LEARNING PROGRESSIONS: SUPPORTING INSTRUCTION AND FORMATIVE ASSESSMENT

MARGARET HERITAGE

National Center for Research on Evaluation, Standards and Student Testing (CRESST)
Graduate School of Education and Information Studies
University of California, Los Angeles

I.

INTRODUCTION

By its very nature, learning involves progression. To assist in its emergence, teachers need to understand the pathways along which students are expected to progress. These pathways or progressions ground both instruction and assessment. Yet, despite a plethora of standards and curricula, many teachers are unclear about how learning progresses in specific domains. This is an undesirable situation for teaching and learning, and one that particularly affects teachers' ability to engage in formative assessment.

The purpose of formative assessment is to provide feedback to teachers and students during the course of learning about the gap between students' current and desired performance so that action can be taken to close the gap. To do this effectively, teachers need to have in mind a continuum of how learning develops in any particular knowledge domain so that they are able to locate students' current learning status and decide on pedagogical action to move students' learning forward. Learning progressions that clearly articulate a progression of learning in a domain can provide the big picture of what is to be learned, support instructional planning, and act as a touchstone for formative assessment.

There is no shortage of standards or curricula in education today. However, as the Committee on Science Learning K-8 (2007) notes, "many standards and curricula contain too many disconnected topics that are given equal priority. The way many standards and curricula are conceived limits their utility for planning instruction and assessing learning. Too little attention is given to how students' understanding of a topic can be supported from grade to grade" (p. 231). Although the authors are referring specifically to science, this charge can be leveled equally at other domains.

Even though meeting standards is the ultimate goal of instruction, most state standards do not provide a clear progression for understanding where students are relative to desired goals. In fact, many state standards do not necessarily even provide a clear picture of what learning is expected. In the main, they consist of propositional knowledge for different ages, without providing operational definitions of understanding (Smith et al., 2006). While most existing standards describe what students should learn, by a certain grade level "they do not describe how students learn in ways that are maximally useful for curriculum and instruction" (NRC, 2001:256). It is fair to say that if the standards do not present clear descriptions of how students learning progresses in a domain, then they are unlikely to be useful for formative assessment. Standards are insufficiently clear about how learning develops for teachers to be able to map formative assessment opportunities to them. This means that teachers are not able determine where student learning lies on a continuum, and know what to do to close the gap between current learning and desired goals. Explicit learning progressions can provide the clarity that teachers need. By describing a pathway of learning they can assist teachers to plan instruction. Formative assessment can be tied to learning goals and the evidence elicited can determine students' understanding and skill at a given point. When teachers understand the continuum of learning in a domain and have information about current status relative to learning goals (rather than to the activity they have designed to help students meet the goal), they are better able to make decisions about what the next steps in learning should be.

There are a number of reasons why many curricula are also problematic for planning learning and formative assessment. Curricula are often organized around scope and sequence charts that specify procedural objectives to be mastered at each grade. Usually, these are discrete objectives and not connected to each other in a larger network of organizing concepts (NRC, 2000). In this context, rather than providing details about the status of the student's learning relative to the desired learning goal, (the hallmark of formative assessment) that can inform pedagogical actions, assessment related to the objectives will be of how well the student completed the task. Textbooks suffer from the same problems. Many math and science textbooks, for example, cover a wide array of topics, (which are not always organized in a logically connected way – see, for instance, Stern & Roseman, 2004), often leading to superficial coverage of ideas without building connections between and among them. This situation contrasts with how curricula are organized in countries that outperform the U.S. on international assessments and leads to charges that students in the U.S. experience a curriculum that is a "mile wide and an inch deep" (Schmidt, McKnight & Raizen, 1997:1)

Curricula organized into "units" of instruction around particular topics present better, but less than optimal, opportunities for instructional planning and formative assessment. When 'units' are described in terms of a core concept or "big idea" and supporting sub-concepts teachers are more easily able to map formative assessment onto these learning goals. However, this approach to organizing content has its own set of drawbacks. Units are often not connected to each other in a coherent vision for the progressive acquisition of concepts and skills, and therefore limit teachers' ability to see how learning develops in a specific domain. Teachers are unable to locate students' learning status on a continuum of development and are confined to seeing learning as a chunk of content that has to be mastered in a given timeframe. By contrast, learning progressions describe a trajectory of learning in a domain that spans a much longer period and provides multi-year image of successively more sophisticated performance levels.

This progression of learning allows teachers to position their students' learning, not only in relation to their current class(es) and the objectives for that cohort, but also in relation to prior and subsequent classes. Consequently, teachers are able to view current learning against a bigger picture of development. In terms of instruction, they are able to make connections between prior and successive learning. Also, information from formative assessment can be used to pinpoint where students' learning lies on the continuum. Sometimes this will mean that teachers have to move backwards along the continuum, for example, if key building blocks are missing. Similarly, they might move learning further forward if some students are outpacing their peers. In both cases, the continuum allows them to make an appropriate match between instruction and the learners' needs.

In this paper, I first present definitions and attributes of learning progressions. Next I discuss how learning progressions can support instructional planning and formative assessment. Then I describe several different learning progressions and examine the implications of their design for instruction and formative assessment. Finally, I outline three different approaches to constructing learning progressions.

II.

DEFINITIONS AND ATTRIBUTES OF LEARNING PROGRESSIONS

A number of definitions of learning progressions exist in the literature and include the following:

- Masters & Forster (1997) describe learning progression as progress maps which are vertical maps that provide "a description of skills understanding and knowledge in the sequence in which they typically develop: a picture of what it means to 'improve' in an area of learning" (p.1)
- Referring to the domain of science, Wilson and Bertenthal (2005) define learning progressions as "descriptions of successively more sophisticated ways of thinking about an idea that follow one another as students learn: they lay out in words and examples what it means to move toward more expert understanding" (p.3).
- The authors of Taking Science to School (NRC, 2007) define learning progressions as "descriptions of the successively more sophisticated ways of thinking about a topic that can follow one another as children learn about and investigate a topic over a broad span of time" (p. 8-2).
- Stevens et al., (2007) describe learning progressions as descriptions of how students gain more expertise within a discipline over a period of time. "They represent not only how knowledge and understanding develops, but also predict how knowledge builds over time" (p.2).
- Popham, (2007) defines learning progressions as a "carefully sequenced set of building blocks that students must master en route to a more distant curricular aim. The building blocks consist of sub skills and bodies of enabling knowledge." (p. 83)
- For Smith et al., (2006) learning progressions are "based on research syntheses and conceptual analyses and describe successively more sophisticated ways of reasoning in a content domain that follow one another as students learn" (p.2).

Inherent in each of these definitions is the notion of vertical development over an extended period of time. Learning is envisioned as a development of progressive sophistication in understanding and skills within a domain. An important point to note is that none of the definitions contains references to grade or age level expectations, in contrast to many standards and curricula. Instead, learning is conceived as a sequence or continuum of increasing expertise. Current standards and curricula tend to define learning horizontally rather than vertically. For example, they describe what "goes into" the sixth grade math curriculum or the ninth grade language arts curriculum. A vertical conceptualization of learning is intrinsic to the notion of learning progressions, thus supporting a more developmental view of learning (Wiliam, 2007). In turn, a developmental view invites teachers to conceptualize learning as a process of increasing sophistication, rather than as a body of content to be covered within specific grade levels. It is axiomatic to learning that students do not proceed in lock step – they do not move forward at the same rate or with the same degree of depth. Student learning is differential and may lie at different points along the vertical progression. Lee and Ashby (2001), for example, showed that the conceptual understandings in history of *some* 8-year-old students are more advanced than those of *many* 14-year-olds; other research indicates that instead of learning becoming increasingly homogeneous as students move through school, the spread of achievement increases with age (for a full discussion of the achievement spread see Wiliam, 2007).

Another idea represented in these definitions of learning progressions is *progression*, that is, there is a sequence along which students can move incrementally from novice to more expert performance. Implicit in *progression* is the notion of continuity and coherence. Learning is not viewed as a series of discrete events, but rather as a trajectory of development that connects knowledge, concepts and skills within a domain. With clear connections between what comes before and after a particular point in the progression teachers can calibrate their teaching to any missing precursor understanding or skills revealed by assessment, and determine what the next steps are to move the student forward from that point.

III.

USING LEARNING PROGRESSIONS FOR INSTRUCTIONAL PLANNING AND FORMATIVE ASSESSMENT

Learning Progressions and Instruction

A well-constructed learning progression presents a number of opportunities to teachers for instructional planning. It enables teachers to focus on important learning goals in the domain, centering their attention on what the student will learn rather that what the student will do (i.e., the learning activity). In planning instruction the learning goal is identified first, and the sequence of activities or experiences that teachers will use to enable students to meet the goal is connected to the goal. Consequently, the all too common practice of learning being activity driven rather than driven by the learning goal is avoided.

A progression also helps teachers see connections between what comes before and after a specific learning goal, both in the short and long term. For example, in the Smith, Wiser, Anderson & Krajcik (2006) progression of Molecular-Atomic Theory (see Appendix), a teacher who was focusing on the goal of understanding that "the weight of an object is a function of the material it is made of" would be able to see that understanding "objects have properties that can be explained and measured "is an important precursor for their current goal, and that a more sophisticated development of this understanding is " the mass and weight of an object is explained by the masses and weights of its atoms." This means that teachers have the opportunity to build explicit connections between ideas for students that thread the development of increasingly complex forms of a concept or skill together.

