

Initial Evidence of the Effects of Linguistic Framing on Transfer

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Abstract

This paper investigates the idea that it is not just the content of what students learn that influences transfer, but also how learning and transfer contexts are linguistically framed. In a one-on-one tutoring experiment we manipulated framing while controlling for several known transfer mechanisms. We contrasted an expansive framing in which students are positioned as contributing to larger conversations that extend across time, places, people, and topics, with its opposite. We then measured the degree to which high school biology students transferred knowledge from a learning session about the cardiovascular system to a transfer-of-learning session about the respiratory system. We found that students in the expansive condition were more likely to transfer: (a) facts, (b) a conceptual principle, and (c) a learning strategy from one system to another.

Keywords: Transfer-of-learning; Linguistic framing; Social interactions and learning; Human tutoring; Self-explaining

Introduction

Transfer-of-learning, or the application of something learned in one context to another context, is one of the most important but difficult issues in cognitive science and education (e.g. Gick & Holyoak, 1983; Lave, 1988; Lobato, 2006). As Barnett and Ceci (2002) explain, “there is little agreement in the scholarly community about the nature of transfer, the extent to which it occurs, and the nature of its underlying mechanisms.” This paper focuses on an instructional mechanism that has rarely been investigated systematically: the linguistic *framing* of learning contexts (Engle, 2006). In this paper, we report the first experimental study of this mechanism in an educational context: a tutoring experiment testing whether framing affects transfer.

Framing Contexts as a Mechanism for Transfer

Most research on transfer mechanisms does not focus on *contexts* or their framing, but on the nature of the *content* students transfer. For example, the importance of comparing multiple examples to form generalizations is often emphasized (e.g. Gick & Holyoak, 1983; Gentner, Lowenstein & Thompson, 2003). When context is addressed, the focus is on similarities between objective features of learning and transfer contexts, like their physical locations and who is present (e.g. Catrambone & Holyoak, 1989; Spencer & Weisberg, 1986).

Our approach to the relationship between context and transfer investigates the idea that otherwise objectively similar contexts can be linguistically framed as different

social realities (e.g. Duranti & Goodwin, 1992; van Dijk, 2008) that may encourage or discourage transfer (Engle, 2006; Laboratory for Comparative Human Cognition [LCHC], 1983; Greeno, Smith & Moore, 1993; Hammer et al., 2005). As Pea (1987, p. 647) explained, “contexts [that matter for transfer] are *not* defined in terms of physical features of settings, but in terms of the *meanings* of these settings constructed by the people present.”

We use the term *framing* to refer to the linguistic processes of establishing these social realities (e.g., Tannen 1993). For explaining transfer, the framing of boundaries of learning and transfer contexts is particularly important as it affects which contexts students view as being relevant sites for using what they have learned. For example, when a teacher introduces a lesson as providing students entry into knowledgeable roles within communities they plan to participate in throughout their lives, the social boundary of the lesson expands to encompass additional contexts for which each student’s understanding of the lesson will be relevant. In contrast, the teacher could have introduced the same lesson as only relevant to the next day’s quiz, thus framing it as divorced from other contexts-of-use.

Here we investigate the hypothesis that transfer is more likely when learning and transfer contexts are framed *expansively* as opportunities for students to actively contribute to larger conversations that extend across times, places, people, and activities (Engle, 2006). The boundaries of expansive contexts are framed as wide-ranging and permeable to increase the contexts that can become linked with them (Floriani, 1994; Gee & Green, 1998). Additionally, learners become positioned as authors who share their knowledge more generally. Thus, learners learn under the assumption that they will be expected to transfer what they learn to other contexts (LCHC, 1983; Pea, 1987). In potential transfer contexts they act under the assumption that they are accountable for using what they know from other times, places, and people (Greeno et al., 1993; Pea, 1987).

Existing Evidence About Framing and Transfer

Few studies have empirically investigated potential connections between framing and transfer. Hammer et al. (2005) showed that when two transfer contexts were re-framed as being about active sense-making rather than the replication of knowledge, students transferred-in their prior knowledge in ways that helped them understand physics concepts. Engle (2006) showed how a classroom case of

successful transfer that occurred despite weak content-based supports could be explained by a teacher's expansive framing of time, participants, and roles. Finally, Hart and Albarracín (2009) found that people were more likely to repeat an action they had just engaged in—the most basic form of transfer that there is—if they were prompted to describe it using a progressive verb tense that frames it as a continuing activity ("I was doing...") versus a perfective tense that frames it as a completed action (e.g., "I did...").

