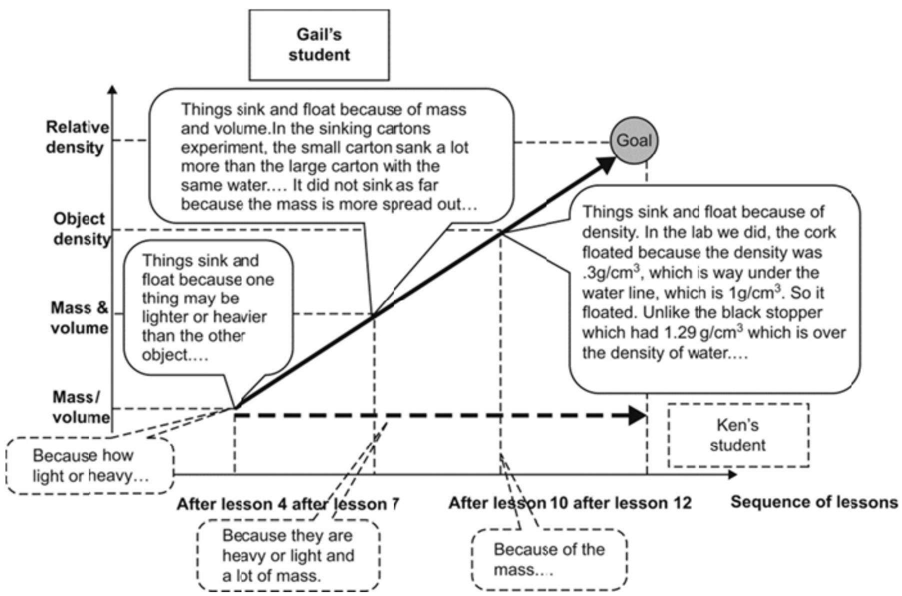


*Figure 2. Learning progression for sinking and floating differs for two students: one student taught by a "successful" guided-inquiry science teacher (Gail) and one student taught by an "unsuccessful" open-ended discovery science teacher (Ken). From "On the Role and Impact of Formative Assessment on Science Inquiry Teaching and Learning," by R. J. Shavelson, Y. Yin, E. M. Furtak, M. A. Ruiz-Primo, C. C. Ayala, D. B. Young, M. L. Tomita, P. R. Brandon, and F. Pottenger in Assessing Science Learning: Perspectives from Research and Practice by J. E. Coffey, R. Douglas, and C. Stearns (Eds.) (p. 34), 2008, Arlington, VA: National Science Teachers Association. Copyright 2008 by the National Science Teachers Association. Reproduced with permission of National Science Teachers Association via the Copyright Clearance Center.*

With a few exceptions, learning progressions following the curriculum and instruction road have not been empirically validated, at least in the strong sense that each learning progression posited has been researched, replicated, and validated as described by Corcoran et al. (2009). Empirical validation of learning progressions might be obtained through cognitive workshops, short essays, predict-observe-explain probes, teaching experiments, and the like that elicit students' explanations of natural phenomena (e.g., why do things sink and float?). Indeed, SEAL research suggests that context—in this case teacher and teaching method—will greatly influence the validity of a learning progression interpretation of student performance.

Even though learning progressions following the curriculum and instruction road have seldom been adequately validated empirically, we need to follow this road to the development of learning progressions for a number of reasons. Logical analysis and psychologizing can only take us along the road; empirical research can help guide us. But given the immensity of the curriculum, how might we accomplish the kind of self-correcting research needed to fine-tune and validate learning progressions? We don't know, but we have a proposal—one that might be surprising. We believe that teaching experiments and action research with collaborating teacher and researcher teams might amass the evidence and provide the practical wisdom needed to study and refine learning progressions. (Our proposal contrasts with that of Shavelson, Phillips, Towne, and Feuer, 2003, who argue that such experiments are only a beginning and need to be replicated on large scale). We envision such teams working on particular progressions, learning what does and does not work, fine-tuning the progressions, and making their findings available to others working on the same progression. In this way, we might expand both our knowledge of developing and validating learning progressions and our practice in using them. If we assemble a critical mass of teams working on important learning progressions, we might jump start the research and development agenda and create enough replications to evaluate the validity and utility of the proposed progressions. We would then be in a position to know if this is a road worth taking as we logically analyze and psychologize learning progressions. All of this might then lead to new and improved methods for studying learning progressions, which seem a practical necessity.

