Using Learning Progressions to Monitor Progress Across Grades

A science-inquiry learning profile for preK–4 students

By Karin K. Hess

Learning progressions (LPs)—descriptive continuums of how students develop and demonstrate more sophisticated understanding over time—have become an increasingly important tool in today's science classrooms. There is a growing body of knowledge surrounding their use as well as ongoing research in identifying and validating content-specific learning progressions. In addition, research has shown that accurately tracking student progress with learning progressions can have a positive effect on science teaching and learning (Corcoran, Mosher, and Rogat 2009; NRC 2001a, 2001b, 2007). As an educator and researcher who has participated in the development of innovative assessments, I discuss some of the research behind learning progressions and present The Science Inquiry Learning Profile for PreK–4 (see NSTA Connection). This is a tool developed using available research and hundreds of student work samples, which teachers may find useful in assessing students' development of inquiry skills. Although the profile was developed to support teachers involved with the New England Common Assessment Program (NECAP; see NSTA Connection), the tool can be used by teachers anywhere as a starting point for collaborative planning and adapted to fit the specific needs of any program.

Looking at LP Research

Many curriculum and content specialists have attempted to define the use of learning progressions for instruction and assessment purposes over the years. Current thinking on learning progressions is aptly summarized in *Taking Science to School: Learning and Teaching Science in Grades K–8*, which describes learning progressions as "anchored on one end by what is known about the concepts and reasoning of students entering school… [for which] there now is a very extensive research base." At the other end of the learning continuum are "societal expectations (values)" about what society wants students to know and be able to do in the given content area. Learning progressions propose the *intermediate* understandings between these anchor points that are "reasonably coherent networks of ideas and practices…that contribute to building a more mature understanding." Further, they explain that often, the "important precursor ideas may not look like the later ideas, yet crucially contribute to their construction (NRC 2007, pp. 219–220).

Simply stated, a learning progression can help teachers to visually and verbally articulate a hypothesis, or an anticipated path, of how student learning will typically move toward increased understanding over time with good instruction. The use of student work and assessment evidence to validate these hypotheses and to understand how learning progresses has often been noted as a key factor in collaborative planning, more focused instruction, and targeted formative assessment use (Corcoran, Mosher, and Rogat 2009; Wiggins and McTighe 2001).

Four Guiding Principles

Drawing from the body of research about learning progressions, four unifying ideas begin to emerge that can shape our thinking about what makes a well-constructed learning progression or how one might go about developing, refining, and using learning progressions for different purposes. These four principles are elaborated on below.

I. Learning progressions are developed (and refined) using available research.

Available research is a combination of information found in the existing literature combined with what you can learn from your own classroom action research as you analyze student work samples with colleagues. A considerable amount of research in science education provides insights into common science misconceptions and how children learn and develop science concepts and skills. For example, Figure 1 features research synthesized from a variety of sources (AAAS 2001, 2007; Driver et al. 2002; Harlen 2001) to create a general learning progression for how the skill of observation generally develops. The gist of this progression is that when children learn the skill of making observations in science, they tend to find it easier to distinguish differences in physical characteristics before seeing the similarities. After observing and differentiating differences and similarities of physical characteristics, they can move on to categorizing by characteristics and then by function (or use).

This learning progression of science observation applies to each different content domain in science. Just as with reading for a specific purpose, knowing the purpose and focus of the observation greatly enhances development of the skill (e.g., how the beaks of birds are different and how different beaks help them to eat different foods to survive).

II. Learning progressions have clear binding threads that articulate core concepts and processes.

The big ideas, meaning the "essence" of important concepts and processes, are the binding threads that connect learning across grades over time. Measuring progress is only possible when these binding threads are clearly evident in the learning progression and connect learning that gets at these core ideas and enduring understandings (Hess 2008b; NRC 2007; Wiggins and McTighe 2001). In each content area, these essential threads interact to build greater understanding of the discipline. Identifying a small number of essential threads makes the learning progression manageable in terms of tracking ongoing progress in the classroom.