A Tutoring Experiment to Investigate the Effects of Framing on Transfer

We conducted a tutoring experiment using a 2x2 design with framing condition (expansive vs. its opposite, bounded) as a randomized variable and student population (first year General Biology vs. Advanced Placement [AP] Biology) as a fixed variable included to assess the generality of effects across populations. To reduce pre-intervention differences between conditions, matched pairs of students from the same classes who performed similarly on a screening test were randomly assigned to each framing condition (Shadish, Cook & Campbell 2002). Each student participated individually in a 3-4 hour learning session about the cardiovascular system on one day followed by a 1-2 hour transfer-of-learning session about the respiratory system the next day. Each session's order was: instructions, pre-test, tutoring, survey, and post-test. In all conditions we aimed to strongly support learning while moderately supporting transfer via known instructional mechanisms.

Participants and Their Originating Biology Classes

24 biology students from the same Northern California high school participated in the experiment, 14 from General Biology and 10 from AP Biology, with half of each population assigned to each condition. Instruction in both biology courses was generally consistent with a bounded framing. Students took notes from lectures, the textbook, and educational movies, and teachers evaluated their ability to correctly recall individual facts from these sources. The AP course may have been framed somewhat expansively by its implicit linking to the end-of-year AP exam and college.

Similarities in Procedures Across All Participants

We controlled for objective features of the contexts in which tutoring occurred as well as elements of instruction commonly known to affect learning and transfer.

Objective Features of Context On day 1, the tutor was the first author and the videographer was a research assistant. On day 2, the tutor and videographer were different research assistants. Both days of the study occurred in the same laboratory room, but the student, tutor, and videographer were located in different places on each day.

Target Content to Transfer The learning goal for the first day was to have all students master the same facts and principles about the cardiovascular system. Transfer to the

respiratory system would be assessed on day 2. For facts, students learned the sequence of body parts through which blood flows—a sequence that overlaps with where oxygen travels within the respiratory system. This material is necessary for forming correct mental models of each system (Chi et al., 1994; Liu & Hmelo-Silver, 2009). For principles, students learned that *pressure differentials* determine the direction of blood flow in the cardiovascular system, which applies to gas movement in the respiratory system and fluid flow more generally. They also learned that a large collective *surface area* increases diffusion across capillaries, which applies to increasing the rates of diffusion across alveoli in the respiratory system as well as chemical reactions, heat transfer, and many other processes.

Tutoring Methods The foundation of day 1's tutoring was having each student self-explain the same text and diagrams about the cardiovascular system (Chi et al., 1994, 2001). This method, which promotes learning and transfer (e.g. Chi et al., 1994; Rittle-Johnson, 2006), also allowed us to reduce and control for the tutor's role as provider of content. Drawing on methods established in prior research (Chi et al., 1994; McNamara, 2004), we first trained students to self-explain using an unrelated science text, and then asked them to read each sentence from the cardiovascular system text out loud and self-explain it. Although most students self-explained without difficulty, if the tutor observed a student only paraphrasing (cf. Hausmann & vanLehn, 2007), she prompted for a more elaborate explanation.

Self-explaining was supplemented by having students:

1. Identify key body parts from the text on diagrams.
2. Answer questions about structures, behaviors, functions, and their relationships (Goel et al., 1996).
3. Draw diagrams to represent their evolving models of the cardiovascular system (Ainsworth & Loizou, 2003).
4. Interact with a gestural or physical model for each target principle.

Tutoring about the respiratory system on day 2 was less guided. Students were first asked to anticipate what they would need to learn about the respiratory system. They were then given as long as they wished to "think aloud" while reviewing a text (adapted from Hmelo-Silver & Pfeffer, 2004), hypermedia system (identical to Liu & Hmelo-Silver's 2009), and diagrams. They were also provided with pen and paper, but not required to use it, which provided an opportunity for them to transfer the learning strategy of drawing diagrams from day 1. Each student was also asked to: (a) explain a lung model representing pressure differentials, and (b) explain why there are so many alveoli in the lungs, which relates to the surface area principle.

Known Instructional Supports for Transfer Use of known transfer mechanisms was controlled for all students in ways designed to avoid floor and ceiling effects. All students received the same: (a) overlapping surface linguistic cues between learning and transfer contexts (Catrambone, 1998), (b) examples of each principle (e.g. Gick & Holyoak, 1983), (c) comparisons between those

examples (e.g. Gentner et al., 2003), and (d) level of abstraction of statements of each principle (e.g. Reeves & Weisberg, 1994). No students were given any direct hints (e.g. Anolli et al., 2001; Gick & Holyoak, 1983), nor was the respiratory system mentioned prior to day 2.

