Discourse as a lens for reframing consideration of learning progressions

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Abstract: Learning progressions – descriptions of increasingly sophisticated ways of thinking about a topic – have generated much interest in the science education community, as a means of bridging the chasm between cognitive science research and methods for supporting and assessing student learning. In order to fulfill this promise, learning progressions must be developed and refined based upon a rigorous process that explores the match between the learning progression and available evidence of student learning and is complicated by the nature of students' thinking. This paper explores the implications of reframing consideration of learning progressions using Gee's notion of discourse. This reframing is posited as a means of making sense of students' use and interpretation of words that have both everyday and scientific meanings and their apparent inconsistency in responding to assessment items. Data collected about students' understandings relative to two learning progressions is used to explore this approach.

Learning progressions – descriptions of increasingly sophisticated ways of thinking about a topic (National Research Council [NRC], 2007) – have generated much interest in the science education community. The National Science Foundation (NSF) has issued special calls for projects focused on learning progressions (NSF, 2005, 2006, 2009); the National Research Council has advocated for their use to inform science curricula (NRC, 2007) and assessments (NRC, 2006); and the National Assessment of Educational Progress (NAEP) science framework called for the inclusion of learning-progression-based items (National Assessment Governing Board, 2008). Learning progressions have been promoted as solutions to wide range of current educational issues, including a lack of curricular coherence (Gotwals & Songer, 2008), the developmental inappropriateness of current curricula (Stevens, Shin, Delgado, Krajcik, & Pellegrino, 2007), misalignment between instruction and assessment (Black & Wilson, 2007), and weaknesses in support for valued teaching practices (Alonzo, 2009; Furtak, 2009). Learning progressions are viewed as a means of bridging the chasm between cognitive science research and methods for supporting and assessing student learning.

In order to fulfill this promise, learning progressions must be developed based upon existing research and refined based upon a rigorous validation process. The central question guiding this work is the extent to which the learning progression (as a hypothesis about student learning) matches available evidence. This evidence necessarily relies upon methods for eliciting and interpreting student responses relative to the learning progression. Thus, the iterative process of developing and refining a learning progression must involve simultaneous consideration of both student learning and the means by which that learning is assessed. Both the learning progression and its associated assessment items are influenced by assumptions that are made about what is progressing and the goal of learning.

This paper explores an alternative framing of these assumptions, as a means of addressing two current challenges in work to describe and assess student learning through the use of learning progressions. The paper first provides an overview of these challenges. Second, the paper describes an alternative framing – a different way of considering what is progressing – drawing upon Gee's (1991) notion of discourse. This framing is then applied to consider evidence of student learning. The paper concludes with a discussion of implications for future work on learning progressions.

Throughout this paper, two learning progressions are used to illustrate these ideas. The first was designed to describe the learning that might take place during students' first formal study of *Force & Motion* (*FM*; Alonzo & Steedle, 2009), typically in a middle or high school physical science course. It focuses upon students' ability to make predictions about situations involving force and/or motion: predicting the force(s), given information about an object's motion, and vice versa. The second learning progression describes elementary school students' learning about *Plant Nutrition* (*PN*; Alonzo, Benus, Bennett, & Pinney, 2009). It is comprised of three "progress variables" (Wilson, 2005): *Food for Plants*, *Energy for Plants*, and *Plants as Producers*. The discussion in this paper is limited to the first two progress variables, which pertain to students' explanations surrounding the source of plants' food and energy, respectively.

Two Challenges in Current Work on Learning Progressions

Work to develop learning progressions (and associated assessment items) must grapple with the nature of student thinking. Prior work (Alonzo & Steedle, 2009) explored two characteristics of students' thinking that pose challenges to efforts to describe and assess their learning. Each of these challenges will be briefly described here and illustrated with examples from the two learning progressions.

