Abstract: Research has shown that it is uncommon for students to transfer what they learn about science to their other classes, let alone their everyday lives. However, a set of recent studies provides empirical evidence that the expansive framing of learning contexts can foster transfer. In this paper, we further our investigations of the idea that transfer is promoted by the instructional practice of framing learning contexts expansively. We do so by offering a microgenetic analysis of a relatively surprising case of transfer by a student in a high school biology class. In particular, we use her case to evaluate five recently proposed explanations for exactly how expansive framing may foster transfer, and close with additional hypotheses for how transfer may have been supported with this particular student.

Introduction

If students are to be successful and if schooling is to have a significant impact on their lives, it is essential that students regularly transfer what they learn (Renkl, Mandl & Gruber, 1996; Schwartz, Bransford & Sears, 2005). Specifically, this research is based on the premise that it is not just the nature of the particular science content that students learn that matters for transfer, but also how learning and transfer contexts are framed. In this paper, we examine the idea that transfer can be promoted through an expansive framing of learning contexts by conducting a microgenetic analysis of a case of one struggling student in a high school biology class (Maxwell, 2004; Siegler, 2006). First, we explain and describe what we mean by expansive framing, and then briefly present recent studies that provide evidence that framing affects transfer. In the core of this paper, we evaluate how expansive framing may have promoted transfer for this particular student by evaluating five recently proposed explanations for how it may do so (Engle, Lam, Meyer & Nix, in press). We present relatively strong evidence for four out of the five explanations with data that we have collected in this target classroom. Finally, we close by proposing additional explanations for this student’s unexpectedly high rate of transfer that may be less related to the expansive framing of her instruction.

What is Expansive Framing?

Framing is the meta-communicative act of characterizing what is happening and how different people are participating in a given context (Bateson, 1972; Goffman, 1974; Tannen, 1993). For example, a teacher can frame a lesson as a one-time event of learning something that students are unlikely to ever use again, or as beginning to discuss an issue that students are likely to be actively engaging with throughout their lives. Our claim is that the first kind of framing, which we refer to as “bounded,” will tend to discourage students from later transferring what they learn, while the second, which we refer to as “expansive,” will tend to encourage students to transfer what they have learned. This claim is consistent with several prior proposals by situative and sociocultural theorists (Greeno, Smith & Moore, 1993; Laboratory for Comparative Human Cognition, 1983; Pea, 1987) who argue that it is not just the physical aspects of contexts that matter for transfer (Catrambone & Holyoak, 1989; Spencer & Weisberg, 1986), but also how social interactions frame contexts as particular kinds of social realities (Gee & Green, 1998; Searle, 1995).

There are several aspects of learning contexts that can be framed in ways that can affect transfer (see Figure 1). First, a learning setting may be framed in an expansive manner by extending it to include past and future times, different places, and additional participants. In contrast, a bounded framing of a learning setting may constrain it to the present time, place, and just a few participants. Furthermore, in an expansive framing of roles, learners may be positioned as active contributors and authors of their own ideas. In contrast, in a bounded framing of roles, learners may be positioned on the periphery of a learning context, where they are expected to report on the ideas of others.

In the biology class we studied, the teacher exhibited expansive framing of all of these aspects with great frequency (Meyer, Mendelson, Engle & Clark, 2011). With regards to settings, the teacher regularly referenced other times like the beginning of the school year and later in life; other places like college and after-school environments; and other participants like friends, family members, and scientists. For example, during a lesson on cells, the teacher explained the following:
Now all this, all of this cell stuff, is kind of described on its own as the cell theory. And every biology student in the world, okay, maybe not the whole world but [inaudible] learns the cell theory. So whether you're going to be in this class, or you're moving to Texas, or you're going to be going to Berkeley, eventually someday you're gonna walk in, and they're gonna say, "Hey, tell me about the cell theory," so here you go.