Recent work by Heritage, Kim & Vendlinski (2008) has underscored the importance of clarity for teachers about what comes before or after a particular learning goal. In a study of teachers' mathematical knowledge, 130 sixth grade mathematics teachers reviewed student responses to assessments of their understanding of core principles underlying mastery in algebra I. Teachers could mostly identify the core principle that the assessment addressed, and for the most part could also draw appropriate inferences about what the student did or did not understand about the principle. However, they had considerable difficulty determining what they would do next instructionally, and what feedback they would give the students to move their learning forward. A learning progression, by providing a sequence for learning that under girds instruction, could remedy this situation. Take for example the NCTM Focal Points (NCTM 2007). These are descriptions of the core mathematical ideas that need to be learned at each grade level. It would be possible to develop a learning progression for these ideas. In the case of algebra, for example, among the core ideas for grade 6 is:

- solve simple one-step equations by using number sense, properties of operations, and the idea of maintaining equality on both sides of an equation

This idea extends into Grade 7 as:

- understand that when the properties of equality to express an equation in a new way are used, solutions obtained for the new equation also solve the original equation

The idea also has antecedents in the earlier grades, for example:

- use patterns, models, and relationships as contexts for writing and solving simple equations and inequalities (Grade 5)
- identify, describe and extend numeric patterns involving all operations and nonnumeric growing or repeating patterns (Grade 4)
- use properties of addition and multiplication to multiply whole numbers and apply increasingly sophisticated strategies based on these properties to solve multiplication and division problems involving basic facts (Grade 3)

Using these ideas, a sixth grade teacher whose students were having problems solving simple one-step equations by using properties of operations might decide that she needs to focus on developing a better understanding of these properties, for instance, that division undoes multiplication and that subtraction undoes addition. It may be that for some students she needs to revisit antecedents of this from earlier grades, for example, using models and relationships as contexts for writing and solving simple equations. For others who have full grasped the 6th grade idea, the teacher might decide to move them forward toward the 7th grade idea by working on two-step equations.

However, to be maximally useful for instruction and for formative assessment, these ideas will need to be fleshed out. In their current form they would provide the teachers in the mathematical knowledge study described above with a clear view of the building blocks in one aspect of algebra. But to be able to know what to teach next or what feedback to give students (recall that they were by and large not able to do this), more detail and connections among these ideas is necessary. Indeed, the NCTM specifies that the Focal Points should be used as a framework for planning. With the ideas providing the spine for a more detailed progression, it should be possible for teachers in a school or district to pool expertise and figure out the interlocking parts between the core ideas, and to spell out, for example, what is involved in understanding and using the properties of operations to solve equations, or the kind of models and relationships students need to learn to use to solve equations, or that moving to solving two-step equations would be a next step in developing ideas from 6th to 7th grade. It is not difficult to imagine the improvements to teachers' knowledge, to instruction, and to formative assessment that would accrue from such a process. Teachers would have sufficient knowledge be able to pull out short-term goals for manageable chunks of instruction and formative assessment (e.g., teaching one of the properties of arithmetic), while being able to locate the purpose of any one lesson in a trajectory of instruction that supports student learning over time (Alonzo & Gearhart, 2006).

Learning Progressions and Formative Assessment

Formative assessment has three key elements: 1) eliciting evidence about learning to close the gap between current and desired performance; 2) providing feedback to students; and 3) involving students in the assessment and learning process. Learning progressions are foundational to these elements.

Eliciting Evidence. To be effective, formative assessment cannot be treated as a series of *ad hoc* events. Instead, evidence of learning needs to be elicited in systematic ways so that teachers have a constant stream of information about how student learning is evolving toward the desired goal. A constant stream is necessary because if assessment is used effectively to inform instructional action then that action will render previous assessment information out of date: student learning will have progressed and will need to be assessed again so that instruction can be adjusted to keep learning moving forward. With clear learning goals outlined in a progression, teachers can match formative assessment opportunities to them, and can make plans in advance of and during instruction about when, what, how and who to assess. Even when formative assessments arise spontaneously in the course of a lesson, interpretations of how learning is evolving can be made based on the trajectory of learning represented in the progression. The information from the assessments maps back onto the progression and assists teachers to identify where students are in their learning and to decide what they need to do next.

Feedback to Students. Feedback to students is critical to formative assessment. A considerable body of literature documents the nature and benefits of quality feedback for student learning, motivation and self-regulation (e.g., Bangert-Drowns et al., 1991; Butler, 1986; Butler & Nisan, 1986; Kluger & DeNisi, 1996; Pintrich & De Groot, 1990.) Quality teacher feedback needs to be timely, specific, linked to explicit criteria (that are known to the student) and provide suggestions for how to improve (OECD, 2005). The explicit criteria, or "what a good performance looks like," Sadler (1989:120), have also been termed "success criteria" (e.g., Clarke, 2005; Wiliam, 2007). These criteria serve as sign-posts for students about where they are going in their learning, as a means for teachers to assess the current state of students' learning, and for students themselves to reflect on their performance.

Returning to the science goals described earlier, if teachers are clear that their learning goal is to develop understanding that "objects have properties that can be explained and measured" they have a basis for determining what a good performance looks like. For example, in a classification task the students should accurately sort objects according to weight, length and area, be able to explain their classification system and describe reasons for why they have put specific objects in one category rather than another. The task would provide the teacher with information about students understanding of the goal and enable her to provide specific feedback to the students, for example, "there are three objects that belong in this category and one that doesn't. Look again, think about your explanations, and see if you can figure out which one does not belong and why." The teacher is able to analyze how the student performance differs from the criteria and provides feedback that requires the student to think more about the classification she has made. The teacher also knows that these criteria connect with an earlier learning goal of understanding that "objects are constituted of matter" (which she may need to return to depending on the information from the assessment task) and to the subsequent goal of understanding that "objects are made of matter that takes up space and has weight" (which she may move to more quickly than she anticipated as a result of the assessment).

The feedback is given in relatively frequent and manageable chunks so that the requirements for improvement are both understandable and doable (Brookhart, 2007). Quality feedback does not involve comparison with peers, but instead helps students to understand their own performance in relation to the learning goal. Thus, the learning process is transparent and also provides students with models of "learning how to learn" (OECD, 2005).

Involvement of Students. Cognitive theories note a central role for metacognition (i.e., thinking about thinking) in students' learning. In the context of formative assessment, metacognition involves students in monitoring and evaluating their own learning process to determine what they know and understand, and to develop a variety of learning strategies so that they can adapt their learning to the task at hand. Sharing the criteria for success with the students at the outset of the instructional segment not only provides transparency on the learning process, it also means that the students can monitor their learning while engaged in the learning task. But how can students monitor their learning while they are learning? Won't they need to have learned what they need to learn to be able to know if they have learned it? To answer these questions, more on success criteria and the tension between summative and formative assessment is in order here.

Teachers have traditionally been trained to write learning goals as "by the end of… students will…". Clarke (2005) refers to these as product criteria that describe a longer-term learning goal. These product criteria are often accompanied by rubrics, usually on a one to four point scale, that specify what performance for each score point looks like. Rubrics are provided to students (or are developed by students and teachers together) at the beginning of the learning sequence. Students know what they are aiming for and using the rubric they are able to evaluate their product. Teachers might use the rubric as part of the students' grade. I would argue that this represents summative rather than formative assessment. Students and teachers evaluate learning expected at the end of a longer-term objective, which stands in contrast to the notion of a steady stream of information to guide "minute-by-minute, day-by-day" instruction and learning (Leahy et al., 2006).

Without a doubt it is desirable for students to know what the longer-term goal is or what the final product of the learning will be. Increased involvement in learning occurs when teachers share with the students what their longer-term goals are and enable them to participate in evaluating the degree to which they have met the goals. However, long-term goals represent too much of a stretch for students (and for teachers) to be able to profitably *monitor* their learning and to respond to feedback from teachers and peers. Needed for formative assessment are short-term objectives (for one or two lessons) and process criteria for students to help them while they are engaged in the task. In other words the key steps or ingredients students need to meet the learning goal of the lesson or lessons (Clarke, 2005). What does this look like in practice? Take, for example, the long-term writing goal: students will use conditionals in past and future to speculate about possible causes (past) and review a range of options (future). A short-term goal or objective toward meeting this goal could be to have students use some connectives in their writing to show causality. The process criteria for the students might be: "in your writing today remember to use words like *because, so, as, however, therefore* to express the reasons why things did or should happen." These criteria become the means for students to be reflective while they are learning to use the connectives to show causality, as well as being the basis for teachers' assessment while the students are writing. Further reflection and the opportunity to be actively involved in learning could come at the end of the lesson when students respond to the question "how well do you think that you used connectives to show causality – why do you think this?" and leave their responses on cards for the teacher to read as they leave class. Alternatively, she could ask them to review their writing against the success criteria, identify where they have used the connectives well and note a place where they could improve their writing the following day. Through this process students have a manageable way to be self-reflective about their learning *while* they are learning. Furthermore, the teachers' observations from the lesson, analysis of the writing samples against the criteria, and the students' end of the lesson reflection, give her the means to make decisions about how well learning is progressing and the kind of feedback she will give to the class as a whole or to individual students. Not only does she have the criteria on which to provide specific feedback to the students about their learning, she also has information to guide her lesson the next day. At the same time, process criteria enable students to be involved in peer- as well as self-assessment. Peers can review each other's work against the criteria and provide feedback on areas for improvement.

Ultimately, the teachers and the students will likely want to evaluate how well they have met the longer-term goal of "using conditionals in past and future to speculate about possible causes (past) and review a range of options (future)," which could involve evaluating with a rubric a piece of writing intended to display this competence. Critically, though, prior to this the students will have had many opportunities to reflect on the short-term goals during the course of learning, with corollary opportunities to adjust their learning in response to their own reflection and to teacher and peer feedback.

IV.

EXAMPLES OF LEARNING PROGRESSIONS

In this section I describe eight different learning progressions (see Appendix for full text of progressions): 1) A Counting and Ordering Process Map, (Masters & Forster, 1997); 2) The U.K. National Curriculum in History (Qualifications and Curriculum Authority, 2007); 3) Stages of Listening Comprehension and Speaking Skills (Bailey & Heritage, in press); 4) Stages of Spelling (Gillet & Temple, 2000); 5) A Developmental Model for Learning Functions (Kalchman & Koedinger, 2005); 6) FAST trajectory (Shavelson, Stanford Educational Assessment Laboratory (SEAL) & Curriculum Research & Development Group (CRDG), 2005); 7) A Conceptual Flow for Genetics (DiRanna & Topps, 2005); and 8) A Progression of Molecular-Atomic Theory (Smith, Wiser, Anderson & Krajcik, 2006). I have selected these progressions not because they are necessarily exemplary, but rather because each addresses an area of K-12 learning, and have sufficiently articulated a progression to be able to characterize their main features.