Students' Definitions for Words with Scientific and Everyday Meanings

In many areas of the science curriculum, students encounter words that have both "scientific" and "everyday" meanings. For example, the word "force" has a variety of everyday meanings (Halloun & Hestenes, 1985) across a range of different contexts. A sports fan might consider ways in which this word is used as a verb – for example, forcing a double play [in baseball], a game four [in a playoff situation], or a turnover [in basketball or football] – and as a noun, referring to a player as "a force" [such as a defensive lineman in football]. These examples might lead one to conclude that force has a meaning like "making something happen" (or stopping something from happening), a much broader definition than that of a physicist. Ioannides & Vosniadou (2001) explored the ways in which children from 4 to 15 years of age used the word "force". They identified four well-defined, internally consistent meanings for this word and found that students' use of these definitions varies with age. Thus, it seems likely that students' ideas about the word "force" change along with their ideas about the content of the *FM* learning progression: the relationship between (the scientist's definition of) force and motion.

Revisions to the *FM* learning progression (Alonzo & Steedle, 2009) included consideration of the way in which students' definitions for the word "force" were treated. Students in the target population were expected to hold an "acquired force" (Ioannides & Vosniadou, 2001, p. 26) or "impetus" view of force (Buridan, as quoted in Halloun & Hestenes, 1985, p. 1057): the idea that moving objects have some internal property, imparted to them by a push or a pull. Typical physics textbooks (e.g., Hewitt, 1997) introduce a scientific definition for force and then assume students will use that definition to make sense of subsequent discussion of the relationship between force and motion. Similarly, initial versions of the learning progression first addressed students' definitions for the word force, such that a lower level (Level X on the left side of Figure 1) was reserved for students who hold an impetus view of force. Higher levels of the learning progression (Levels X+1 and X+2 on the left side of Figure 1) described increasingly sophisticated ideas about the relationship between force and motion, assuming that students at those higher levels hold a scientific view of "force".

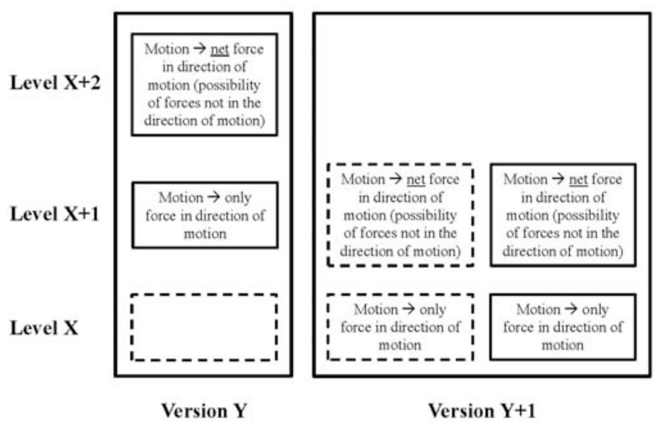

Figure 1. Revisions to the *FM* learning progression, reflecting students' definitions for the word "force". Dashed boxes represent an "impetus" view of force: solid boxes represent a scientific view of force.

Perhaps not surprisingly, interview data revealed that students with an impetus view of force could have different ideas about the relationship between force and motion (Alonzo & Steedle, 2009). For example, when asked to identify the forces acting upon a ball thrown up into the air, students might say that only the throwing force is acting on the ball or that both the throwing force *and* gravity are acting on the ball. The first response is consistent with the view that the only force acting on an object is one in the direction of its motion. The second response is slightly more sophisticated, recognizing the importance of *net* force and the possibility of forces acting on an object that are not in the direction of its motion. Both of these ideas about the relationship between force and motion could also be held by students with more scientific views of the word "force". Thus, as shown on the right side of Figure 1, the learning progression was revised to reflect the possibility of students with two different views of "force" making progress in thinking about the relationship between force and motion, such that students' ideas about "force" and their use and interpretation of this word were treated as two separately progressing entities.