### *The Cognition and Instruction Road*

While the curriculum and instruction road begins with a logical analysis of content, the cognition and instruction road begins with a psychological analysis of cognition underlying content—what does it mean to understand core ideas in science? How can we use knowledge about cognition to build instruction that improves the chances of all students learning at high levels?

There is a long tradition in the psychological analysis of cognition related to subject-matter learning; studies by David Ausubel (1963), Robert Gagne (1965), Jerome Bruner (1966), and Robert Glaser (1963) are early examples. The goal of this work is to map the growth of cognition as a student learns about particular concepts, such as force and motion. That is, what does the path look like as a student, over time, moves from naïve conceptions of force and motion to expert conceptions consistent with the understanding accepted by the scientific community? Most importantly, what do the paths look like between novice and expert, and how might they inform curriculum, teaching, and assessment?

More recently, Mark Wilson (2009) and Alicia Alonzo and Jeffrey Steedle (2009) have mapped learning progressions from a cognitive perspective. A third example, a learning progression for force and motion—specifically for explaining constant speed—is shown in Table 1. The progression describes what the student knows and can do when confronted by force and motion phenomena, more specifically when a force is and is not present, and when the object is and is not in motion. That is, the learning progression maps a cognitive progression for "understanding" force and motion from naïve (Level 1) to expert (Level 4).

*Table 1. Force and Motion Learning Progression.*

| Level (Facets) | Description and Expected Responses to Item Types |
|---|---|
| 4 (00) | When balanced forces act on an object, the object is either at rest or moving with a constant speed. When unbalanced forces act on an object, the object's speed changes<br>*Balanced forces*: When balanced forces act on an object, it is either at rest or moving with a constant speed<br>*No force*: After a force is removed, an object slows down because of friction, which acts in the direction opposite motion<br>*Constant motion*: An object is moving with constant speed when forces are balanced<br>*No motion*: An object remains at rest when a horizontal force is equal to an opposing friction force. The force of gravity is equal to the upward force for an object at rest on a surface |
| 3 (30, 70) | When balanced forces act on an object, the object is at rest or slowing down. An unbalanced force in the direction of motion is needed to maintain constant speed. Speed is proportional to applied force<br>*Balanced force*: When balanced forces act on an object, it is either at rest or slowing down<br>*No force*: After a force is removed, a force continues to act on an object as it slows down<br>*Constant motion*: A constant net force or unbalanced force or force of motion maintain constant speed<br>*No motion*: *Same as level 4* |
| 2 (90) | No motion implies that no force is acting on an object. Exception: gravity may act on objects at rest. Motion implies that a force is acting on an object<br>*Balanced force*: *Same as level 3*<br>*No force*: *Same as level 3*<br>*Constant motion*:<br>*No motion*: A horizontal force on an object that remains at rest is zero. No force or gravity only acts on an object at rest on a surface |
| 1 (80) | If an object is pushed horizontally and remains at rest, there must be a greater force keeping the object at rest<br>*Balanced force*: When balanced forces act on an object, it is moving at a constant speed<br>*No force*:<br>*Constant motion*:<br>*No motion*: An object remains at rest when a horizontal force is not great enough to overcome a larger friction force, gravity, or the inertia of the object. The force of gravity is not equal to the upward force for an object at rest on a surface |

*Note. From "Supporting Valid Interpretations of Learning Progression Level Diagnoses," by J. T. Steedle and R. J. Shavelson, 2009, Journal of Research in Science Teaching, 46, p. 707. Copyright 2009 by Wiley Periodicals, Inc. Reproduced with permission of Wiley Periodicals, Inc. via Copyright Clearance Center.*

An issue with this kind of learning progression is whether it accurately reflects cognition. Put another way, does students' knowledge actually grow in this linear, progressive way? Put still another way, does the progression provide a valid and practically useful way of portraying the pathway of cognitive development? By valid we mean whether students' knowledge actually grows in this way. By useful we mean that if their knowledge does grow this way, can the progression inform curriculum development, classroom teaching, and assessment?