Here, the teacher explicitly mentioned times other than the present by saying “eventually someday,” he also referred to places outside of the classroom such as “the world,” “Texas,” and “Berkeley,” and involved other participants by including “biology students” and “they.” This type of expansive framing of settings was frequent in his instruction. Furthermore, with respect to roles, the teacher routinely expected students to author their own ideas, credited students for ideas that they shared with the class, and held them accountable for their contributions. A common activity he had students engage in was a class discussion of double multiple-choice questions that he projected on the board. During these activities, students were asked to individually choose an answer before the class was polled for their choices by a raise of hands. If discrepancies arose from the poll, students were expected to respectfully argue with each other for their answer choices until all students understood why one of the answers was the best choice. While these discussions took place, the teacher would stand quietly to the side unless he believed his input was needed to guide the students’ conversation. Typically, the teacher’s only contributions to the discussion were to ensure that the students directed their conversations at each other and not at him, credit a student for a statement he/she made and ask others to respond to it, and encourage individual students to argue for the answers they chose.

Evidence that Expansive Framing Promotes Transfer

A growing series of studies has empirically investigated connections between the framing of contexts and transfer. Several classroom case studies have provided evidence that transfer may be affected by framing in real-world learning environments (Engle, 2006; Engle Meyer, Clark, White & Mendelson, 2010; Hammer et al., 2005; Mendelson, 2010). Additionally, two experiments have systematically tested one or more aspects of this hypothesis, with results consistent with a causal connection between expansive framing and transfer (Engle, Nguyen & Mendelson, 2011; Hart and Albarracin, 2009).

Five Proposed Hypotheses for How Expansive Framing May Foster Transfer

Although prior research has shown that framing contexts differently can affect transfer, it has not explained how this occurs. In Engle et al. (in press), we proposed five explanations—not mutually exclusive—for how expansive framing may promote transfer:

1) Connecting settings with each other encourages transfer during learning when students expect they will later need to transfer what they are learning and in response may be more likely to prepare for this possibility (e.g., Bereiter, 1995; Brown, 1989).

2) Connecting settings also encourages transfer during potential transfer contexts, when students view prior content as continuing to be relevant and so are reminded of it (e.g., Leander, 2001; Pea, 1987; Ross, 1984).

3) By connecting to prior settings and by positioning students as authors, students are likely to view their own prior knowledge as relevant to current learning, encouraging them to “transfer-in” more of their prior knowledge during learning, as they construct new understandings, which can enhance the quality of learning and therefore transfer (e.g., Bransford, Brown & Cocking, 1999; Schwartz, Bransford & Sears, 2005).
A Somewhat Surprising Case of Transfer
Elaine was a Hispanic 9th grader who qualified for the free and reduced lunch program, and whose parents had a high school level education. Her 8th grade standardized test score in science was not particularly strong (“basic,” as opposed to “proficient” or “advanced”). For the first month of school she often did not attend class consistently nor do her biology homework, earning a D the first semester. She was also a student who had a long history of getting into trouble in school. She was identified by the high school as a student at risk and also reported “everybody assumes that I have straight F’s”. Thus, Elaine did not fit the typical profile of a student that would be expected to demonstrate strong learning, let alone transfer.

We assessed Elaine and her classmates’ transfer of the concept of concentration gradient, as it was central to the course. In particular, we had students explain scenarios about osmosis and diffusion (Odom & Barrow, 1995) that were designed to be more or less analogous to what students had learned in class (Gick & Holyoak, 1983). Scenarios that were analogous were included in a knowledge assessment given after the class unit on osmosis and diffusion a month into the second semester. Scenarios that were less analogous were included in the transfer assessment administered 3 months later.

Elaine scored surprisingly high on the transfer test in comparison to the rest of the class. She transferred 78% ($z=+1.22$) of the knowledge elements she had known on the knowledge assessment while the class as a whole transferred a mean of 57% of what they knew. In addition, her score on the transfer test was 67% higher than her score on the knowledge assessment, suggesting she used more knowledge on the more challenging transfer questions than on the more straightforward questions in the knowledge assessment.