Work on the second learning progression was similarly complicated by students' definitions for words such as "food" and "energy". A review of the literature indicated that students often use these words interchangeably (Leach, Driver, Scott, & Wood-Robinson, 1996) to describe things that are necessary for plants to be healthy. Students who do differentiate "food" and "energy" tend to equate food with things that are "eatable" (Wood-Robinson, 1991; Simpson & Arnold, 1982). Initial data collection surrounding this learning progression elicited evidence of students' definitions for these words, along with evidence of their thinking about plant nutrition (Alonzo et al., 2009). Once again, it appeared that students could make progress with respect to underlying ideas about *Food for Plants* and *Energy for Plants*, while holding a range of different definitions for words such as “food” and “energy”. The work reported in this paper was motivated by an interest in this central problem: the way in which students’ definitions for words (particularly those with both everyday and scientific meanings) impact their learning and expression of scientific ideas.

Apparent Inconsistency of Students’ Thinking

In physics, students’ inconsistency in approaching problems addressing the same underlying principles is well-documented. Chi, Feltovich, and Glaser (1981) demonstrated that a key characteristic differentiating between novices and experts is the way in which they categorize physics problems, with experts viewing problems in terms of underlying principles and novices attending to surface features. Halloun and Hestenes (1985) and Finegold and Gorsky (1991) identified frameworks that college-level students used to reason about motion and force, respectively; however, students did not apply these frameworks consistently across different problem situations.

Reinforcing these findings from the literature, inconsistencies were observed in student responses elicited to explore the *FM* learning progression (Alonzo & Steedle, 2009). For example, a student might describe the forces acting on a stationary object (such as a book on a table), by explaining that “gravity is always acting.” Yet this same student might respond that only a throwing force is acting on a ball tossed into the air, rejecting the notion that gravity is acting on the moving ball. Reliabilities for sets of items assessing understanding with respect to the learning progression were all moderate. In addition, a relatively low percentage (59%) of student responses were at the same level across pairs of items that asked essentially the same question in two different contexts. Similarly, in interviews designed to inform revision of the *PN* learning progression (Alonzo et al., 2009), inconsistencies were observed in the way in which students discussed the source of food for plants. At the beginning of the interviews, students were asked to describe the different parts of a plant and to explain what each part did “to help the plant live and grow.” Many students began by explaining that the roots take in food for the plant. Yet later in the interview, these same students might express the idea that plants “make” or “produce” their own food.

Thus, listening to students discuss a set of force and motion problems or talk about “food for plants”, it can be easy to conclude that students’ thinking simply doesn’t make sense. Although the work described in this paper was not undertaken to address this puzzle, as will be discussed below, attempts to make sense of students’ use of language had the unexpected, but fruitful, side effect of also suggesting an alternative interpretation for the apparent inconsistency of students’ thinking.

Reframing Thinking about Learning Progressions in Terms of Discourse

Gee (1991) defines discourse as “a socially accepted association among ways of using language, of thinking, and of acting that can be used to identify oneself as a member of a socially meaningful group or ‘social network’” (p. 3). Elizabeth Moje and colleagues (2004) have explored the implications of this perspective for literacy and content instruction in science classrooms; this paper explores implications for describing and assessing student learning via learning progressions.

Returning to a consideration of everyday meanings for the word force, it becomes evident that these definitions, while inconsistent with a scientist’s definition, are completely consistent with one’s everyday experiences with force and motion. In everyday experience, forces are required to keep objects moving. A force is, indeed, required to make something happen (in this case, the motion of an object). One might conceptualize the whole “package” of one’s ideas, experiences, and ways of talking as comprising an “everyday discourse” with respect to force and motion. We know a lot about words such as “force”, “food”, and “energy” by virtue of the way in which we use them to talk about experiences in our everyday lives. Those definitions do not exist in isolation; rather, they are a part of how we “are in” and interact with the world and, thus, inform the way in which we think about related ideas (such as the relationship between force and motion or plant nutrition). While these ideas are perhaps not a central part of our identities, the particular experiences we have in the world – by virtue of being, for example, a sports fan – do influence our thinking about words that have both everyday and scientific meanings and, thus, are tied up with how we make sense of the world.