Operationalization of the Framing Manipulation

We manipulated the framing of five key aspects of contexts: *who*, *when*, *where*, *what*, and *how* (Engle, 2006). Here we provide illustrations of each framing in classrooms and then in the experiment, with each sentence presenting the more bounded framings first and the more expansive ones second.

Who Is Involved? Lessons can be framed as just involving the teacher and each student, or as being relevant to a much larger community in the classroom and beyond. In our experiment, we framed the student as interacting separately with each tutor versus collectively with the whole research team and anyone else students mentioned.

When Is It Happening? The temporal horizon of a lesson can be framed as an isolated event that has been completed or as part of an ongoing activity that will be continuing. In our experiment, we framed each day as separate studies that consisted of separate completed sub-events versus as one ongoing study that extended across the two days and beyond to other times students mentioned as being relevant to them.

Where Is It Happening? Lessons can be framed as only being relevant to the particular classroom or as also being relevant to other settings like the rest of the school, the local community, a workplace, etc. We framed tutoring as being contained to the room versus being relevant throughout the university and anywhere else students mentioned.

What Is the Scope of the Activity? Two lessons can be framed as being relevant to separate classes, topics, or curriculum units; or as being part of the same larger subject area, unit or topic. In our experiment, we framed each day as a separate tutoring session about a different topic versus part of a pair of tutoring sessions about a larger topic.

How Are Learners Positioned Intellectually? In lessons, learners can be framed as disconnected recipients reporting about the ideas of others or as authors and respondents who take ownership of their own ideas. In our experiment, we framed the learner as a spokesperson for the text versus as the author of his or her own ideas about the body.

Instruments

Post-tutoring Survey To measure whether students detected the intended framing and their general level of motivation during tutoring, the videographer asked each student to complete a survey during a break after tutoring. The tutor was out of the room during its administration.

Cardiovascular System Pre/Post Test At the start and end

of day 1's tutoring session, a written pre/post test (adapted from Chi et al., 1994) measured students' knowledge of the target facts and principles about the cardiovascular system that could be applied to the respiratory system.

Respiratory System Pre/Post Test To measure transfer we devised analogous written assessment questions about the respiratory system. The fact question and the first question about each principle comprised the three-item screening test used to select students to participate in the study.

Analytical Methods

We coded assessments at all five time points—screening, pre-cardiovascular, post-cardiovascular, pre-respiratory, and post-respiratory. Coding was done blind to condition and not by the first author.

We assessed transfer of facts and principles using three different but partially overlapping measures in order to measure converging evidence of transfer effects. *Transfer-of-knowing* is when a student *knows* something about one topic that they apply later to a related topic. It was measured by calculating the proportion of material included in either of the cardiovascular tests that re-appeared in the respiratory system pre-test. *Transfer-of-learning* is when a student *learns* something about one topic that they apply later to a related topic. It was measured by calculating the proportion of material that appeared in the cardiovascular system post-test but not in its pre-test that then re-appeared in the respiratory system pre-test. Finally, *transfer-after-exposure* is when a student increases the extent to which they use a set of ideas with one topic after being *exposed* to those same ideas with a related topic. It was measured by calculating the proportion of material not known in the respiratory screening test that was included in the same parts of the respiratory pre-test.

We measured transfer of the learning strategy of diagram drawing by simply recording which students spontaneously chose to draw diagrams during day 2's tutoring.

Results

Students Perceived Differences in Framing

Day 1's survey indicated that students generally perceived the intended differences in framing. Students in the expansive condition perceived greater use of expansive framing than those in the bounded condition ($F(1,19)=10.6$, $p < .01$), a large effect (Cohen's $d = 1.4$). There was no interaction effect or main effect of population. Follow-up analyses found that students were most aware of the framing of intellectual positioning and temporal horizon.

No Differences in Other Factors Affecting Transfer

There were no significant differences between conditions in common factors affecting learning and transfer. Prior knowledge, as measured by the screening test, was similar across groups. There also were no differences in time spent learning or in responses to the motivation question ("how

much did you care about learning the cardiovascular system?""). Perhaps most importantly, there were no differences by condition in how much students learned the facts and principles whose transfer serves as the main outcome of this study.

Differences by Condition in the Transfer of Facts

To assess the transfer of facts, we examined responses to a question on each corresponding test that required listing the body parts that *oxygenated* blood (cardiovascular system) or *oxygen* (respiratory system) passes through between the lungs and the body's cells. Because these two paths involve the same 10 body parts we assessed transfer by counting how many were listed in each test and comparing them.