Counting and Ordering Progress Map *(Masters & Forster, 1997).* The purpose of this map is to provide a description of development in an area of learning that can be used as a guide to instruction and assessment. Student development in counting and ordering is represented along a continuum from lower level to higher-level, more sophisticated skills and understanding. For example, at the lower portion of the map the student progresses from skip counting in 2s or 3s using a number line, hundred chart or mental counting, to using unitary ratios of the form of 1 part to X parts. The map presents a multi-year trajectory of development, thus providing "a 'whole-school' view of learning" (Masters & Forster, 1997:2). Teachers are able to see the growth of student learning in context of progress made in earlier and later years. Assessments are used in conjunction with the map to locate student learning along the continuum so that teachers can determine the instruction that is likely to be the most beneficial for students at that particular point.

The U.K. National Curriculum in History *(Qualifications and Curriculum Authority, 2007).* This progression provides a description of levels of attainment in history that span the early years of schooling to age sixteen. As in the previous example of counting and ordering, a development of learning in history starts at a rudimentary level with students recognizing the distinction between present and past in their own and other people's lives, for example, and progresses at the highest level to students using their factual knowledge and understanding of the history of Britain and the wider world to analyze the relationships between events, people and changes, and between the features of different past societies and cultures. Each attainment level is accompanied by a program of study, which provides a more detailed description of the elements of learning. The content of the programs of study builds progressively, and provides sufficient detail for instructional planning. It is also clear what the points of focus of formative assessment should be to keep learning moving forward. A multi-year, whole-school development of history is represented within which learning at any point on the continuum is set in the context of prior and successive learning. A national system of assessment is linked to the progression and student performance is described in terms of the level of attainment that has been reached.

Stages of Listening Comprehension and Speaking Skills *(Bailey & Heritage, 2008).* The stages in the listening comprehension and speaking skills progression represent a typical range of development for students from five to twelve years of age. Each stage comprises four categories: word: sentence and discourse level and prior content knowledge. Within each category development increases in sophistication. For example, at the sentence level in stage 1 speaking skills, students use word order conventions to make meaning of syntactically simple sentences (e.g., subject + verb + object = declarative statement; verb + subject + object = question form; verb + object = imperative form) and by stage 3 they are expanding their repertoire of recognizable sentence structures to include frequently used complex syntax (e.g., relative clauses) for meaning making. A formative assessment task tied to this level might be that children are asked to create their own question in response to content material so that teachers can ascertain their level of syntactic knowledge of this form. This progression complements a progression in reading (also in the same volume), which is organized into similar categories. So while children are developing the speaking skills described above they are simultaneously using their knowledge of syntactically simple sentences to aid reading comprehension. Together, the two progressions illustrate the intertwined nature of language and reading development. This progression is not linked to a specific system of assessment, but rather is intended as a guide for teachers to map formative assessment to the descriptions of development at each stage.

Stages of Spelling *(Gillet and Temple, 2000).* This progression represents five stages of spelling development, ranging from pre-phonemic at the earliest stage of emergent literacy to derivational spelling. The spelling progression has parallels to reading development. For example, at the pre-phonemic spelling stage, letters and forms are used randomly in children's attempts at writing. This parallels children's early reading when they are isolating phonemes aurally and beginning to understand that phonemes have letter correspondences. At the derivational stage of spelling when they read students are using their knowledge of morphemes to make meaning of text, for example, how verbs can change to nouns (e.g., -ion, ism, -ology) and how nouns can change to verbs (e.g., -ify, -en, -ize). The sequence of spelling development in this progression is generally thought to take from three to six years to complete. Teachers can use the progression for formative assessment (e.g., examining writing samples against the stages, using a spelling inventory, collecting misspellings of the same words at intervals and contrasting the attempts) and, based on their assessment, they can use the stages to plan instruction that will increase spelling competence.

A Developmental Model for Learning Functions *(Kalchman & Koedinger, 2005).* The Model for Learning Functions is an instructional plan, encompassing four levels from 0 to 3. It is intended to build and secure students conceptual understanding, their facility in representing functions in a variety of ways, and their ability to solve for unknown variables so that they can tackle unknown problems with confidence. The authors state that the model is designed to produce "grounded competence whereby students can reason with and about multiple representations of mathematical functions flexibly and fluently" (p.389). In contrast to the prior examples, this progression is intended as a unit of study, taking approximately 650 minutes of class time to complete rather than a multi-year description of learning. The unit is represented as a progression of numeric and spatial understanding, level 0 characterizing the kinds of numeric/symbolic and spatial understanding students typically bring to learning function, and level 3 describing the understanding about how linear and nonlinear terms can be related that students achieve at this level. The unit can be taught at the sixth, eighth, tenth and eleventh grades and the authors recommend that, regardless of grade level, the unit should be taught in sequence because the concepts addressed in level 3 are dependent on a deep understanding of concepts in levels 1 and 2.

Buoyancy Trajectory *(Shavelson et al., 2005).* The buoyancy trajectory identifies 'progress variables' for the development of student understanding of why things sink and float. The trajectory contains tasks that are embedded in instruction to provide teachers with formative feedback about how students understanding of relative density is evolving. The trajectory encompasses a instructional time period of approximately twelve weeks, and traces the development of student understanding about why things sink and float from alternative conceptions like 'buoyancy depends on the object being flat, hollow, filled with air, etc.', to understanding that buoyancy depends on the density of the object relative to the density of the medium (relative density). Tasks are embedded into instruction at critical junctures in the trajectory. For example, after several investigations of the relationship of mass to volume and how both properties affect an object's capacity for floating and sinking, students engage in tasks that enable the teacher to differentiate between students who understand this concept from those students who have different levels understanding on the trajectory. Each performance level is defined in terms of what the student knows (e.g., floating depends on having a small mass and a large volume), what the students needs to progress to the next level (e.g., student needs to understand the concept of density as a relationship between mass and volume) along with a sample response (e.g., "an object floats when its mass is small and its volume is large"). Teachers know which students have understood the concept and what they need to learn next, and they also know which students still need more experiences to develop the understanding that is the target of the instruction at a particular point in the learning sequence.

Conceptual Flows *(DiRanna & Topps, 2005).* A part of the *Assessment Centered Teaching Portfolio,* The Conceptual Flow is intended to function as both a tool and process that help teachers establish science learning goals and the framework for an assessment plan. Essentially, the tool and process provide a means to engage in "backward planning" (e.g., Wiggins & McTighe, 2005). Teachers identify the big ideas in a strand of science that will be the focus of an instructional unit and from those develop a sequence of learning as a hierarchy of ideas. The big ideas are supported by small ideas, and those small ideas are supported by even smaller ideas, representing a series of "nested concepts." In the representation of the conceptual flow teachers are encouraged to use different widths of lines to connect ideas. The lines indicate the strength of the links between ideas - thicker lines indicate a strong link, while thinner lines indicate a weaker link. Teachers can match formative assessment to the ideas represented in the flow to assess how well students are progressing toward understanding the big ideas. Resources (e.g., textbooks, instructional materials) are then identified that can be used to support teaching. During the course of instruction teachers use formative assessment matched to the ideas represented in the flow to assess how well students are progressing toward understanding the big ideas.

A Learning Progression of the Atomic-Molecular Theory of Matter (Smith, et al., 2006). This progression is divided into three grade bands that progressively describe the development of understanding: K-2 – Developing an Understanding of Materials and Measurement: 3-5 – Developing an Explicit Macroscopic Understanding of Matter; and 6-8 – Developing an Initial Understanding of the Atomic Molecular Theory. Throughout, content and process skills are linked in four inter-related strands: 1) know, use, and interpret scientific explanations of the natural world; 2) generate and evaluate scientific evidence and explanations; 3) understand the nature and development of scientific knowledge; 4) participate productively in science practices and discourse. The beginning stage of the progression identifies several ideas that children have at the start of school about matter, and the learning progression is described, in part, by progressively more sophisticated answers to the questions. Each segment of the progression is dependent on the preceding one, enabling children to develop a framework for assimilating increasingly abstract ideas and exploring questions at deeper levels.

In the next section I examine differences and similarities among the progressions and consider their implications for instruction and for formative assessment.

Design Implications for Instruction and Formative Assessment

All the progressions share the characteristic of moving from less to more sophisticated understanding or skills. Where they differ is in the span of the progression, and in the level of detail or granularity. Some progressions are described as a discrete unit of study, which is intended to take place over a relatively short period, usually a matter of weeks (e.g., the buoyancy progression, developmental model of functions and the conceptual flow). Others describe a multi-year trajectory of learning, which might span several or all years of schooling (e.g., the spelling progression, the counting and ordering progress map, the history progression, the atomic-molecular theory progression). There are variations in the progression in terms of the level of detail provided - progressions that cover a shorter time span tend to provide a more detailed description. The differences in time-span and detail of the progressions highlight one of the tensions in creating a progression to serve the dual purpose of instruction and formative assessment, namely, the appropriate degree of granularity for teachers to see the big picture, understand what the essential building blocks are, make connections between and among them, and yet have the specifics to guide assessment and instruction without ending up with what Lorrie Shepard terms the "thousand mini-lesson problem" (Shepard, 2007). Perhaps one way to resolve this tension is to provide a big picture, multi-year progression that outlines essential building blocks and then drills down from the building blocks into more detailed descriptions. Teachers who are responsible for a particular range of the progression could have the detail they need for planning and for formative assessment. They would also be able to see how the focus of their instruction connects to a larger picture of learning, and in the case when assessment information shows that one or more of their students are performing outside the range they would know what precursor understanding or skills need to be developed for students to move forward.

The U.K. National Curriculum presents an example of what this approach could look like. A program of study that focuses on the core ideas of the domain is provided for each of the attainment levels. The program of study outlines in some, but not overwhelming, detail what the core ideas at each attainment level look like. For example, at the earliest stages the program of study for historical inquiry specifies that students learn how to find out about the past from a range of sources of information, (e.g., stories, eyewitness accounts, pictures and photographs, artifacts, historic buildings and visits to museums, galleries and sites, the use of information and communication technology based sources). Students build on this learning in later stages to develop an understanding that people represent and interpret the past in many different ways, (including in pictures, plays, films, reconstructions, museum displays, and fictional and nonfiction accounts) and that the interpretations reflect the intentions of those who make them (for example, writers, archaeologists, historians, filmmakers). The way the core ideas develop progressively through the attainment levels is reminiscent of Jerome Bruner's notion of the "spiral curriculum." He expressed the hypothesis that "any subject can be taught effectively in some intellectually honest form to any child at any stage of development" (Bruner, 1960*:* 33). Consequently, he proposed that as any curriculum develops should revisit these ideas and build on them in successive ways (*ibid*).