This “everyday discourse” can be contrasted with a “scientific discourse”.[1] The latter includes the use of words consistent with their scientific definitions, as well as the application of a set of scientific ideas derived from those definitions to very specific sorts of situations. In many cases, this means accepting a narrower view of words and ideas than those in one’s everyday experience. For example, a physicist would not say that forces make “something” happen. He/she would use force only to apply to case in which “something” refers to a change in motion (speed and/or direction). The scientific discourse also requires – to a certain extent, at least in physics – that one reside in a fairly idealized world: one in which friction and air resistance are usually ignored.

Taking a discourse perspective recasts what is progressing in a learning progression in terms of a transition between “everyday” and “scientific” discourses. In their current forms, the *FM* and *PN* learning progressions describe the evolution of students' thinking about a scientific topic. Students' definitions for relevant words, such as force, food, or energy, are treated as existing separately from their understanding of the scientific topic and as a challenge to accessing the real focus of the learning progression. Taking a discourse perspective puts students' definitions and ideas back together again. This reframing also permits a reinterpretation of students' seemingly inconsistent responses as struggles to reconcile their everyday and scientific discourses. Sometimes there may not be a conflict between these two discourses. However, where everyday and scientific discourses yield different ways of interpreting and reasoning about a given question, students must choose how they will consider the question being asked. Subtle aspects of the situation – such as the context in which questions are being asked, the particular problem context involved in a given question, and even particular wording of a question – might influence the extent to which students draw upon their everyday and scientific discourses in making sense of the situation.

Reconsidering Evidence of Student Learning

In this section, data collected with respect to the *FM* and *PN* learning progressions are reconsidered in light of the discussion above, in order to answer the research question, "Does a discourse lens help to interpret students' responses with respect to the two learning progressions?" This is intended as a "proof of concept" exploration, as the data were not collected specifically to test the ideas above. Rather, the intent is to explore the fruitfulness of this reframing, in order to inform future data collection that might more directly evaluate these ideas.

Evidence with Respect to the *FM* Learning Progression

The data considered in this section was collected as part of two separate studies, both conducted in the Midwestern United States. Study 1 involved students from a middle class rural high school who answered questions about force and motion directly following a unit on this topic in their physical science classes. Data included 58 students' responses to ordered multiple choice (OMC; Briggs, Alonzo, Schwab, & Wilson, 2006) items. Study 2 involved 1088 students from six high schools, representing a mix of rural and suburban communities. By virtue of their course enrollment, students were expected to have learned about force and motion concepts (either in their current science course or one taken in a previous year). Data included students' responses to a set of OMC force and motion items, plus one question that asked students to indicate whether they had learned about the content of those items before.

The source of students' reasoning about the OMC items was not evident in their responses. However, one might hypothesize that students who have access to the scientific discourse are more likely to reason using that discourse in situations further removed from their everyday experiences. The available data permits a small exploration of this hypothesis. In particular, the set of 16 items presented to students in both Study 1 and Study 2 include three pairs of items in which an almost identical question is asked in a familiar and an unfamiliar context. Questions A and B ask students to describe the motion of an object, first under the influence of a constant force and then once that force is no longer being applied, respectively. These questions are asked both in the relatively familiar context of pushing a car (albeit across a frictionless surface) and the less familiar situation of a rocket traveling in outer space. Question C asks students to describe the forces acting upon a stationary object, both a boulder resting upon the ground (familiar context) and a mysterious blob suspended in the air in a scientific laboratory (unfamiliar context). Analysis of responses to these six questions involved the 58 students from Study 1 and 798 students from Study 2 (those who indicated that they had learned about force and motion concepts before). Students who had not studied force and motion were excluded, as these students may not have access to the scientific discourse and, thus, would not be expected to exhibit variation in the discourse used to reason about the different problem contexts.