For transfer-of-knowing, there was a large main effect of condition (see Fig. 1, error bars are SEM), with students in the expansive condition transferring 42% of facts they knew while those in the bounded condition only transferred 21% of them ($d = .89$; $F(1,20) = 4.37$, $p = .04$). There were no population nor interaction effects. For transfer-after-exposure, there was also a large main effect of condition ($d = .94$), with students in the expansive condition listing 20% more facts than they had during the screening test while students in the bounded condition listed only 3% more facts ($F(1,19)=4.82$, $p = .04$; Fig. 1). Again, there were no other effects. For transfer-of-learning, there was a trend of more transfer for expansive (36%) versus bounded (13%) conditions ($F(1,20)=3.27$, $p = .09$; Fig. 1), with no other effects found.

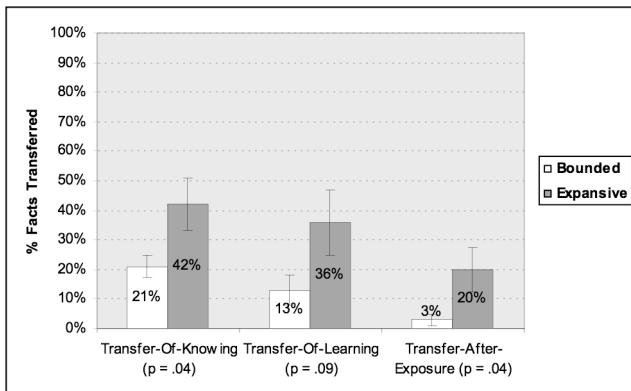


Figure 1: Greater transfer of facts in expansive condition.

Partial Evidence for Differences by Condition in the Transfer of Principles

To measure degree of transfer for principles, we divided each principle into a set of propositions that could be included in student responses to analogous questions at each testing occasion. There were 12 codeable propositions relevant to the differential pressure principle and 11 codeable propositions relevant to the surface area principle (91% agreement; Kappa = .82).

For the differential pressure principle, there was a large main effect ($d = .95$) of condition on transfer-of-knowing

($F(1,20) = 5.42$ $p = .03$), with no interaction effect or main effect of population (see Fig. 2). Students in the expansive condition transferred much ($M = 78\%$) of what they knew while those in the bounded condition transferred only about half ($M = 55\%$). For transfer-of-learning, there was a trend for students in the expansive condition to transfer more than the bounded condition (74% vs. 46%; $F(1,21)=3.04$, $p=.098$; see Fig. 2). Upon further examination of the data, however, we suspect this trend was driven by the General Biology students. There were no differences between groups in transfer-after-exposure. Thus, we found a statistically reliable effect of framing for one of the three measures of transfer for the differential pressure principle.

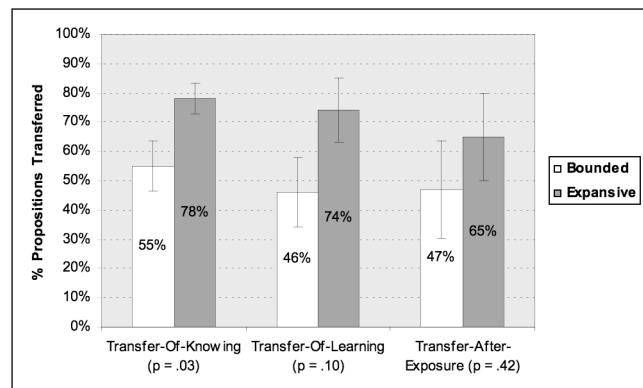


Figure 2: Generally greater transfer of the differential pressure principle in the expansive condition.

In contrast, for the surface area principle there were no main or interaction effects on transfer when measured in each of the three ways. Although the observed means did favor the expansive condition with the transfer-of-knowing measure, there is no reliable evidence that framing affected students' propensity to transfer what they knew or learned about the surface area principle.

Differences by Condition in the Transfer of the Learning Strategy of Drawing Diagrams

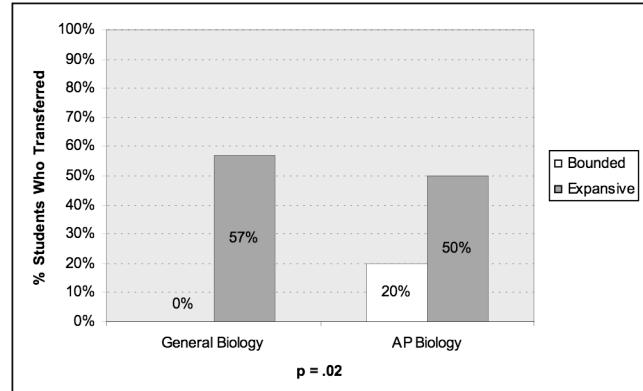


Figure 3: Greater transfer of the strategy of drawing diagrams in the expansive condition.