Clarity about how core ideas develop from their earliest to more sophisticated forms presents a number of advantages for teaching and learning. First, the description of the ideas at each of the attainment levels helps teachers keep the big picture in mind, and enables them to see where their focus of learning fits in a larger trajectory. Thus, they expand their knowledge of the domain and can connect prior and successive learning to the students' current learning focus. Knowing that at a later stage students will be learning that representations and interpretations of history differ, for example, could prompt a teacher of an earlier stage to not only help children understand there are different sources of evidence about the past, but to also lay the ground work for the future by connecting the idea of who provided the source of evidence and what that person's role was or is.

Second, the descriptions of attainment at each level provide sufficient detail for instructional planning and help teachers to map formative assessment opportunities on to the key elements of learning in the description. Recall that there are several components of formative assessment: eliciting evidence, providing feedback, and the involvement of students. The descriptions in the program of study support all these components. Teachers have sufficient detail from which to derive criteria for success, which can be shared with students. They are able to decide on appropriate pedagogical strategies that will assist students to meet the criteria and use these strategies as formative assessments to elicit evidence of how learning is evolving toward the criteria. For example, in the history inquiry strand when students are learning about source material they might investigate a set of artifacts related to a period of history, noting important details. Teachers might then give students other source material, photographs of the artifacts in use, for instance, and ask them to extract information about the period from the sources. This activity could serve the dual purpose of supporting the development of historical reasoning while eliciting evidence of the students' ability to reason beyond observations. The criteria become the focus for determining how learning is progressing and enable teachers to provide descriptive, criterion-based feedback that can help students understand their current status in learning and provide pointers so they know what to do to move forward. For instance, the teacher feedback could let the students know that are able to extract information beyond the observations but that they are not yet combining information from sources, which is the ultimate goal. The feedback is in manageable chunks and learning is transparent – students know where they are and where they are going. Additionally, sharing criteria with the students at the beginning of the instructional sequence establishes the expectation that students will be involved in the learning process and helps them monitor and adjust their own learning.

A further way in which I suggest the progressions differ is in their notions of development, which also has implications for instruction and assessment. The spelling progression describes stages of typical development and specifies what students could accomplish during each stage. The progression of listening comprehension is organized in a similar way, providing descriptions of development without being prescriptive about grade level. The counting and ordering progress map is also developmental, as is the history progression. While both are linked to levels of attainment, neither is specifically linked to grade level expectations. The molecular-atomic theory progression is linked to grade level bands, but these bands span several years of learning. In all these progressions, learning is conceived of as moving along a trajectory and, although students might be expected to accomplish a certain range of building blocks during the course of say one of more years, they are not restricted to a specific period time.

The unit progressions also clearly state a sequence of learning and identify dependencies among concepts. However, implicit in the unit progressions is the idea that mastery of the concepts will be achieved in a period of several weeks of instruction, in contrast to the progression that describe a multi-year trajectory. In terms of planning for instruction and assessment the unit plans are tightly organized, presenting clarity about the hierarchy of learning, (what building blocks precede others) and giving definition to what elements of learning need to be assessed to ensure each sub concept is in place before moving onto the next. However, we know that learning does not proceed uniformly, so what happens if students do not master the concept(s) in the expected time frame? Does the unit as a whole get repeated later that year or during another year? If not, how do teachers know how to connect the concepts that have not been fully understood to later learning? Furthermore, are students expected to learn all there is to know about genetics, for example, in the space of one unit covering a few weeks? What are early understandings of genetics and how do conceptions of genetics become progressively more sophisticated? How is the development of core ideas coordinated over successive years? How is the study of genetics linked to other areas of the discipline? These seem to me to be important questions that are not answered by a unit approach.

A developmental progression spanning a longer period and tracing how concepts and skills build progressively can be organized into increments for instruction. However, if teachers know how learning moves forward or backwards along a progression they have greater flexibility in planning for learning. In the case when all the learning goals of a unit of instruction have not been met, teachers can trace the threads of the concepts, identify subsequent opportunities along the progression when these concepts connect with later ones, and revisit them at this point. Alternatively, they might need to go further back in the progression to clear up misconceptions or to fill gaps in students knowledge that are preventing them from meeting the goals of the unit. Additionally, a longer developmental trajectory enables teachers of students whose understanding outpaces that of their peers to focus instruction on developing their thinking to higher levels, which might be beyond that outlined in the unit.

One more point about the differences among the learning progressions. Some of the progressions advance in isolation and some are connected to other areas of the discipline. For example, the spelling progression parallels development in reading wherein students are using their knowledge of sound/symbol correspondences to decode as well as encode. The listening and speaking progression parallels a progression for reading and writing development (these are not shown in the appendix) with clear links among them. This design provides an even bigger picture of learning within the domain and enables teachers to use formative assessment opportunities in one area to inform how learning is progressing in another. For example, an examination of student writing might be used to elicit evidence of students' knowledge of sound symbol correspondences, which is important information not just for encoding but also for decoding in reading. Similarly, students listening comprehension skills in relation to certain syntactic structures can provide a window to reading comprehension. If students are not able to understand specific structures (e.g., subordinate clauses) in listening, then this is important information for teachers in relation to their reading instruction.

Each of the progressions I have discussed focuses on the content of a discipline and the development of content knowledge from less to more sophisticated forms. In formative assessment practices other aspects of development are invoked, namely metacognition and self-regulation. Although a full discussion of these more generalizable features of development are beyond the scope of this paper, it is important to note both their relevance to learning and the need for teachers' awareness of how they can be supported through their actions in the classroom. Indeed, recognizing the changing capacities of a broad range of developmental characteristics prompts us to reflect on the wide range of necessary knowledge and skills for teachers to use learning progressions and formative assessment practices (for a description of the knowledge and skills teachers need see Heritage, 2007).

V.

CONSTRUCTING LEARNING PROGRESSIONS

In *Knowing What Students Know (KWSK)* a committee of the National Research Council advanced an ambitious vision for a system of assessment based on three critical principles: *coherence, comprehensiveness and continuity* (NRC, 2001). A *coherent* system is built on a well-structured conceptual base, which is foundational to both large-scale and classroom assessments. The same constructs are being assessed regardless of their level of implementation (although they may be more differentiated at the classroom level). Thus, all assessment is aligned along a vertical dimension. A *comprehensive* assessment system includes a range of measurement approaches at different levels of detail to provide the variety of evidence to support educational decision-making. *Continuity* refers to a system that is temporally aligned wherein student learning is measured over time to provide a continuous stream of evidence about how learning is progressing. In the authors' view, an important step toward realizing this vision is the development of user-friendly models of student progression in learning, where clear targets for instruction and assessment are identified.

The authors of *KWSK* also stress the importance of alignment of curriculum, instruction and assessment so that all three parts of the system are working toward a common set of learning goals. In their vision "assessment will not simply be aligned with instruction, but integrated seamlessly into instruction so that teachers and students are receiving frequent but unobtrusive feedback about their progress" (NRC, 2001:256). Essentially, what is presented here is a vision for formative assessment.

However, we remain at some distance from the implementation of this vision. We lack comprehensive models of student progression in many domains. Current research only defines how a limited number of areas can be divided into learning progressions (Herman, 2006). As described earlier, what teachers have in the way of standards and curricula fall short of a coherent progression of learning in a domain. Until there is a sufficiently well developed research base to inform learning progression in each domain, we need other strategies for figuring out learning progressions (Herman, 2006). Teachers cannot wait for the research community to catch up. They need better tools than standards and existing curricula to realize the promise of formative assessment to student learning. Moreover, there is considerable value to the development of teachers' knowledge about a discipline when they define a progression of learning.

In what follows I consider three examples of approaches to constructing learning progressions. It should be noted though that these approaches are by no means the only ways to construct learning progressions (see, for example, DiRanna & Topps, 2006; Stevens et al., 2007; Wiliam, 2007; Wilson & Draney, 2004), nor are they *the* only possible progressions for a particular learning outcome. While research and experience will likely continue to show that some components of a progression are best taught and learned before others, it is doubtful that there would ever be complete agreement on the sequence of a progression. The progressions I consider are intended to be illustrative, rather than exhaustive, of possible approaches and sequences. In general, the different approaches to creating learning progressions can be loosely described as 'top-down' or 'bottom-up'. In a 'top-down' progression, experts in the domain (e.g., physicists, mathematicians, historians), and other experts such as development specialists construct a progression based on their domain and research knowledge. The resulting progression represents their decisions about what constitutes the 'big ideas' of the domain and how they connect together. A 'bottom-up approach' involves curriculum content experts and teachers in developing a progression that is based on their experience of teaching children. Their sources for developing the progression are curricula, their views of what is best taught when, and their knowledge of children's learning. For sure there are times when the domain experts consult teachers and when teachers consult researchers, but on the whole the genesis of the progressions come from different sources of expertise.

First, progress maps developed by the Australian Council of Educational Research (Masters & Forster, 1996), which I consider a 'bottom-up' approach to developing a progression. The goal of the progress maps is to "obtain an estimate of student's current location on the map as a guide to the kinds of learning experiences likely to be most useful at that stage in the student's learning and as a basis for monitoring growth" (p.1). The development of the maps usually begins with teachers' understandings from their day-to-day experiences about how student learning typically occurs in specific areas and what the indicators of progress are. Once this initial sketch is outlined it is then tested against a set of questions including: Do other teachers agree with this? What is the empirical evidence for this map? Is this picture consistent with theoretical understandings of how learning occurs? How useful is the resulting map in practice? Once in use "the maps are constantly checked, updated and enriched" (p.13). Information derived from observations of learning and records of student performance illustrate the nature of progress and are used to revise the map. For example, the information might show that concepts that appear at one point in the progression would be better addressed earlier or later.