Table 1 shows the percentage of students in each study choosing the option corresponding to the highest learning progression level (as an indicator of the use of scientific discourse) for each item. Shaded cells indicate statistical significance ($p < .05$), using the McNemar test. For all comparisons, students selected the highest learning progression level at a similar or higher rate in the familiar context, as compared to the unfamiliar context. However, these rates were statistically significant for only two pairs of items (Question B in Study 1 and Question C in Study 2). Thus, across the two studies, students who had studied force and motion concepts seemed somewhat more likely to apply scientific discourse to analysis of unfamiliar contexts, lending a small degree of support to the proposed reframing.

Table 1: Percentage of students selecting the highest learning progression level for a given item.

	Study 1 (N=58)		Study 2 (N=798)	
	Familiar Context	Unfamiliar Context	Familiar Context	Unfamiliar Context
Question A	17.2%	22.4%	16.5%	17.3%
Question B	31.0%	53.4%	40.4%	40.2%
Question C	43.1%	53.4%	37.8%	60.0%

Evidence with Respect to the *PN* Learning Progression

In order to inform revisions of the *PN* learning progression, semi-structured interviews were conducted with 30 students (grades 1-6) who attended a suburban elementary school in the Midwestern US. Because of its proximity to a large research university and hospital, the school enrolled many children whose parents were associated with these institutions. The school was located on the edge of town and, thus, some of its students lived on surrounding farmland. A small houseplant was used as a prop during the interviews, and efforts were made to elicit students' ideas about words such as "food" and "energy", as well as their school-based and everyday experiences with plants. However, the richest interview data came from students who spontaneously explained their answers in terms of their own experiences and everyday discourses.

Interviews were labeled with the gender and grade level of the student, as well as the order in which they were conducted. For example, 04-M1 indicates the fourth interview, conducted with a male first grader. All interviews were videotaped, and the videotapes were transcribed prior to analysis. For the purposes of this paper, interview transcripts were coded to identify instances in which students explicitly provided evidence of their everyday or scientific discourses; this evidence included explicit use of the words "food" and "energy" as well as students' discussion of related ideas. Students' examples of how they used words such as "energy" in their everyday lives, descriptions of out-of-school experiences with plants, and explanations for personal experiences that informed their thinking about plants were all considered to be evidence of everyday discourse. Students' discussion of ideas explicitly identified as having been learned in school or from a science text were considered to represent their scientific discourse. The surrounding interview transcript was then examined for ways in which students' ideas about plants' sources of food and energy may have been influenced by these two types of discourse. Themes emerged with respect to each of the two progress variables and are illustrated with examples from the interview transcripts.

Food for Plants

Consistent with findings from other research (e.g., Cañal, 1999), the students in this sample often expressed the view that plants manufacture their own food along with the view that plants take in food from the environment. Some students expressed each idea separately, at different points in the interview, while other students stated that plants get food both from sources. Although the latter position is represented in the current version of the *Food for Plants* progress variable, a student who exhibits the former type of response to the interview questions appears to be at one level of the progress variable at some times and at a completely different level at other times. Such a student poses challenges to current conceptualizations of learning progressions, which assume that a given student will hold a consistent set of ideas that can be used to diagnose his/her level. However, since each view about the source of food for plants is consistent with a different discourse, students' thinking may be reinterpreted as struggles to reconcile two different ways of thinking and talking about food for plants.

Although most students did not explicitly address the source of their ideas about plants manufacturing their own food, this is unlikely to be a part of most students' everyday experiences and, thus, may be interpreted as representing a scientific discourse. For example, a second grade boy's interview (20-M2) included the following statement about the role of the sun in plants' growth: "I think plants use the sun to make their food… I think in the photosynthesis they do that." Later in the interview, he explained that he had read about photosynthesis in a science book. Through their school science experiences, many students in the interview sample had developed a discourse surrounding seeds and their source of food. For example, a third grade girl (02-F3) explained that she had learned in school that "the seed doesn't need food 'cause they have already food… they have food in their shell."