Data Sources for Explaining Elaine’s Transfer
1. Student framing survey: Conducted midway through the school year, it used open-ended and Likert-style questions to measure the degree to which students were aware of their teacher’s expansive framing of their biology class and the degree to which they were responsive to his expansive framing in their own actions.
2. Video and audio recordings: One video camera captured a view of the students and the other, a view of the instructor. The audio recorders captured conversations among pairs and groups of students during class activities.
3. Instructional materials and graded student work: These were collected to supplement the video and audio recordings, as well as to track individual students’ performances.
4. Student interviews: Conducted at the end of the school year, Elaine and other students were asked to update and elaborate on their responses to the framing survey and share their perspectives on two recorded excerpts from class in which the teacher explained aspects of his expansive framing of settings and roles.
5. Teacher interviews: We draw on excerpts in which he discussed Elaine.

Explaining How Expansive Framing May Have Led to Elaine’s Transfer
We first show that Elaine’s higher-than-expected transfer was paralleled by high awareness and responsiveness to the teacher’s expansive framing. We then use her case to investigate evidence relevant to each of the five proposed hypotheses for how framing can foster transfer.

Elaine was especially aware of and responsive to the teacher’s expansive framing
Survey results indicated that Elaine perceived and responded to the teacher’s expansive framing to a greater extent than her classmates (Figure 2). On average, students in this biology class scored 3.66 when asked questions aimed at the degree to which they were aware of their teacher’s expansive framing, and 3.33 when asked about how they responded to this framing (on a five point scale from 1 [“never”] to 5 [“all the time”]). However, Elaine was aware of the teacher’s expansive framing with an average score of 4.42 and responded to the framing with an average score of 3.99, both about one standard deviation unit above the class means. Thus, Elaine appears to have been more aware of and responsive to the teacher’s expansive framing than the average student in her biology class. Specifically, many of Elaine’s responses to survey questions about her awareness of particular aspects of framing were more than a full standard deviation above the average score of her peers: the teacher’s framing of place (4.17, $z=+1.07$), participants (4.40, $z=+1.56$), and roles (5.00, $z=+1.32$). She also indicated particularly higher responsiveness to expansive framing related to time (4.88, $z=+1.50$) and place...
According to the prior studies cited above, these results predict that Elaine would have a higher rate transfer of than her classmates.

1. The student expects future transfer, so prepares for it by studying more or better

There is only partial evidence that this explanation helps explain Elaine’s enhanced transfer as we have strong evidence that Elaine expected she would need to transfer what she had learned in the future, but weak evidence that she prepared for transfer by studying more or better. When asked in the survey about the frequency with which the teacher told the students what they are learning may be useful to them at various times in the future (the next day, the next few weeks, the next year, and beyond the next year), Elaine frequently reported that this happened “often” or “all the time” (4.50, z = +0.97). Furthermore, she reported thinking “all the time” about how to apply what she learned at all of these times in the future (5.00, z = +1.17).

On the other hand, evidence that Elaine strongly prepared for future transfer is weak. When asked about her studying habits she stated “I’m lucky if I look over my notes like, once, like I never study for anything…’cause I’m lazy or I’m doing something else.” However, evidence from the teacher and grade reports shows that Elaine completed more biology homework as the year progressed, gradually improving her grade. When asked specifically about turning in assignments, Elaine said, “I kinda caught up now, ’cause um how I said [the teacher] kinda pushed me to do better…’cause um how I said [the teacher] kinda pushed me to do better…I’ m doing better in his class, in specific, so everything’s kinda working out.” Moreover, she also appeared to recognize the value in studying and doing homework, even though she did not regularly do these things herself. For example, when asked if she thought that completing the pre-lab assignments were helpful she responded “like me, if you kinda wait ‘til the last minute or try to copy it… it doesn’t help you at all,” suggesting that she was aware of the fact that completing the assignments would have helped her had she prepared better. In summary, while Elaine may not have exhibited strong preparation for future transfer to the extent that we would have expected her to be, considering her successful rate of transfer, her class performance improved over the course of the school year and she appeared to be aware of the value of preparation for class.