On the basis of a 2x2x2 loglinear analysis, students in the expansive condition were much more likely to draw diagrams than those in the bounded condition ($G^2(2) = 8.28, p = .02$). Only 1 of the 12 students in the bounded condition drew diagrams while 7 of the 12 students in the expansive condition did so (see Fig. 3). There was a trend of this effect being greater for General Biology than AP Biology students ($G^2(4) = 8.52, p = .07$).

Discussion

We found compelling initial evidence that framing may in fact influence transfer. Students in the expansive condition were more likely than those in the bounded condition to transfer: (a) the learning strategy of drawing diagrams; (b) facts they knew or (c) had been exposed to; and (d) what they knew about the differential pressure principle. In addition, (e) General Biology students in the expansive condition were more likely to transfer what they learned about the differential pressure principle.

The fact that several large effects of framing on transfer were found within a small-scale experiment suggests that it is likely that framing does play an important role in transfer. Also framing does not appear overly specialized in terms of what kinds of transfer it can influence. In this study it affected the transfer of facts, principles, and strategies while in prior research it influenced the transfer of actions, experiences and explanatory schemes (Engle, 2006; Hammer et al., 2005; Hart & Albarracin, 2009).

In future research it will be important to investigate whether it is the framing of one particular aspect of contexts that is responsible for the effects or whether all are necessary. For example, is the manipulation of intellectual positioning as authors versus spokespersons the most important, or is it the way in which time and other aspects of settings are framed as being linked with each other? If more than one aspect of expansive framing matters, does each one make its own independent contributions or is the whole greater than the sum of its parts? To address these questions, future experiments can manipulate each aspect of framing alone and in coordination. This will simultaneously advance understanding of how exactly framing works, provide replication of the effects reported here, and guide educators about which aspects of framing to focus on.

Although transfer of the differential pressure principle was found, no differences were detected across conditions in any kind of transfer of the surface area principle. This contrast opens up issues about how framing may interact with other mechanisms for supporting transfer. This could suggest that framing's effects on transfer may be found only when there is at least some minimal level of content-based support for transfer. In this study, we provided more examples and comparisons for the differential pressure principle than the surface area principle. However, this outcome could also be due to the fact that the surface area principle is arguably more complex. To distinguish between these possible interpretations, follow-up experiments could

cross content-based support with framing while controlling for principles.

More generally it is possible that the framing of learning contexts in an expansive manner makes it more likely that students assume they will need to transfer what they have learned, which may prompt them to make better use of those content-based supports for transfer that are available to them (Engle, 2006). For instance, students learning with an expansive framing may be more likely to bring in multiple examples from a wide range of contexts. In anticipation of applying what they are learning, they may also be more likely to make systematic comparisons between multiple examples to form abstract generalizations. Although tracking which examples, comparisons, and generalizations students made was beyond the scope of this study, it would be a compelling focus of future investigation. Future investigations also should more systematically probe whether motivational variables like utility, relevance, and importance mediate these effects (Pugh & Bergin, 2006).

What is potentially so powerful about expansive framing is that it is much less targeted and content-specific than previously studied instructional supports for transfer. Because of this, it may be easier for teachers to implement expansive framing than instructional supports for transfer that rely on sophisticated content knowledge. In addition, as students come to regularly orient to learning activities in an expansive fashion, one would expect them to make greater use of prior knowledge more generally as they become increasingly accountable for sharing what they know across connected contexts.

At the same time, we do not claim that expansive framing is the be-all and end-all for instruction. Our informal observations of the tutoring sessions and broader theoretical considerations suggest that there may be costs as well as benefits of expansive framing for both learning and transfer. For example, we observed a few students in the expansive framing condition that brought in so much prior knowledge while self-explaining that they became overwhelmed or had difficulty focusing on what the text could contribute to their understanding. Thus, it may make sense for the starts and ends of lessons and curriculum units to be framed more expansively, but to use a less expansive framing when students need to focus on learning particular new material. Also, expansive framing should ideally be paired with activities in which students critically evaluate the knowledge they transfer in for its relevance and validity.

In closing, this study provides converging evidence that framing is an important instructional mechanism to consider when trying to enhance transfer, one that can potentially affect the transfer of many different kinds of knowledge.

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