Many of the same students also had everyday discourses surrounding food and, in particular, plants' source for food. Consistent with Roth's (1991) interpretation of student thinking, some students brought in ideas about human nutrition to explain their ideas about plant nutrition. For example, a third grade girl (17-F3) said, "We grow because we eat healthy food… Like, if we ate candy bars, like, every single day, like ten a day. We would get really, really sick. And we wouldn't, like, be very healthy. And we wouldn't grow as well." She went on to explain that it wouldn't be healthy for plants to take in "a kind of bad soil that's really sugary." Two students (04-M1 and 21-M5) discussed food for plants in terms of experiences with Venus flytraps, which "eat bugs" that they fed to the plants. The first grade boy (04-M1) had difficulty reasoning about food for regular plants, which he recognized did not eat bugs. Most students' out-of-school experiences with plants were situated in a discourse about plants needing things from people and those things constituting food for plants. For example, a third grade girl (02-F3) described in vivid detail her experiences planting trees on her family's farm over the weekend preceding the interview. She had provided the new trees with both "special food" and water (that "carries food in it"). For other students, including another third grade girl (17-F3), the water itself, as something that was required for life, was also food for the plant. She explained that this saying, "'Cause just like people, they need water to survive." For these students, ideas about human nutrition and human interactions with plants (part of their everyday discourse) fairly straightforwardly informed their ideas about plants.

However, the interviews also offered numerous examples of students who appeared to be using different discourses to make sense of the different questions being asked about food for plants. Many of these students appeared to be struggling to reconcile everyday and scientific discourses. Often, student's scientific discourses did not appear to be robust enough to support detailed reasoning about food for plants. Students seemed to have learned a phrase, such as "plants produce their own food" without details about this process. For example, consider the following segment of interview transcript involving a second grade girl (02-F3):

> 02-F3: [Plants] produce the food.
> Interviewer: Do they use any of the food that they produce?
> 02-F3: What do you mean "they produce"?

The idea of plants producing food seems to have limited meaning to the girl. When her ideas about plants' source of food was probed further in the interview, she seems to have combined ideas about plants taking in food and water (provided by people such as herself) to explain that "The water actually goes to the leaves and the leaves can turn it into food. The leaves could have to make the food out of the soil. The water too." Thus, like many students in the sample, she appears to be reconciling her ideas about plants taking in food and water from the environment (to serve as food) with the idea of plants making their own food.

Energy for Plants

Perhaps not surprisingly, students in the interview sample seemed to have limited access to a scientific discourse surrounding energy. However, they provided many examples of their everyday discourse about energy, allowing examination of the way in which this discourse informed their thinking about energy for plants. Students expressed three main ideas about energy – associating energy with movement, electricity, and the sun – all of which were contained in a segment of an interview with a third grade girl (17-F3):

> Well, energy can come from the sun. Energy is, like, a thing that makes you move. Like, if you're really hyper you can have a lot of energy so you can, like, run around a lot. And energy is, like, batteries have energy in them. And electronics. And, energy from the sun also, like, it has vitamins in it. Kind of. So that, like, when it comes down and hits stuff, it makes it healthy.

Thus, consistent with other research (e.g., Nicholls & Ogborn, 1993), students' everyday discourses about energy often involved movement. These students then tried to make sense of energy for plants in terms of this way of thinking about energy. One second grade girl (14-F2) used her ideas about energy ("Like if you run then you kinda get your energy") to conclude that plants would not have energy "unless someone moved it… If someone picked it up and ran with it, maybe it would have energy." A third grade girl (02-F3) explained that plants have energy "not in order to, from here, this plant to move from here to here. Not that type of energy." She later explained that plants needed energy so "the roots can move around to get the food." Thus, she associated plant's energy with motion of its roots. Other students invoked the movement of substances such as food or water to explain how plants use energy. For example, a fourth grade boy (01-M4) explained that plants might use energy "to get the food to the, everywhere it needs to go… Like the leaves."