The next approach I describe is a 'top-down' approach' to developing the atomic-molecular theory progression and documented in *Taking Science to School* (NRC, 2007). Two design teams comprising scientists, science educators and experts on children's learning were asked to use existing research to construct possible learning progressions for the atomic-molecular theory and evolution, both core ideas in modern science. The teams approached the task in similar way. First, they organized the learning progression around big ideas important to the discipline. Second, both teams identified several high-level abstract ideas that go into building the core ideas, but which are accessible to children at the start of schooling, thereby acknowledging that young children have the important domain-specific ideas that serve as the foundation for their learning. Essentially, the atomic-molecular theory and the theory of evolution were seen as emergent ideas. These ideas provided a framework for organizing children's learning of new facts, inquiry and explanation. For example, in molecular theory the distinctions that young children can make between objects and what they are made of can be resources to support the development of understanding about why objects have the characteristics they do and for understanding transformations. Third, the design teams, recognizing that understanding an idea means that the learner must be engaged in practices that support using and developing the ideas, specified the nature of those practices. Among these practices are using ideas to question, describe, classify, identify, predict, use data and evaluate ideas and make arguments. Finally, the teams took the view that understanding of the core ideas involves understanding the data patterns and knowledge construction and evaluation practices that give rise to the ideas. In the case of the atomic-molecular theory progression this meant the designers focused on ideas of measurement, models and evaluation of idea using data and argument (NRC, 2007). The authors note that this process is still partial and incomplete and has not yet been discussed and critiqued by the larger community. Furthermore, teachers have not used it so evaluations of the utility to practice are not available.

The final example I describe is a ' bottom-up' process undertaken by Heritage and Osmundson, working in collaboration with the Wisconsin State Department of Education, to develop learning progressions in reading. Teams, comprising curriculum content experts who had a district-wide or school wide role and current classroom teachers (elementary, middle and high school), first reviewed the Wisconsin content standards and isolated the subcomponents. For example:

A4.1 Use effective reading strategies to achieve their purposes in reading

- Use a variety of strategies and word recognition skills, including rereading, finding context clues, applying knowledge of letter-sound relationships, and analyzing word structures (*subcomponents are underlined*)

The next step was to work collaboratively to identify the sub skills or sub concepts that would lead to understanding of the concept or acquisition of the skill. In the case of analyzing word structure, for instance, sub skills identified were use of knowledge of regular letter/sound correspondences to analyze words, use of knowledge of irregular spelling patterns, diphthongs, digraphs, and use of knowledge of prefixes, affixes, suffixes, inflections to read words. To identify these sub skills, teams drew from their combined expertise of working with students, and from their knowledge of the substantial body of literature on reading development.

Once the teams had decided on the key sub skills or sub concepts they laid them out in a progression that was logical for them and made sense in terms of what they knew about learning and instruction. For this process they used sticky notes so that they could move around the sequence as ideas were discussed in the group. One striking factor was that teachers, no matter the level of experience and expertise with content, consistently muddled learning goals with the context for how the learning would be achieved. For example, teachers identified creating area models as the learning goal rather than viewing them as a means for developing student understanding of the concept of equivalent fractions. I suspect that these teachers are not atypical in gravitating to the activities students will do or the materials the students need. However, in the course of the sessions the teachers did become much clearer about the difference between the two, but not without a good deal of guidance from those facilitating the sessions. At one point, one of the facilitators went to a group and removed all the sticky notes that did not specify to a learning goal – after this the group was left with two notes only. While this might be considered rather drastic action, it did have the effect of really making the teachers think about the goals, which they did with considerable success. The 'lesson learned' from this experience is that we cannot assume that all teachers will be able to identify a progression of learning without there being expertise in the group from either colleagues or external resources. We also need to realize that, while developing the progressions will take time and cannot be accomplished as a one shot deal, the benefits to teachers' understanding of the structure of knowledge domains will be substantial.

With the Goldilocks metaphor in mind, another challenge at this stage in developing the progression was the level of detail for building blocks – in other words, deciding on the 'just right' 'grain size.' Teams decided that the issue could not be resolved at this stage in development, and progression would be adjusted when experience with them showed what building blocks were providing too little or too much information to be helpful for instruction and formative assessment. Once the initial progression was completed the following questions prompted further discussion and planning:

- Are the major building blocks (i.e., critical concepts/skills) in the learning progression addressed?
- Are they linked in way that helps build understanding and skills?
- Do other teachers agree with this description of the progression?
- What is the research evidence for this progression of learning?

These questions could also be used for reviewing the progression at regular intervals when teachers have the benefit of implementation experience.

Although the process started with individual grade-level standards, the intention was to ultimately develop a K-12 progression. Standards may be the "benchmark" along the way, but teachers would have a multi-year trajectory of learning, rather than simply chunks of a progression for each standard.

Collaborating to develop the progressions forced participants to think deeply about learning, an undoubted benefit of the process. Even with an early iteration of the progression teachers were able to match instructional plans to the progression and identify ways in which they could formatively assess how learning was developing. The leader of one team, a district curriculum director, commented:

> *"We have done backwards design planning in our district for many years but this process gave us the missing piece. Focusing on the important building blocks is what we needed. We can see what we need to teach and to assess."*

A few words of caution about learning progressions are in order here. First learning progressions are not developmentally inevitable but are dependent on good instruction (NRC, 2007). As Herman (2006) notes "whether and how children are able to engage in particular learning performances and the sequence in which they are able to do so are very much dependent on previous opportunities to learn." (p.122). Therefore, a coordinated approach to teaching and assessing in a school is essential to effectively using learning progressions.

Second, the notion of a learning progression implies a linear sequence. While concepts and skills may have specific precursors, learning does not always take place in a linear trajectory. Stevens et al., (2007) define learning progressions, in relation to science specifically, as " strategic sequencing that promotes both branching out and forming connections between ideas related to a core scientific concept or big idea" (p.4). This idea is equally applicable to other domains. In reading the strands of phonological awareness, decoding skills, sight recognition of familiar words, background knowledge of the subject of the text, receptive and expressive vocabulary, knowledge of grammatical structures, inferential skills, and knowledge of different styles of discourse, including different genres (e.g., narrative, expository) are inter-related (Scarborough, 2001). In mathematics the strands of conceptual understanding, procedural fluency, strategic competence, adaptive reasoning and productive disposition do not advance independently but are interwoven and interdependent (NRC, 2001). In history the strands of chronological understanding, knowledge and understanding of events, people and changes in the past, historical interpretation, historical enquiry, and organization and communication are all inter-related (QCA, 2007). Perhaps conceiving of progressions as a braid of interconnected strands might be a useful way to show connections among ideas of discipline.

VI.

WHAT NEXT?

In this paper I have taken the view that learning progressions provide an important foundation for instructional planning and for formative assessment. I have described some extant learning progressions and three processes for developing learning progressions. However, there is quite a row to hoe to successfully cultivate the development of learning progressions. To this end, I propose that three areas should be addressed: 1) re-thinking standards; 2) research on learning within domains; and 3) the preparation and development of teachers. In what follows I discuss each of these in turn.

Less is More

A major obstacle to the creation of a learning progression representing a trajectory of development of increasing sophistication in understanding and skills inheres in the way that many state standards are conceived. Routinely, standards for each subject area provide teachers with a long list of what needs to be covered for each grade level, which in turn leads to a burgeoning and often disconnected curriculum that centers on coverage rather than on understanding core ideas of the domain from their least to most sophisticated manifestation over the K-12 period of schooling. Moreover, ideas are often given equal weight so that a core concept in a domain is not differentiated from a less significant skill in terms of its importance.

The Commission on Instructionally Supportive Assessment (2001) concluded that fewer, but more powerful standards would lead to increased coherence in curriculum and instruction, deeper learning for students and more valid assessment. If standards were rethought and centered on the key ideas and topics of a domain (in other words, more powerful standards), then not only would the curriculum be more manageable for teachers, but a clear progression of how these central ideas build on each other could be developed and provide the sequence of building blocks to guide curriculum planning and formative assessment. The National Council of Teachers of Mathematics Curriculum Focal Points (NCTM, 2006) represents a step in this direction of less is more? Intended as a framework to guide curricular expectations and assessment, the Focal Points specify the most important mathematical ideas for each grade level that a student needs to understand in-depth for future mathematics learning. It is not difficult to see how teachers could come together to construct coherent and connected learning progressions from these ideas with sufficient detail to be used effectively for formative assessment.

In the spirit of the French maxim, plus can change, plus chest la meme chose (the more things change, the more things stay the same) it is interesting to note that nearly fifty years ago Jerome Bruner wrote about the role of structure in learning and how it could be made central to teaching: “the teaching and learning of structure, rather than the simple mastery of facts and techniques, is at the center of the classic problem of transfer…if learning is to render later learning easier, it must do so by providing a general picture in terms of which the relations between things encountered earlier and later are made as clear as possible” (Bruner, 1960:12). Had we taken this sage advice long ago, perhaps we would not be faced with the laundry list of standards and the mile wide inch deep curricula we have today. However, attention to the homily “better late than never” might serve us well.

Research that Helps

Ideally, learning progressions should be developed from a strong research base about the structure of knowledge in a discipline and about how learning occurs. Yet, the research base in many areas is not as robust as it might be. The authors of *KWSK* propose that to develop progressions, the necessary content expertise should be gathered together, and this expertise should be informed by research on how students learn in specific domains. To this end, they suggest "research centers could be charged with convening the appropriate experts to produce a synthesis of the best available scientific evidence of how students learn in particular domains of the curriculum" (NRC, 2001: 256). They also observe "findings from cognitive research cannot always be directly translated into classroom practice" (NRC, 2001:258). Therefore, they conclude that research syntheses would need to be couched in ways that are useful for practitioners. However, until we have such syntheses, and indeed research that fills the gaps in existing knowledge about learning, educators and others involved in constructing learning progressions will have to draw as best they can from what research does exist. Perhaps what is really needed is for domain experts, researchers, content experts and experienced teachers to unite in a common effort to develop clear conceptions of learning. It is not difficult to imagine the benefits of pooling expertise and perspectives on how children learn to create progressions that make sense to both the research and practitioner communities. Once constructed, such progressions could be empirically verified. As stated in *Taking Science to School*, "ultimately, well-tested ideas about learning progressions could provide much needed guidance for both the design of instructional sequences and large-scale and classroom-based assessments" (NRC, 2007: 8-6).