There is another way to conceive of the pathway from naïve to expert understanding of a core science conception. It builds on two principles in cognitive science. The first principle is that knowing and doing are embedded in a cognitive network. The second principle is that memory is reconstructive. Together these principles lead to the hypothesis that when confronted by a natural phenomenon and posed a problem, students will construct an explanation that is context-dependent, drawing on bits and pieces of knowledge embedded in a memory network to reconstruct their knowledge and, thus, to provide an explanation. Note that if students at different places in the evolution from naïveté to expertise have bits and pieces of knowledge organized in a coherent linear manner, their cobbled-together explanations would most likely follow a linear learning progression, such as the one shown in Table 1.

But suppose students' knowledge is not so orderly. Suppose they have bits and pieces of loosely related knowledge about force and motion in their cognitive networks, garnered from extensive personal experiences and brief classroom encounters. In this case, their explanations will most likely be quite context-specific; if superficial characteristics of the problem change, we suspect students would change their explanations in ways not explicated by the learning progression in Table 1. Progress might not be neat and linear, although our statistical and qualitative modeling might force it, Procrustean style, into something neat and linear. Rather, progress from novice to expert might be better conceived as somewhat hectic and non-linear. If we conceive of memory as a complex network, at various times a student might make progress by building up bits and pieces of knowledge about force and motion into a small subnet, but other bits and pieces might still be unconnected. Of course, students might vary on which subnets they develop and which bits and pieces of knowledge lie scattered in memory. Depending on the context of a force and motion problem, an appropriate subnet might be accessed by one group of students but not by other groups.

If knowledge comes in bits and pieces, then the knowledge appears organized and coherent only when a high level of competence is reached. Anything less than expertise gives rise to multiple "mental models" and explanations for the same underlying phenomenon by the same person under different contexts. And if this is so, prescriptions based on a linear learning progression might not be accurate; if inaccurate, they might be heuristic at best and misleading at worst.

Jeffrey Steedle's (2008) doctoral dissertation provides examples of our concern. He examined the extent to which students' responses to force and motion test items fit a learning progression. He made this examination for three different learning progressions dealing with conceptions in force and motion, including constant speed as shown in Table 1. He used multiple-choice item data where the alternatives included naïve conceptions or "facets" of understanding from Jim Minstrell's Diagnoser (Minstrell, 2000). In a Bayesian latent class analysis of the data, comparing models based on the learning progressions and models based on "knowledge in pieces" in a cognitive network, Steedle and Shavelson (2009) report:

> Students' actual response patterns aligned with the proposed learning progressions for two sorts of students: those whose understanding is (nearly) scientifically accurate and those [naïve students] who believe that velocity is linearly related to force. Learning progression diagnoses for these levels could be interpreted validly (with few caveats), but diagnoses for the other levels could not because students diagnosed at those levels are not expected to consistently express the ideas associated with their learning progression levels … This suggests that it is not feasible to develop learning progressions that can adequately describe all students' understanding of problems dealing with Explaining Constant Speed. Finally, an analysis of relationships between learning progression levels and facet classes indicated that the confirmatory [learning progression] model failed to make important distinctions between latent classes that the exploratory [knowledge in pieces] model made. (p. 713)

Therefore, Steedle and Shavelson (2009) conclude:

> Students cannot always be located at a single level of the learning progressions studied here. Consequently, learning progression level diagnoses resulting from item response patterns cannot always be interpreted validly. It should be noted that the results presented here do not preclude the possibility that some individuals systematically reason with a coherent set of ideas. These results do, however, provide strong evidence that there are few substantial groups of physics-naïve students who appear to reason systematically about the forces acting on objects with constant speed. Further, these results corroborate findings from other physics education research indicating that many physics-naïve students should not be expected to reason systematically across problems with similar contextual features. (p. 713)

There is, then, evidence gathered on the cognition and instruction road that gives us pause as we proceed in the pursuit of learning progressions. This evidence suggests re-thinking how we conceive of learning progressions or even if learning progressions are the "right" way to think about the growth of students' knowledge. Indeed, the evidence supports the not-so-tidy definition of learning progressions used in the NAEP 2009 Science Framework (NAGB, 2008). Progressions are not developmentally inevitable but depend on instruction interacting with students' prior knowledge and new knowledge construction; there is no one "correct order" for the progression. That is, progressions evolve in a succession of changes that take place simultaneously in multiple, interconnected ways. Progressions are, to date, partly hypothetical and inferential since long-term longitudinal accounts do not exist for individual learners.