2. Viewing what was learned before as having continued relevance in transfer situations

There is strong evidence that this explanation is significant to Elaine’s case as we found she viewed ideas from the past as continuing to be relevant. Based on survey and interview data, we found that Elaine noticed the teacher regularly referred to what the students had learned at various prior times and recognized that topics in class built upon each other:

It’s not always something brand new… we always elaborate on what we know. So … like the only time it’s really brand new is in the beginning of the year … [Otherwise,] we always refer back to certain stuff. …Like um, with mitosis and meiosis, we had to know that for evolution …we always just kinda adds -- add something new, but it builds on what we already know.

In this example, Elaine showed that she was aware that the content in class built upon prior lessons and that what she previously learned had continued relevance.

Elaine also reported that she frequently drew on ideas from previous times in class. For example, Elaine once asked: “I have a question….It just relates to sorta what we were doing last week, but you know how…we said that…an animal will blend in with like its environment? So, um, does that kinda happen with
plants and stuff too?” Elaine drew on what she had learned before about animals to pose a new transfer question to the class about whether the same idea extends to plants, and then began engaging the class in answering her question.

3. Prior knowledge as author is relevant, so transfer-in more prior knowledge, including examples or generalizations that can enhance learning and therefore later transfer.

We also have evidence that this explanation is relevant to explaining Elaine’s transfer. Elaine reported that she appreciated participating in class, which in this particular case meant drawing on her prior knowledge to author her own ideas. As evidence, we saw Elaine bring in knowledge from outside of school to help her learn biology, which is necessary for future transfer. For example, when the teacher was introducing different cell parts and displayed a picture of a centriole (a long, tube-shaped structure), Elaine exclaimed “It looks like a churro!,” a similarly long and tube-shaped Hispanic pastry. By comparing the shape of centrioles to churros, Elaine brought in her cultural knowledge in ways that likely enhanced her memory of the structure of centrioles, allowing her to draw on it later. In one lesson, Elaine was also able to transfer-in her cultural knowledge to interpret the species name of a cougar, concolor: “In Spanish, it’s ‘with color,’ except that there is a space.” Potentially, Elaine may generalize the idea that her cultural knowledge is applicable to learning contexts to help her remember concepts and interpret Latin words.

We also have evidence of Elaine transferring-in prior knowledge that is not based on culture. During a lesson that began with the topic of animal traits, students became engaged in a discussion about plant characteristics that may deter predators from injuring them. Elaine contributed to the discussion by saying, “So a cactus has thorns to stop animals from eating them,” bringing in a specific example of cacti characteristics to help understand the general idea that plants have traits that help prevent them from being eaten by predators. This act of transferring-in additional examples and comparing them to each other can also directly enhance transfer (e.g., Gentner, Loewenstein & Thompson, 2003; Gick & Holyoak, 1983).

4. Students become publicly recognized as the author of particular content that they then become accountable for sharing.

Elaine’s ability to transfer was likely affected by being regularly positioned as an author of ideas and questions during discussions. As a result, she was regularly held accountable for the biology content that she was authoring in class. For example, during a particular class discussion about chromosomes, Elaine shared with the class that she did not think human eggs and sperm have 46 chromosomes. The teacher followed her contribution to the discussion by asking the class “What do you think about what Elaine said?” In doing so, he publicly credited Elaine for her ideas and made them a part of the instruction. Later in the discussion, the teacher even asks Elaine to repeat what she had shared, re-emphasizing her ideas. Our survey results indicated that Elaine noticed that the teacher regularly credited her “for coming up with important ideas in class” and that it came with an expectation that she would continue to “comment intelligently on what we are learning in class...all the time.”

Our data also reveal evidence that Elaine was recognized as an author and accountable for sharing her knowledge outside of class. During her interview, when she was asked for details about her survey response where she indicated that she talked about biology to those around her at home, Elaine elaborated:

Just last night, my step-dad said that he was sick or something, and that -- something about amino acids and then I asked him... ‘Well, you know what that is?’ Like, ‘How do you even know what that is?’ And um, he started laughing and he -- he told me, um, well how do you not know what that is... And he says, um, do YOU know what it is? And I was like yeah, we just learned that this year. And I kinda explained it him, like what I -- MY understanding of what they were and all that, and he just kinda stayed quiet and was like, ‘mm hmm’ and shook his head like, ‘yeah.’