Teacher Preparation and Development

No reader of this paper can fail to be impressed by the extent of knowledge that teachers need to have to develop learning progressions and to use them effectively for formative assessment. If developing and using learning progressions is going to become a routine part of practice then teachers will have to have more support in their preparation and professional development programs than they do currently. Why is it that so many teachers have difficulty in separating a learning goal from the context through which it will be achieved? Surely before entering the profession they should know the difference. The fact that they don't speaks volumes about the nature of their preparation. Anecdotally, I can report that one of the newly credentialed teachers at the learning progression session in Wisconsin described earlier, lamented that his preparation courses had not included considering what a progression of learning might look like in a domain, or developing skills in formative assessment to analyze how learning was moving forward. We need to have teachers leaving their initial preparation programs knowing more than they do about learning.

Similarly, too many professional development programs fall into the category of 'tips for teachers' rather than extending knowledge about learning develops in a domain that can be applied and enriched as teachers acquire experience teaching. The emphasis in recent years across the country on early literacy to make sure children are competent readers by the end of third grade, combined with the strong research base in this area, has resulted in significant increases in teachers' knowledge of how early reading develops. More sustained efforts of this kind in later reading and other content areas would go a long way to shoring up teachers' knowledge base.

At the risk of running into a 'chicken and egg' problem, it seems to me that better preparation and professional development about the structure of learning, in combination with opportunities for teachers to come together with others (e.g., content experts, researchers) to develop learning progressions, could enhance both teacher knowledge and the learning progressions themselves.

Realizing learning progressions in all domains is no small task. Ultimately, it is an undertaking that will have to involve the combined effort of researchers, teacher educators, administrators at the state, district and school levels, teachers, and policy makers. However given what we know about the benefits of formative assessment to students learning and the importance of learning progressions to the practice of formative assessment, we need to act now. We cannot wait for the research community to catch up, for standards to be rethought, and for teacher preparation and professional development programs to be changed. At the very least, support, encouragement and guidance need to be provided to districts, schools and teachers about the necessity of professional groups coming together to map out what a reasonable and effective progression of learning in a domain might look like. Of course, this represents a considerable investment in time and resources. But the potential benefits to teacher understanding of how learning progresses in a domain, how ideas within the domain are inter-related, and how instructional planning and formative assessment can be mapped onto the progression are surely worth the investment. Our students deserve no less.

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APPENDIX

Examples of Learning Progressions

A Counting and Ordering Progress Map

(Australian mathematics profile)

From Curriculum Corporation. (1994). *Mathematics Profile for Australian Schools.* Carlton: Curriculum Corporation. In Masters, G., & Forster, M. (1997). *Developmental Assessment*. Victoria, AU: The Australian Council for Educational Research Ltd.

5

Uses unitary ratios of the form 1 art to X parts
(The ratio of cordial to water was 1 to 4)
Understands that common fractions are used to describe ratios of parts to whole
(2 in 5 students ride to school. In school of 550, 220 ride bikes)
Uses percentages to make straightforward comparisons
(26 balls from 50 tries is 52%; 24 from 40 tries is 60%, so that is better)
Uses common equivalences between decimals, fractions and percentages
('One-third off is better than 30% discount')
Uses whole number powers and square roots in describing things
(finds length of side of square of area 225 sq cm as square root of 225)

4

Counts in decimal fraction amounts ('0.3, 0.6, 0.9, 1.2, …')
Compares and orders decimal fractions
(orders given weight data for babies to two decimal places)
Uses place value to explain the order of decimal fractions
(which library book comes first 65.6 or 65.126? why?)
Reads scales calibrated in multiples of ten
(reads 3.97 on a tape measure marked in hundredths, labeled in tenths)
Uses the symbols =, < and > to order numbers and make comparisons
(6.75 < 6.9; 5 x $6 > 5 x $5.95)
Compares and orders fractions (one-quarter is less than three-eights)

3

Counts in common fractional amounts
('two and one-third, two and two-thirds, three, three and one-third')
Uses decimal notation to two places
(uses 1.25m for m 25cm; $3.05 for three $1 coins and one 5c coin; 1.75kg for 1750g)
Regroups money to fewest possible notes and coins
(11x $5 + 17x $2 + 8 x $1 regrouped as 1x $50 + 2x $20 + $5 +$2)
Uses materials and diagrams to represent fractional amounts
(folds tape into five equal parts, shades 3 parts to show 3/5)
Expresses generalizations about fractional numbers symbolically
('1 quarter = 2 eighths' and '1/4 = 2/8')

2

Counts forwards and backwards from any whole number, including skip counting in 2s, 3s, and 10s
Uses place value to distinguish and order whole numbers
(writes four ten dollar notes and three one dollar coins as $43)
Estimates the size of a collection
(up to about 20)
Uses fractional language (one-half, third, quarter, fifth, tenth) appropriately in describing and comparing things
Shows and compares unit fractions
(finds a third of a cup of sugar)
Describes and records simple fractional equivalents
('The left over half pizza was as much as two quarters put together')

1

Counts collections of objects to answer the question 'How many are there?'
Makes or draws collections of a given size
(responds correctly to 'Give me 6 bears')
Makes sensible estimates of the size of small collections up to 10
(for 7 buttons, 2 or 15 would not be a sensible estimate, but 5 would be)
Skip counts in 2s or 3s using a number line, hundred chart, or mental counting
('2, 4, 6 …')
Uses numbers to decide which is bigger, smaller, same size
(if he has 7 mice at home and I have 5, then he has more)
Uses the terms first, second, third ('I finished my lunch second')

A Progression of Attainment in History

(U.K. National Curriculum)

From Qualifications and Curriculum Authority. (2007). *Attainment Targets for History*. Retrieved July 5th, 2007 from http://www.nc.uk.net/webdav/harmonise?Page/@id=6001&Session/@id=D_rDeVtq54ioMIzavOn88E&POS[@stateId_eq_main]/@id=3276&POS[@stateId_eq_at]/@id=3251

Level 1

Pupils recognize the distinction between present and past in their own and other people's lives. They show their emerging sense of chronology by placing a few events and objects in order, and by using everyday terms about the passing of time. They know and recount episodes from stories about the past. They find answers to some simple questions about the past from sources of information.

Level 2

Pupils show their developing sense of chronology by using terms concerned with the passing of time, by placing events and objects in order, and by recognizing that their own lives are different from the lives of people in the past. They show knowledge and understanding of aspects of the past beyond living memory, and of some of the main events and people they have studied. They are beginning to recognize that there are reasons why people in the past acted as they did. They are beginning to identify some of the different ways in which the past is represented. They observe or handle sources of information to answer questions about the past on the basis of simple observations.

Level 3

Pupils show their developing understanding of chronology by their realization that the past can be divided into different periods of time, their recognition of some of the similarities and differences between these periods, and their use of dates and terms. They show knowledge and understanding of some of the main events, people and changes studied. They are beginning to give a few reasons for, and results of, the main events and changes. They identify some of the different ways in which the past is represented. They use sources of information in ways that go beyond simple observations to answer questions about the past.

Level 4

Pupils show factual knowledge and understanding of aspects of the history of Britain and the wider world. They use this to describe characteristic features of past societies and periods, and to identify changes within and across different periods. They describe some of the main events, people and changes. They give some reasons for, and results of, the main events and changes. They show some understanding that aspects of the past have been represented and interpreted in different ways. They are beginning to select and combine information from different sources. They are beginning to produce structured work, making appropriate use of dates and terms.

Level 5

Pupils show increasing depth of factual knowledge and understanding of aspects of the history of Britain and the wider world. They use this to describe features of past societies and periods and to begin to make links between them. They describe events, people and changes. They describe and make links between events and changes and give reasons for, and results of, these events and changes. They know that some events, people and changes have been interpreted in different ways and suggest possible reasons for this. Using their knowledge and understanding, pupils are beginning to evaluate sources of information and identify those that are useful for particular tasks. They select and organise information to produce structured work, making appropriate use of dates and terms.

Level 6

Pupils use their factual knowledge and understanding of the history of Britain and the wider world to describe past societies and periods, and to make links between features within and across different periods. They examine and explain the reasons for, and results of, events and changes. Pupils describe, and begin to analyze, why there are different historical interpretations of events, people and changes. Using their knowledge and understanding, they identify and evaluate sources of information, which they use critically to reach and support conclusions. They select, organize and deploy relevant information to produce structured work, making appropriate use of dates and terms.

Level 7

Pupils make links between their factual knowledge and understanding of the history of Britain and the wider world. They use these links to analyze relationships between features of a particular period or society, and to analyze reasons for, and results of, events and changes. They explain how and why different historical interpretations have been produced. Pupils show some independence in following lines of enquiry, using their knowledge and understanding to identify, evaluate and use sources of information critically. They sometimes reach substantiated conclusions independently. They select, organize and use relevant information to produce well-structured narratives, descriptions and explanations, making appropriate use of dates and terms.

Level 8

Pupils use their factual knowledge and understanding of the history of Britain and the wider world to analyze the relationships between events, people and changes, and between the features of different past societies and cultures. Their explanations of reasons for, and results of, events and changes are set in a wider historical context. They analyze and explain different historical interpretations and are beginning to evaluate them. Drawing on their historical knowledge and understanding, they use sources of information critically, carry out historical enquiries, and reach substantiated conclusions independently. They select, organize and deploy relevant information to produce consistently well-structured narratives, descriptions and explanations, making appropriate use of dates and terms.

Exceptional performance

Pupils use their extensive and detailed factual knowledge and understanding of the history of Britain and the wider world to analyze relationships between a wide range of events, people, ideas and changes and between the features of different past societies and cultures. Their explanations and analyses of reasons for, and results of, events and changes, are well substantiated and set in their wider historical context. They analyze links between events and developments that took place in different countries and in different periods. They make balanced judgments based on their understanding of the historical context about the value of different interpretations of historical events and developments. Drawing on their historical knowledge and understanding, they use sources of information critically, carry out historical enquiries, develop, maintain and support an argument and reach and sustain substantiated and balanced conclusions independently. They select, organize and deploy a wide range of relevant information to produce consistently well-structured narratives, descriptions and explanations, making appropriate use of dates and terms.

Stages of Listening Comprehension and Speaking Skills

From Bailey, A.L., & Heritage, M. (2008) Formative Assessment for Literacy, Grades K-6: Building Reading and Academic Language Skills Across the Curriculum. Sage/Corwin Press: Thousand Oaks, CA.