For example, the learning progression for science observation described in Figure 1 falls under the essential thread of "Conducting Investigations," one of four broad areas of inquiry in which student understanding and progress is assessed in state and other assessment tests (e.g., the NECAP). The other three essential threads are Formulating Questions and Hypothesizing, Planning and Critiquing Investigations, and Developing and Evaluating Explanations.

Conducting investigations also encompasses such inquiry skills as using tools, recording data, interpreting data, and following procedures. Collectively, the skills related to the four broad unifying threads weave the tapestry of what it means to be applying inquiry in science. Each thread develops both in isolation and in relation to the other threads and the content domains. As with cloth, the whole of it will be stronger than any single strand of thread.

III. Learning progressions articulate movement toward increased understanding.

There seems to be general agreement that learning progressions are not linear or lock-step sequential routes to a learning goal (Corcoran, Mosher, and Rogat 2009; NRC 2001a, 2001b, 2007); they articulate movement toward increased understanding in the way that a map provides both the network of interrelated routes with surrounding terrain and potential pit stops that might affect the journey. This movement toward increased understanding can be described in several possible ways:

1. Greater depth of understanding;
2. Increased ability to generalize and transfer learning; and/or
3. Movement from "novice" or naive understanding of the content or concept to more sophisticated or "expert" thinking and complex reasoning.

The Science Inquiry Learning Profile for PreK–4 (see NSTA Connection) is an example of a learning progression that was developed using empirical research from science, mathematics, and language learning and national curriculum documents to identify descriptors along a continuum. It generally describes a hypothesis of how inquiry skills develop and become broader and more sophisticated across grades.

However, research serves merely as a guide. Teachers should be aware that, with or without the profile, they must continually monitor their students to determine their understandings and carefully plan and sequence units of study and assessments to be sure that all science domains—life science, Earth and space science, and physical science—are incorporated with inquiry skills each year and important "gaps" in instruction and assessment are avoided. The profile provides a framework for connecting appropriate instructional practices with assessment strategies and progress monitoring across the domains of science.

IV. Learning progressions go hand-in-hand with well-designed assessments.

Learning progressions offer guidance about how learning generally will develop, and consequently, how to create or use shorter ongoing assessment "probes" (e.g., Keeley, Eberle, and Farrin 2005) and longer performance assessment tasks that reveal where particular students might be at any point in time along the learning continuum. Formative and performance assessments can take many different forms; however, those tasks that "uncover" student thinking provide the greatest benefits when used with learning progression development, planning next steps for instruction, or monitoring progress over time.

Because science instruction can provide many meaningful opportunities for students to integrate and apply reading, writing, and mathematics skills and concepts, the profile can also be used to complement the systematic

Figure 1.

A learning progression for science observation: Least to more complex observational skills.

1. Foundational skill: must first be able to see/hear/smell/taste/feel/understand what a difference or change is
2. Distinguish (external) differences in physical characteristics of objects and materials (e.g., a bike is different from a car; a bike is smaller than a car, a bike has two wheels and a car has four wheels, etc.). Gross features are noticed before details.
3. Observe/identify similarities in (external) physical characteristics (e.g., a bike and a car both have wheels)
4. Observe/identify both similarities and differences in (external) physical characteristics
5. Observe/identify differences and similarities in (internal) physical characteristics (e.g., both animals and plants have cells; both use food for energy to grow, but the food is different)
6. Distinguish differences and/or similarities in function of objects and materials (e.g., a bike and a car are both vehicles; they both move, but one carries more people)
7. Categorize objects and materials by physical characteristics or use before being able to explain why they belong to a specific group
8. Distinguish relevant differences from nonrelevant differences when trying to answer a specific question (e.g., a student can understand/identify a key variable to observe when seeking an answer to a testable question and is able to base conclusions on observations made of that variable—what really changed or was affected as a result of the actions taken?)
9. Tend to first see/observe the result of an event/series of events before they see the process to get there (e.g., a student might observe that a cold glass of water has drops of moisture on the outside of the glass but may not have noticed how long it took for them to appear after adding ice cubes to the water or that a temperature change caused the condensation to occur)
10. Tend to draw/represent what they think they should see (e.g., a round leaf with a stem) before they see/draw the actual details of what was observed (e.g., the leaf is pointy and has no stem)
11. Observe and record detailed and relevant information (e.g., labeled drawing, written summary, precise measurements) related to key ideas and predictions being explored