In this example, Elaine was authoring her own ideas about amino acids, emphasizing “MY understanding of what they were” while her step-father held her accountable for sharing her understanding. This accountability appears and is likely to increase opportunities and the social expectation for students to continue contributing to conversations about the ideas that they have and the ideas that they have previously authored.

5. Authorship becomes a practice so students regularly adapt what has been learned to earnestly attempt or propose novel problems.

There is strong evidence that Elaine’s practice of being an author may have contributed to her high transfer results. First, it is clear that over time Elaine strongly adopted authorship as a practice. By the end of the year, she said “I participate as much as I can.” With respect to being generative, Elaine always made a genuine attempt to answer all of the questions on the transfer assessment while other classmates occasionally left questions blank or responded with “I don’t know.”
Elaine’s role as an author is best summarized by an excerpt from the teacher during a class discussion several months into the school year when Elaine proposed an incorrect answer to a question:

**Teacher:** I think without question I can say the reason Elaine is doing so much better in here is because she is willing to say ‘No, I think it’s … A because it’s what a gamete is’ and that takes some guts because she’s not sure but it’s what she thinks … and that’s really good. Is that the right thing to say though? I mean, is that a correct statement?

**Students [in unison]:** No

**Teacher:** No, it’s not a correct statement, ok, but she’s not over there crying because she was wrong, but what it did then was give … everybody else who thought it and get a chance to correct her which reinforces the right answers for them, allows Elaine to rethink through her response and change her mind. She’s more likely to remember that now and everybody, now everybody benefits … because Elaine had, you know, was able to say something.

From this transcript, it is clear that the teacher recognized that Elaine earnestly attempted to answer questions and shared with the class even when she was uncertain of her answers. In our survey, Elaine also stated that she shared what she thought in class, even though she was not sure if she was right, “all of the time” (5, z= 1.5). She further reported being “able to say what I feel” and always shared her ideas in class even if she did not know if her answer was correct. These survey data suggest that Elaine attempted problems presented in class and was always willing to share her ideas.

In addition to earnestly attempting novel problems in class, video data captured many instances of Elaine proposing her own novel problems by adapting her prior knowledge to the current learning context. For example, during a lesson when students discussed a visualization of equilibration, Elaine posed the question, “Does it stay at equilibrium after it reaches equilibrium?” In presenting this question to the class, Elaine extended the discussion beyond initial attempts to understand the definition of equilibrium, to the process of how equilibrium is reached and what occurs after that point. The teacher subsequently supported Elaine’s proposal and encouraged students to propose similar questions by responding to Elaine’s question saying “That, ladies and gentlemen, is a ten thousand dollar question. Smart kids don’t give the best answers, they ask the best questions. So in groups, after equilibrium is reached, does it stay that way?” The teacher credited Elaine as the author of a “smart” question, and used her question as a point for further discussion and instruction. Occasions such as this, where Elaine proposed novel problems built from her understanding of the content, occurred often throughout the school year. We believe that this practice of being an author, and attempting or proposing novel problems in class, ultimately enhanced her ability to transfer.

**Other hypotheses for how Elaine’s transfer may have been supported**

In addition to these 5 hypotheses, we also considered how data from Elaine’s case might suggest other hypotheses for how her transfer was supported that may be less related to the effects of the teacher’s expansive framing.

The first hypothesis suggested by Elaine’s data was that she learned more and more deeply in the class because of the quality of the teaching she received, which then allowed her to transfer more of what she learned (Bransford, Brown & Cocking, 1999). Elaine specifically referred to the quality of the teaching in her biology class in an open-ended survey question that asked her to describe her biology class and teacher to a new student:

“[He] always finds fun ways for us to learn all the material….. Everything he teaches us is a pretty hard subject and yet this is the class I’ve learned the most in….. It’s complicated, but [the teacher] does a great job of explaining and breaking things down until we understand.”

