How does the use of analogical mapping as a scaffold for science learners' argumentation support their learning and talking about science?

Abstract: Analogical mapping is evaluated as a scaffold for small-group argumentation and learning. In this study, groups of four students are invited to analogically map simple machines while creating an argument about which two are most analogically similar. Qualitative and quantitative analysis of video and transcripts show dense argumentation with mutual understanding among students numerous claims. Fifteen out of eighteen claims were normative, suggesting student learning was directed toward functional features of simple machines.

Introduction

Informed by a social constructivist framework, recent research in science education research has focused on getting students to discuss possible scientific explanations and persuade one another of their correctness while at the same time attempting to understand a given scientific concept. This process has been referred to as argumentation. (Driver, Newton, & Osborne, 2000; Duschl, 2008; Kuhn, 1993)

Unfortunately, argumentation research has had only limited success. As educators we want students to discuss things in order to help them to understand. But, since they do not discuss well what they do not understand, a chicken-or-egg problem emerges, and the desired learning from argumentation does not occur. Thus, much research has been focused on scaffolding students in doing quality argumentation that leads to productive argumentation, learning, and understanding. (Sampson & Clark, 2008) These scaffolds can be thought of as temporary supports for students. (Wood, Bruner, & Ross, 1976) Various "scaffolds," or ways to support student argumentation, have been evaluated. (Jimenez-Aleixandre & Regosa, 2006).

The scaffold investigated in this research is that of analogy mapping. Gentner (1983) states that an *analogy* is "a comparison in which relational predicates, but few or no object attributes, can be mapped from [one scenario to another]" (p. 158) Relationships between scenarios can be mapped, whereas the things being related are different. The word "mapped" in this definition means an explicit correspondence made between two analogues.

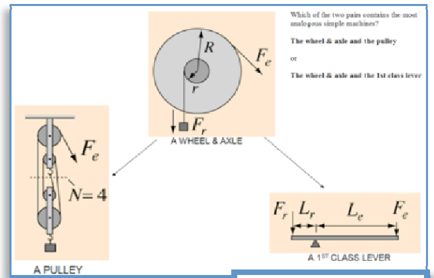
The research presented in this study is based on the belief that students learn and talk together more easily when comparing two (or more) things than when they speak about them in absolute terms. Research on training students on analogical mapping, as in the type of intervention discussed in this paper, has the potential to inform instruction, learning, and curricular development. Analogical mapping could easily be used on any elaborate conceptual analogies used in science classes, of which there are many (e.g., electricity:water, density:population density, cell:house). The fact that even simple machines can be considered analogically (they are usually not) speaks to the flexibility of analogical mapping to scaffold student argumentation and learning.

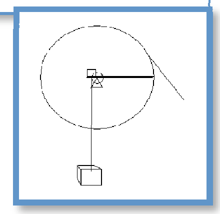
Methodology

This study took place in a science content course designed for pre-service elementary teachers. The course is offered by a large Mid-Atlantic university in the United States and was taught by the principal researcher. It was held twice weekly for 1.5 hours each period. All 24 students provided their permission to be in the study. Working in six groups of four, they were video and audio recorded during their argumentation process. They also created a PowerPoint presentation detailing their final argument statement. The video recording transcripts and PowerPoint slides containing their final arguments were primary sources of data.

This study took place at the end of a four week unit on simple machines, including levers, gears, pulleys, and inclined planes. Before the test, this intervention was offered as a review activity in which the screw and wheel-and-axle were introduced. First, however, students received training on analogical mapping, in which they mapped analogical correspondences in three examples similar to those shown in table 1 but unrelated to simple machines. Next, students received a paper showing a wheel-and-axle, a lever, and a pulley. Students were invited to analogically map the simple machines (see figure 1) and generate an argument stating which machine was most analogically similar to the wheel-and-axle – the pulley or the lever. When groups finished their arguments, the activity was repeated with two similar prompts including different simple machine groups.

Design Rationale





Superficially, the pulley is similar to the wheel-and-axle, since both machines have round parts and have strings attached. Functionally, however, the lever and the wheel-and-axle are most similar. Note figure 2 in which a lever is shown superimposed on a wheel-and-axle. Table 1 lists the correspondences that students were expected to come across and discuss during their argumentation.

Table 1	
Wheel and Axle	**Lever**
Axis of Rotation	Fulcrum
Radius of Wheel (length)	Length of Effort Arm of Lever
Radius of Axle (length)	Length of Resistance Arm of Lever
Effort Distance	Effort Distance
Load	Load
Load Distance	Load Distance

It was expected that students might first consider that the wheel-and-axle and pulley are most analogically similar due to the superficial similarities. However, once students begin to generate a table of analogical mapping correspondences as in table 1, their argumentation would become scaffolded or guided by the triangulation imparted by the analogy. For example, once the axis of rotation is mapped to the fulcrum, it becomes easier to see that the effort arm length of the lever best corresponds to the wheel's radius.

Findings

Findings are summarized below:

1. Most claims made were analogical comparison based, suggesting the task did guide and scaffold students
2. The argumentation was dense with claims, rebuttals, and importantly, evidence of meaning sharing.
3. Most claims made in groups' final arguments emphasized function over superficial similarities and were scientifically normative (15 of 18 among all groups' claims).

Conclusion

We can infer from the findings that the analogical-mapping-based scaffold allowed for argumentation in a shared context that was accessible to students, since most claims were analogical comparison based and were picked up by student groups and made the subject of argumentation. Superficial similarities were most often dismissed in favor of more functional analogical similarities, suggesting that students were attending to and arguing about more pertinent features of the simple machines. Students argued about the relative strength of analogical mappings toward a more normative view of science and away from surface similarities. Attending more to deep structural features and less to superficial similarities is an important in focusing and improving argumentation and learning.

These preliminary results suggest that students were scaffolded in their argumentation and learning about simple machines by the analogical mapping activity. More work needs to be done on analyzing and coding what takes place during student argumentation in order to better understand how exactly the analogical mapping scaffolds and guides group argumentation and learning. Presenting content as an analogical mapping task to student groups to scaffold argumentation seems to scaffold argumentation by guiding and constraining it.

Works Cited

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