Stage 1

Listening Comprehension

Word Level:

- Comprehend a range of frequently used words (e.g., common vocabulary in the domains of Social Language [SL] and School Navigational Language [SNL])
- Identify and intentionally add a small number of new words to broaden receptive vocabulary in the areas of mortar words and Curriculum Content Language (CCL) (by adding new words) and deepen the lexicon (by adding new meanings and nuances to *known* words)

Sentence Level:

- Use word order conventions to make meaning of syntactically simple sentences (e.g., subject +verb+ object = declarative statement; verb + subject + object = question form; verb + object = imperative form).
- Use high frequency inflectional morphology (plural +*s*) to make meaning of syntactically simple sentences

Discourse Level:

- Begin to build spoken language genre knowledge (organization of language and ideas) by interpreting the meanings of a range of oral discourse contexts (conversations with a peer, short teacher monologues, simple one-step instructions/directions)
- Begin to build printed language genre knowledge by acquiring story grammar knowledge and interpreting the meanings of a range of short, simple texts read aloud by the teacher (storybooks, simple expository texts, poetry, puns)
- Comprehend frequently used idioms, clichés and expressions used in the classroom (e.g., *Once upon a time, The End, Are you sitting nicely?*)

Prior/content Knowledge:

- Begin to connect new information heard to that already learned so that general background and content knowledge grow in both depth and breadth

Speaking Skills

Word Level:

- Produce frequently used words (e.g., common vocabulary in the domains of Social Language [SL] and School Navigational Language [SNL])
- Identify and intentionally use a small number of new words to broaden expressive vocabulary in the areas of common mortar words and simple Curriculum Content Language (CCL) (by using new words) and deepen the lexicon (by using the new meanings and nuances of *known* words)

Sentence Level:

- Produce syntactically simple sentences
- Use high frequency inflectional morphology to produce syntactically simple sentences

Discourse Level:

- Begin to display spoken language genre knowledge by producing discourse on familiar topics in a small range of frequently occurring contexts (short conversations with a peer, short responses to teacher requests, simple requests for clarification of teacher directions)

- Produce frequently used idioms, clichés and expressions found in the classroom, often learned in chunks or unanalyzed strings (e.g., *Once upon a time, Mayago [= May + I + go] to recess?*)
- Use language in service of common social functions (*express needs, command*) and simple/common academic language functions (*describe, label*)

Stage 2

Listening Comprehension

Word Level:

- Comprehend a broader range of frequently used words (e.g., common vocabulary in the domains of SL and SNL)
- Identify and intentionally add an increasingly large number of new words to broaden receptive vocabulary in the areas of mortar words and CCL (by adding new words including the academic synonyms of more commonly used words [e.g., *feline* for *cat*]), synonyms to provide more precision or information [e.g., *replied* and *asked* for *said*] and continue to deepen the lexicon (by adding new meanings, shades of meaning [e.g., *anger* vs. *furious*] and nuances to *known* words)
- Begin to use word analysis skills to aid in comprehension (e.g., use high frequency derivational morphology (e.g., adjective +*ness* = noun) to identify parts of speech or understand new meanings (*un* + adjective and *un* + verb = opposite in meaning to root word)

Sentence Level:

- Expand repertoire of recognizable sentence structures to include frequently used complex syntax (e.g., relative clauses)
- Use less common inflectional morphology to make meaning of syntactically complex sentences (e.g., participial modifiers [verb + *ing*] such as *The boys running were late for their class*)

Discourse Level:

- Continue to build spoken language genre knowledge (organization of language and ideas) by interpreting the meanings of a broader range of oral discourse contexts (dialogues between two peers, longer teacher monologues, two- and three-step instructions/directions)
- Continue to build printed language genre knowledge by interpreting the meanings of broader range of simple texts read aloud by the teacher (storybooks, simple expository texts, poetry, puns)
- Comprehend frequently used idioms, clichés and expressions used in the classroom (e.g., *Give it your best, The more the better*)

Prior/content Knowledge:

- Continue to connect larger amounts of new information heard to that already learned so that general background and content knowledge grow in both depth and breadth

Speaking Skills

Word Level:

- Produce a broader range of frequently used words (e.g., common vocabulary in the domains of SL and SNL)
- Identify and intentionally use an increasingly larger number of new words to broaden expressive vocabulary in the areas of mortar words and simple CCL (by using new words) and continue to deepen the lexicon (by using the new meanings and nuances of *known* words)
- Make new words of differing parts of speech from known words using derivational morphology

Sentence Level:

- Produce greater variety of grammatical structures (e.g., inclusion of adjectival and prepositional phrases)
- Use less common inflectional morphology to produce syntactically more complex sentences

Discourse Level:

- Continue to expanded use of spoken language genre knowledge by producing discourse on familiar topics in a broader range of contexts (conversation with a peer, conversation with a group of peers, production of simple monologues such as personal narratives or a short book report, responses to teacher multi-part requests, requests for clarification of teacher and peer directions)
- Produce frequently used idioms, clichés and expressions found in the classroom
- Use language in service of a wider range of social functions (*command, request*) and increasingly complex academic language functions (*explain, summarize*)

Stage 3

Listening Comprehension

Word Level:

- Comprehend a wide range of common and uncommon words in the domains of SL and SNL
- Continue to identify and intentionally add unfamiliar words to broaden receptive vocabulary in the areas of mortar words and CCL (by adding new words) and deepen the lexicon (by adding new meanings, shades of meaning and nuances to *known* words)
- Make inferences about a speaker's stance towards content from their word choices (e.g., *retorted* for *replied*)
- Continue to use word analysis skills to aid in comprehension (e.g., use rarer derivational morphology (e.g. verb +*ate,* [*fixate*] = new verb meaning; adjective +*ify* [*solidify*] = verb)

Sentence Level:

- Comprehend the full range of simple and complex grammatical structures (e.g., nominalization of verb forms [*to form* vs. *formation*] to increase amount of information contained within a sentence), and increase sentence length (e.g., multiple prepositions in a single sentence)
- Continue to use common and uncommon inflectional morphology to make meaning of syntactically complex sentences

Discourse Level:

- Continue to build spoken language genre knowledge (organization of language and ideas) by interpreting the meanings of a broader range of oral discourse contexts (dialogues between multiple peers, extended teacher monologues, plays/dramas, multi-step instructions/directions)
- Continue to build printed language genre knowledge by interpreting the meanings of broader range of simple and challenging texts read aloud by the teacher (storybooks with familiar and unfamiliar story grammars, works of literature, complex expository texts, primary source texts in content areas such as history, poetry, plays, puns)
- Comprehend frequently used idioms, clichés and expressions used in the classroom (e.g., *Don't beat about the bush, All's well that ends well*)

Prior/content Knowledge:

- Continue to connect complex and large amounts of new information heard to that already learned so that general background and content knowledge grow in both depth and breadth

Speaking Skills

Word Level:

- Produce a wide range of common and uncommon words in the domains of SL and SNL
- Continue to identify and intentionally use a wider range of new words to broaden expressive vocabulary in the areas of uncommon mortar words and low frequency CCL (by using new words) and continue to deepen the lexicon (by using the new meanings and nuances of *known* words)
- Continue to make new words of differing parts of speech from known words using derivational morphology

Sentence Level:

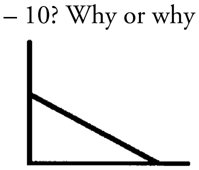
- Produce full range of simple sentences and complex grammatical structures (e.g., relative clauses) and increase sentence length
- Use common and uncommon inflectional morphology to produce syntactically complex sentences

Discourse Level:

- Continue to expanded use of spoken language genre knowledge by producing discourse on familiar and unfamiliar topics in a broader range of contexts (conversation with multiple peers, production of extended monologues, such as personal narratives or book and science reports, responses to teacher multi-part requests, requests for clarification of teacher and peer directions)
- Produce frequently used idioms, clichés and expressions found in the classroom
- Use language in service of a wide range of simple and complex social functions (*command, persuade*) and simple and complex academic language functions (*describe, explain, summarize, hypothesize)*

A Developmental Model for Learning Functions

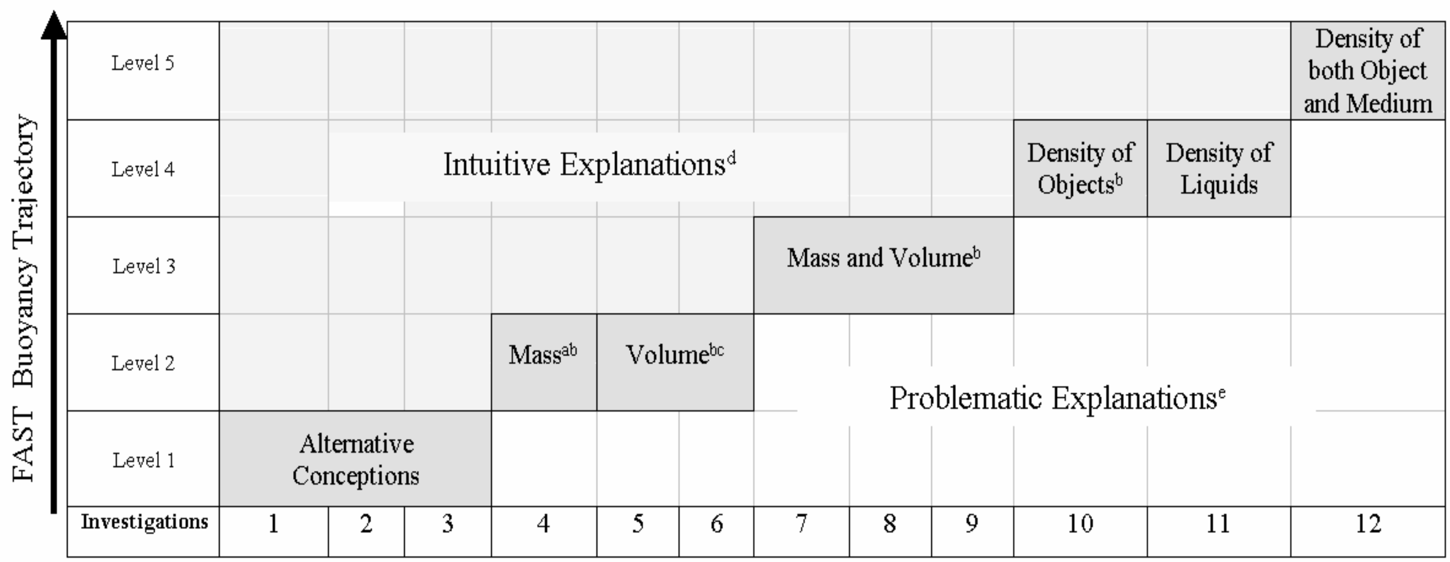
From National Research Council of the National Academies. (2005). How Students Learn: History, Mathematics, and Science in the Classroom. Washington, D.C.: The National Academies Press.