Perhaps conceiving of knowledge growth as a learning progression, let alone attempting to order levels in a learning progression, needs some re-thinking. Rather, conceiving of knowledge growth as a hectic, opportunistic, constructive process of cobbling together bits and pieces of knowledge, as Steedle's (2008) dissertation suggests, might prove to be beneficial as we attempt to assist teachers in building students' understanding of the natural world. Then we would need to figure out how the bits and pieces evolve into coherent models of the natural world with instruction.

## CONCLUDING COMMENTS

The first author was asked to act as a friendly curmudgeon at the LeaPS conference in order to raise issues and ask questions as the learning progression train gathers steam and leaves the station. If we have accomplished anything, it has been to be curmudgeon-like. Our overriding concern is that an inadequately tested idea for improving curriculum, teaching, and assessment is being moved into prime time prematurely. We state this concern with full recognition that the learning progression concept has legs. If the concept is not developed in practice, it will languish in researchers' arcane journals. Nevertheless, we warn that there is the potential that a premature rush to implementation may result in more unintended mischief than intended good at this point.

We must, for example, guard against fitting our data to a preconceived notion of a learning progression. Rather, in a Popperian sense, we should seek disconfirmation; only when we fail should we move the progression into prime time. Even at this point, we need to monitor how well the progression works and agree to modify it as evidence demands.

We also need to make a concerted effort to gather evidence from the field that learning progressions embedded in curricular materials are operating as intended. We posed one possible approach that would move this agenda forward—that of teaching experiments and action research conducted by collaborating teacher-researcher teams. Such teams, on a large scale, might gather the empirical evidence and provide the practical wisdom needed to refine and improve learning progressions. Teams can work on particular progressions, learn what works and what does not, fine-tune the progressions, and make their findings available to others working on the same progression. We trust that those conducting learning progression research will think of other ways to address this area of concern.

A concerted effort should also be made to ensure that cognitive interpretations of learning progressions are accurate, useful, and lead to intended learning with minimal unintended consequences. Learning progressions may not be nice and linear. Teachers need to know this as researchers pursue heuristic representations of progressions to assist in practice, with an expectation of evolution and correction through research and practice over time. It seems that progress from novice to expert may not be linear but may be better conceived as a wandering journey through a complex memory network comprised of bits and pieces of information. Students might be nested in non-linear subnets for particular contextual representations of a problem. Steedle's (2008) research suggests a methodological approach for guarding against imposing theory on data by testing theory—our notion of a particular learning progression—with data. Both substantive psychological theory building and research into learning progressions are needed urgently for the most important science conceptions in the curriculum. A concerted research effort is needed. We again trust that those in the learning progression community will think of other ways to address this area of concern.

We have one final curmudgeonly thought. Whatever we come up with as a learning progression research and development agenda for reform, *it must take into account the capacity of teachers to implement.* The four million teachers in the United States are not, in general, like the teachers who volunteer to work with researchers in developing and testing cutting-edge ideas. It is well known that the former group of teachers lack, on average, the critical content knowledge needed to use learning progressions. They also lack the time needed to acquire that knowledge so that they may address the challenges that emerge when students do not nicely and neatly follow the prescriptions of the progressions and the textbooks. Whatever we do needs to take this reality into account; teacher professional development may not be extensive enough to address this challenge. So, finally, we trust that learning progression researchers will also think of ways to address this area of concern.

In closing, we have discussed two roads taken in the pursuit of learning progressions. In truth, the two roads don't diverge in a yellow wood nearly as much as Frost's roads. Rather, they continually intersect at the point of instruction. So the final challenge is to merge these roads as a major highway of coherent research to support the policy engine that is now steaming down the track… can we even catch up before it derails?

## ACKNOWLEDGEMENTS

We would like to thank Alicia Alonzo and Amelia Gotwals for inviting the first author to address the Learning Progressions in Science (LeaPS) conference. We would also like to thank Jeffrey Steedle and Alicia Alonzo for their comments on earlier drafts of this chapter. They made invaluable suggestions. Any errors of omission or commission are, of course, ours.

## NOTES

[1] The Learning Progressions in Science (LeaPS) conference took place from June 24–26, 2009, in Iowa City, IA.

[2] Incidentally, Bruner (1966) had a particular version of psychologizing in building curriculum. Curricular materials should move from initially enactive (physical manipulation) to iconic (mental image of physical manipulating) to symbolic (symbol replaces mental image).

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