data collection of an existing Response to Intervention plan, an assessment and intervention process for systematically monitoring student progress. Each strand of the inquiry profile reinforces skills essential to science learning and learning in other content areas:

1. Formulating Questions and Hypothesizing: using prior knowledge; asking/answering questions; identifying cause–effect relationships; and making and supporting predictions.
2. Planning and Critiquing Investigations: selecting appropriate measurement tools; developing an understanding of sequence; and planning, reading, and writing step-by-step procedures for an intended purpose.
3. Conducting Investigations: counting, measuring, and organizing data; telling and measuring time; using a variety of representations, keys, and scale to describe results and interpret patterns/trends; and developing content-specific vocabulary to describe and summarize observations.
4. Developing and Evaluating Explanations: clearly conveying ideas with words, sentences, drawings, and data; sorting, classifying, and categorizing objects and materials; distinguishing fact (evidence) from opinion (claims); stating main ideas or comparisons using supporting details; and justifying conclusions.

A combination of well-designed and aligned formative assessments would include: teacher observations (both ongoing and systematic); evidence in student work (e.g., what's there/what's missing); conferencing/interviewing students; and performance assessment tasks that require students to reveal or construct thinking and reasoning (Hess 2008b).

Adapting the Inquiry Profile

The Science Inquiry Learning Profile for PreK–4 was originally developed to support teachers in three states that test science at grade 4 (NECAP). Inquiry skills were researched and broken down into a developmental continuum preK–4 with measurable and observable descriptors. Because the descriptions were developed using both research and actual student work samples at various grades, they are not specific to any one state's science content standards and can be used or adapted by teachers in other states to fit their specific program needs. This approach is consistent with the National Research Council recommendation to "identify and articulate subgoals in order to best help students meet their learning goals…which often requires time and many 'little steps' to reach the larger goal. The underlying structure of the discipline can help serve as a roadmap to guide a teacher in selecting and sequencing activities, assessments, and their other interactions with students" (NRC 2001a, p. 86).

Here are several ways school-based science teams can make use of the science inquiry profile:

Customize the profile for your school. Collaboratively review the grade-level expectations as presented in the profile to determine how closely the descriptions reflect your school's grade-level designations (and content standards for inquiry). Many states have vaguely written expectations for science inquiry, so your team may wish to adopt more measurable indicators as seen in the profile and/or revise some of the wording to create a customized profile for your school that will be used by all teachers preK–4.

Analyze existing science assessments using the continuum in the profile. Most schools already have some assessments commonly used at each grade level for particular units of study (e.g., kit-based science, science notebooks). Use the skills listed in the profile at a particular grade level to match what is actually assessed in each specific assessment. You may be surprised that some assessments you are using only measure a small part of the inquiry skills you want students to demonstrate. This review may result in modifying existing assessments, developing stronger common summative assessments, changing the sequence of current units/assessments, and/or developing a better balance of assessments across life, Earth and space, and physical sciences.

Analyze student work samples using the descriptors in the profile. Collaboratively review the evidence found in a sample of student work at each grade level to determine program strengths and weaknesses. Often these types of reviews can lead to more effective use of preassessments and formative assessments and more targeted instruction during the school year, especially for struggling learners.