Level	General Description	Example Tasks & Understandings
0	Students have separate numeric and spatial understandings.	
	➢ Initial numeric understanding: Students iteratively compute (e.g., "add 4") *within* a string of positive whole numbers.	Extend the pattern 3, 7, 11, 15, __, __, __.
	➢ Initial spatial understanding: students represent the relative sizes of quantities as bars on a graph and perceive patterns of qualitative changes in amount by a left-to-right visual scan of the graph, but cannot quantify those changes.	Notice in a bar graph of yearly population figures that each bar is taller than the previous bar.
1	Spatial and numeric understandings are elaborated and integrated, forming a central conceptual structure.	
	➢ Elaboration of numeric understanding: --Iteratively apply a single operation to, rather than within, a string of numbers to generate a second string of numbers. --Construct an algebraic expression for this repeated operation.	Multiply each number in the sequence: 0, 1, 2, . . . by 2 to get a set of pairs: 0-0, 1-2, 2-4, . . .
	➢ Elaboration of spatial understanding: --Use continuous quantities along the horizontal axis.	Generalize the pattern and express it as y = 2x.
	--Perceive emergent properties, such as linear or increasing, in the shape of the line drawn between points.	Notice that a graph of daily plant growth must leave spaces for unmeasured Saturday and Sunday values.
	➢ Integration of elaborated understandings: --See the relationship between the differences in the y-column in a table and the size of the step from one point to the next in the associated graph. ➢ Interpret algebraic representations both numerically and spatially.	For every 1 km, a constant "up by" $2 in both the y-column of a table and the y-axis in a graph generates a linear pattern (spatial) with a slope of 2 (numeric). Y= 2x can be read from, or produced in, both a table and a graph.
2	➢ Elaborate initial integrated numeric and spatial understanding to create more sophisticated variations. ➢ Integrate understanding of y = x and y = x + b to form a mental structure for linear functions. ➢ Integrate rational numbers and negative integers. ➢ Form mental structures for other families of functions, such as y = xn + b.	Look at the function below. Could it represent y = x – 10? Why or why not?  If you think it could not, sketch what you think it looks like.

3	- Integrate variant (e.g., linear and nonlinear) structures developed at level 2 to create higher-order structures for understanding more complex functions, such as polynomials and exponential and reciprocal functions. - Elaborate understanding of graphs and negative integers to differentiate the four quadrants of the Cartesian plane. - Understanding the relationship of these quadrants to each other.	At what point would the function $y = 10x - x^2$ cross the x-axis? Please show all of your work.

FAST Buoyancy Trajectory

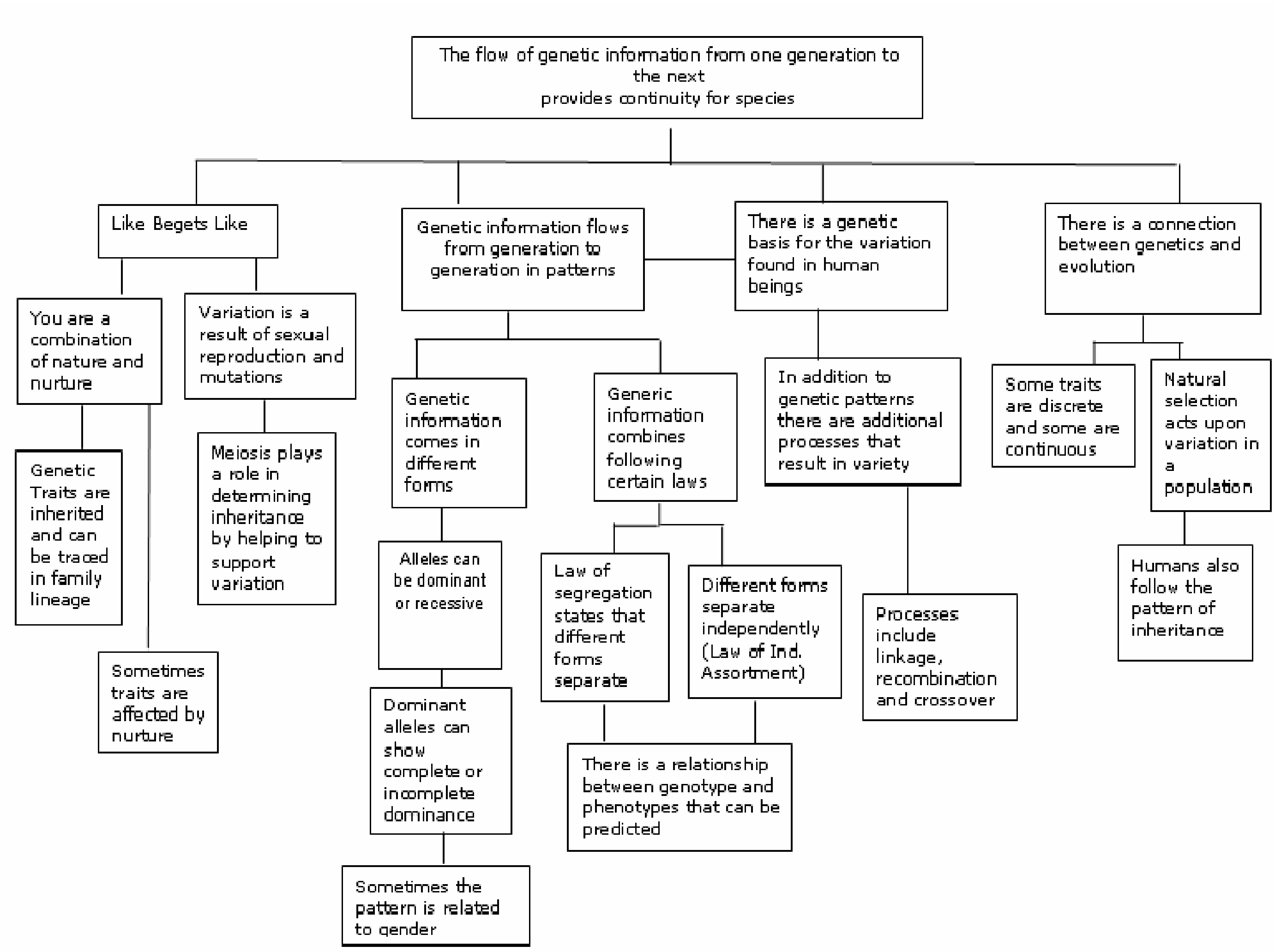
From Shavelson, R., Stanford Educational Assessment Laboratory (SEAL) and Curriculum Research & Development Group (CRDG). (2005). *Embedding assessments in the FAST curriculum: The romance between curriculum and assessment*. Final Report.



[a] Hold volume constant
[b] Hold liquid (water) constant
[c] Hold mass constant
[d] Intuitive Explanations are those that are a student's deeper understanding about WTSF but may not have the appropriate vocabulary.
[e] Problematic Explanations are those where a student uses the correct words (e.g., density), but components of the explanations reflect a more naïve understanding about WTSF.

Graphic Organizer for Conceptual Flow

From DiRanna, K. & Topps, J. (2005). *What's the Big Idea?* San Francisco: K-12 Alliance/ WestEd.



Learning Progression for Matter

From Committee on Science Learning, Kindergarten through Eighth Grade, Duschl, R. A., Schweingruber, H. A., Shouse, A.W. (Eds.). Board of Science Education, Center for Education, & Behavioral and Social Sciences and Education. (2007). *Taking Science to School: Learning and Teaching Science in Grades K-8,* Washington, D.C.: The National Academies Press.

Questions & Big Ideas[a]	Components of Big Ideas	K-2 Elaboration of Big Ideas
1. What are things made of and how can we explain their properties? **1. Objects[b] are constituted of matter, which exists as many different material kinds. Objects have properties that can be measured and depend on the amount of matter and on the material kinds they are made of.**	**Existence of matter and diversity of material kinds.**	Objects are made of specific materials. There are different kinds of materials. The same kind of object can be made of different materials.
	Objects have properties that can be measured and explained. Three important properties are mass, weight, and volume.	Objects have certain properties—weight, length, area, and volume—that can be described, compared and measured. (Only preliminary exploration and construction of volume measurement at this time.)
	Material kinds have characteristic properties that can be measured and explained.	The properties of materials can be described and classified. (Only readily observable properties, such as color, hardness, flexibility, are investigated at this time.)

3-5 Elaboration of Big Ideas	6-8 Elaboration of Big Ideas
Objects are made of matter that takes up space and has weight. Solids, liquids, and air are forms of matter and share these general properties. There can be invisible pieces of matter (too small to see). There are many different kinds of materials.	Matter has mass, volume, and weight (in a gravitational field), and exists in three general phases, solids, liquids, and gas. Materials can be elements, compounds, or mixtures. **1AM. All matter is made of a limited number of different kinds of atoms, which are commonly bonded together in molecules and networks. Each atom takes up space, has mass, and is in constant motion.**
Weight is an additive property of objects that can be measured (e.g., the weight of an object is the sum of the weight of its parts). Volume is an additive property of an object that can be measured. The weight of an object is a function of its volume and the material it is made of.	Mass is a measure of amount of matter and is constant across location; weight is a force, proportional to mass and varies with gravitational field. Solids, liquids, and gases have different properties. **1AM. The mass and weight of an object is explained by the masses and weights of its atoms. The different motions and interactions of atoms in solids, liquids, and gases help explain their different properties.**
Materials have characteristic properties that are independent of the size of the sample. (Extends knowledge to less obvious properties such as density, flammability, or conductivity at this time.)	Materials have characteristic properties independent of size of sample (extends knowledge to include boiling/freezing points and to elaborate on density). **1AM. The properties of materials are determined by the nature, arrangement, and motion of the molecules that they are made of.**