Consistent with Elaine’s comments, we can report that classes taught by this teacher, including this section, generally received higher scores both on standardized tests and in-class conceptual tests as compared to the other biology teachers in this same school. However, while it is clear that the teacher’s success at helping Elaine learn the material was a necessary prerequisite for her transfer, this does not help explain why we observed more transfer with her than other students, as other students also presumably benefited from the high quality of in-class instruction. So by itself, this hypothesis is not sufficient for explaining Elaine’s higher than usual rate of transfer.

We then investigated whether there were any aspects of support that Elaine received that were different other students and found that her engagement in class was supported more strongly, and eventually led to greater engagement when it was originally much weaker than most students. In particular, Elaine had been identified as a potential at-risk student, leading to her biology teacher’s decision to visit her home and better understand her out-of-school constraints and resources. This led to him regularly taking her aside in school to encourage and push her, which Elaine said helped her do better in class as we illustrated in discussing Elaine’s study practices around Hypothesis 1. When we asked exactly how her biology teacher helped her improve, Elaine explained:
“[By] him always reminding me. Having somebody tell me that I have to do this, that I have to do it for myself. Reminding me of the consequences, um, just telling me, like, that I’m capable of doing better. [So I] get home and don’t forget…that I actually have homework to do.”

So the fact that Elaine began doing more schoolwork and therefore learning more that she could then transfer, we attribute to the teacher’s extra efforts to support her engagement with school. However, while this hypothesis would explain why Elaine had learned more material to transfer, it does not fully explain why she transferred a higher proportion of material than other students.

Our final hypothesis centers on the often tricky and subtle issue of student motivation. From Elaine’s interview we found out that she was particularly interested in taking this class as she’d heard from older students about its culminating forensics unit, a career she was seriously considering after a school project in the prior year. In addition, she expressed a particular interest in animals and noted that this also made her more interested in biology. Finally, she reported particularly enjoying this biology class because of the teacher’s sense of humor: “I really enjoy being in [the teacher’s] class…. [He] always finds fun ways for us to learn all the material… He’s very funny too. I come in this class knowing that by the end of the one-hour period, I’ll have a huge grin on my face.”

Both Elaine’s prior individual and current situational interests (Hidi & Renninger, 2006) as well as the future utility value she perceived with the content for her future (Hulleman & Harackiewicz, 2009) could be expected to support Elaine’s engagement with the class as well as the kinds of re-engagement with the content at later times (Renninger, 2000) that become transfer. However, at first glance this hypothesis of Elaine’s strong motivation helping to foster transfer seems inconsistent with the fact that Elaine needed to be reminded to do homework and reported never studying for tests. In the end, though, we do not think this is the case as we learned through the teacher’s home visit that (a) doing schoolwork at home often conflicted with Elaine’s family responsibilities, and (b) completing out-of-class assignments takes more time and effort than the kinds of transfer we observed Elaine evidencing that involved using more of her knowledge on required in-class transfer assessments, making comments in class, or bringing up what she had learned about biology with her friends or family when relevant to ongoing activity. So we believe that it may have been Elaine’s individual and situationally supported interests that interacted positively with the teacher’s expansive framing and other support that fostered her transfer.

Conclusion
Based on our analyses of Elaine’s case of transfer, we found relatively strong support for four of the five proposed explanations for how expansive framing fostered transfer for a student that was not expected to demonstrate strong transfer. We have also developed additional hypotheses that may further contribute to her high rate of transfer such as the quality of instruction she received, teacher support, and personal motivation.

In our presentation, we will further describe how the processes suggested by each explanation unfolded throughout the school year, drawing on data to describe how Elaine’s student activities changed over time. Moreover, we believe that the explanations are not mutually exclusive. Many of the examples we have provided under each of the five explanations are closely related to and even demonstrate one or more of the other four explanations. Therefore, we aim to further develop our theories about how these five explanations are related.

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