Align wording in existing assessment rubrics and teacher observation tools with profile descriptors. Tightening up assessment language used across and within grades will lead to greater coherence and more consistent progress monitoring.

If we think of learning progressions as research-based descriptions of successively more sophisticated ways student thinking develops as children learn and investigate, then we can come to the conclusion that there may always be a deeper, broader, or more complex way of demonstrating this learning. Teachers who know where students are along the learning continuum and what the next small steps might look like are better equipped to take their students as far as they are capable of going. Teachers using learning progressions in their classrooms find them extremely useful when describing progress to parents and students alike, because the evidence in student work can be placed along a continuum of learning that is much more meaningful than a score or a grade. ■

Karin K. Hess (khess@nciea.org) *is a senior associate and educational researcher at the National Center for the Improvement of Educational Assessment in Dover, New Hampshire.*

References

American Association for the Advancement of Science (AAAS). 2001. *Atlas of science literacy, volume I.* Washington, DC: American Association for the Advancement of Science and the National Science Teachers Association.

AAAS. 2007. *Atlas of science literacy, volume II.* Washington, DC: American Association for the Advancement of Science and the National Science Teachers Association.

Corcoran, T., F. Mosher, and A. Rogat. 2009. *Learning progressions in science: An evidence-based approach to reform.* Philadelphia: Consortium for Policy Research in Education.

Driver, R., A. Squires, P. Rushworth, and V. Wood-Robinson. 2002. *Making sense of secondary science: Research into children's ideas*. New York: Routeledge Falmer.

Harlen, W., ed. 2001. *Primary science: Taking the plunge.* Portsmouth, NH: Heinemann.

Hess, K. 2008a. Analysis to action: Tools for using learning progressions. Available online at *www.nciea.org/publications/Analysis%20to%20Action_KH08.pdf*

Hess, K. 2008b. Developing and using learning progressions as a schema for measuring progress. Available online at *www.nciea.org/publications/CCSSO2_KH08.pdf*

Hess, K., V. Kurizaki, and L. Holt. 2009. Reflections on tools and strategies used in the Hawaii progress maps project: Lessons learned from learning progressions. Tri-State Enhanced Assessment Grant: Atlanta, GA: Tri-State Enhanced Assessment Grant. Atlanta, GA. Available online at *www.nciea.org/publications/Hawaii%20Lessons%20Learned_KH09.pdf*

Keeley, P., F. Eberle, and L. Farrin. 2005. *Uncovering student ideas in science*. Arlington, VA: NSTA Press.

Kennedy, C., and M. Wilson. 2007. Using progress variables to map intellectual development. Presentation at the MARCES Conference, University of Maryland College Park.

National Research Council (NRC). 2000. *Inquiry and the National Science Education Standards: A Guide for Teaching and Learning*. Washington, DC: National Academies Press.

NRC. 2001a. Atkin, J. M., Black, P., and J. Coffey, J. (Eds.). *Classroom assessment and the* National Science Education Standards. Washington, DC: National Academies Press.

NRC. 2001b. Pellegrino. J., Chudowsky, N., R. Glaser, R. (Eds.). *Knowing what students know: The science and design of educational assessment*. Washington, DC: National Academies Press.

NRC. 2007. Duschl, R., Schweingruber, H., and Shouse, A. (Eds.). *Taking science to school: Learning and teaching science in grades K–8*. Washington, DC: National Academies Press.

Wiggins, G., and J. McTighe. 2001. *Understanding by Design.* Alexandria, VA: Association for Supervision and Curriculum Development.

Connecting to the Standards

This article relates to the following *National Science Education Standards* (NRC 1996):

Content Standards

Grades K–4

Standard A: Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

National Research Council (NRC). 1996. *National science education standards.* Washington, DC: National Academies Press.

NSTA Connection

Learn more about the New England Common Assessment Program (NECAP) and find The Science Inquiry Learning Profile for PreK–4 at *www.nsta.org/SC1002*.