Students also drew upon their own experiences in thinking about where plants might get energy. For example, the third grade student above (17-F3), like other students in the sample, believed that the sun was a source of vitamins for both people and plants. She also explained that people get energy from healthy food:

> You get your energy from food. Like, carrots, and celery, and, um sugar gives you energy, but it's a bad kind of, well, it's not really bad, but it just, like, doesn't last very long. So, it's not, like, true energy. But, food that has, like, vitamins in it, I think it has, like, the vitamins and the calcium combined, that gives you energy. So, that, like, if you eat a bunch of carrots, and celery, and vegetables, and fruits, that you'll be really energetic because then you have a lot of… you have a lot of nutrients in you. And so then you're like, really healthy."

She went on to explain that plants needed healthy food and vitamins for their energy as well. A second grade girl (05-F2) explained her knowledge of energy in terms of her mom's position as a track coach:

> [Energy] means exercise and fit, so you can stay in shape and stuff. 'Cause I know all this stuff because… my mom's a track coach so she teaches about 85 people in this team. And she has to tell them about keep fit and stay in shape and stuff.

Later in the interview, she explained that she knew plants get energy from water (as well as sunlight) "'cause we get energy from water, 'cause yesterday I ran a mile. And I needed a lot of water."

The students in the interview sample had not had many formal learning opportunities surrounding the concept of "energy", but they drew upon rich everyday discourses to make sense of energy for plants. This led them to make connections between plants and humans, some of which are consistent with a scientific discourse about energy for plants and some of which are not. Thus, we might predict that their subsequent learning about plants will involve some struggle to identify aspects of their everyday discourse that are and are not consistent with scientific discourse.

Conclusions & Implications

The reframing presented in this paper takes as an underlying assumption that science learning involves students' reconciling their everyday and scientific discourses and that this process will occur whether or not it is acknowledged in efforts to describe, support, and assess student learning. While students' prior conceptions are commonly acknowledged, this perspective takes a broader view of students' ideas, explicitly including ways in which students draw upon both language and experiences to make sense of phenomena. The preceding sections of this paper explored whether this assumption was reflected in existing data surrounding students' understanding of force and motion and food and energy for plants. Although the data was not collected to explicitly address students' everyday discourses, the available evidence seems to support the interpretation that students draw upon this discourse in making sense of questions about scientific topics, often in conjunction with the scientific discourse. This interpretation helps to make sense of both students' use of language and their apparent inconsistency in responding to assessment items and interview questions.

This perspective has several implications for the design of learning progressions. First, treating students' ideas about and language surrounding scientific topics as both falling under the "umbrella" of discourse helps to address the perhaps false dichotomy between ideas and language. This helps to resolve the problem of how to "treat" students' definitions for words as part of a learning progression. Second, this approach means reframing what is progressing in a learning progression from ideas about a scientific topic to changes in the extent to which students draw upon scientific discourse in reasoning about scientific questions. It is important to recognize that this process is not one of replacement, in which students make progress by gradually discarding their everyday discourses in favor of a scientific one. Instead, one might view this as a process by which students gradually understand their everyday discourses in light of a scientific one: narrowing definitions and ideas where necessary and adding additional interpretations to explain existing experiences. As students make progress with respect to the learning progression, they may draw upon everyday and scientific discourses to varying degrees; part of what is progressing is students' reliance upon scientific discourse in appropriate situations. Thus, in this view, one does not expect students to consistently rely upon scientific discourse to answer all questions and – to both describe and support student learning – a challenge becomes figuring out the circumstances under which students might be more likely to draw upon everyday discourse and to help them to utilize scientific ways of thinking in appropriate circumstances. The reframing proposed in this paper has the potential to help learning progressions to more accurately reflect the nature of students' thinking and, thus, to be more useful tools for describing, assessing, and supporting student learning.

Endnotes

(1) This discussion is not meant to imply that everyday and scientific discourses are fully dichotomous. Scientific discourse emerges from and attempts to explain everyday experiences, and, indeed, one would expect a scientist (or expert student) to have access to both types of discourse and to flexibly draw upon some mixture of the two, depending upon the context. One might view these two types of discourse as two ends of a continuum (where the continuum is shorter or longer, depending upon the degree of similarity between everyday and scientific discourses in a particular area).

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