FUTURE ELEMENTARY TEACHERS INTEGRATING HYPERTEXT WITH HANDS-ON EXPERIMENTATION IN A DESIGN-BASED CONTEXT

We discuss how future elementary teachers in a physics class progress through the CoMPASS (Concept Map Project-based Activity Scaffolding System) curriculum that facilitates learning by integrating hands-on and hypertext activities in a design-based context. We report on the criteria that participants use while making design predictions, their navigation strategies on the hypertext system, and what they learn about their design task after completing the hypertext and hands-on activities.

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Introduction

The CoMPASS (Concept Map Project-based Activity Scaffolding System) curriculum integrates design-based activities and hands-on explorations with an interactive hypertext system (Puntambekar and Stylianou, 2005). The CoMPASS interface combines an interactive concept map with textual descriptions (Figure 1). Students explore concepts either from the concept map or links within the text. The map uses a fisheye view so that concepts most closely related to the central topic are closer and larger in the map.

Figure 1. Screen capture from the CoMPASS online system screen

The CoMPASS curriculum includes an eight-week unit on simple machines. Students use CoMPASS to explore science concepts related to simple machines with an emphasis on mechanical science concepts, such as force, work and mechanical advantage. In the beginning of the simple machines unit, students are presented with a challenge: their teacher has injured her arm and needs a machine to help her lift heavy objects. The goal of the unit is for students to combine at least three simple machines to create a device that will lift a can of beans with little force.

We investigated how 85 students enrolled in a conceptual-based physics course for future elementary school teachers progressed through the CoMPASS materials for the inclined planes unit alone and not the entire curriculum

Students worked in groups of two to four students with a total of 24 groups. The inclined planes unit challenged students to design the best ramp to move a pool table into a van. Students began by answering a pre-test and anticipation guide about inclined planes. Next, they brainstormed about what they already knew about inclined planes and made predictions about the ramp that would best get the pool table into the van. Then, students came up with topics they would like to learn more about in order to complete the challenge.

Students then used the CoMPASS hypertext system to explore science concepts related to inclined planes. Students chose which concepts to investigate, and we recorded the concepts each group clicked on and the time they spent on each concept. (For more information about the design and effectiveness of the CoMPASS hypertext system, see Puntambekar, Stylianou, and Hübscher, 2003). Next, students experimentally explored the relationship between the length or surface of the board and the force needed to pull their "pool table" into the "van." Finally, they answered open-ended summary questions and a post-test.

Our research questions (RQs) were:

RQ1) What factors do students initially consider in designing the "best" ramp to complete their challenge?

RQ2) How do students use the CoMPASS hypertext system? How does their use of CoMPASS compare to their predictions and questions raised prior to using it?

RQ3) What part of CoMPASS seemed relevant to students and how does this compare with their use of CoMPASS?

RQ4) After completing the activities, how do students describe the best way to get the pool table into the van?

Methodology

Our study included 85 students from a conceptual-based physics class taken by future elementary school teachers. A large majority of students were female (93%) and between the ages of 18 and 22 (92%). Our sources of data include videos of students working through the materials, log files of their use of the CoMPASS hypertext system and their worksheets. We used a phenomenographic approach (Marton, 1986) to analyze students' responses, so our categories of analysis have come directly from the data. We have previously reported students' performance on the pre- and post-test (Haynicz, Rebello, Puntambekar, 2008), which showed a statistically significant ($p<4x10^{-8}$) improvement from pre-test to post-test.

Theoretical Underpinnings

The CoMPASS curriculum takes into account the ideas of Piaget (1964) and Vygotsky (1978). We believe students construct their own knowledge and this construction is influenced by their prior knowledge and experiences. We aim to keep the materials within the students' "zone of proximal development" and to provide scaffolding through questions and experiences. Since we are creating curricular materials focused on science concepts in everyday situations, we expect to see a mixture of everyday and scientific thinking in students' explanations. Hawkins and Pea (1987) have discussed some of the issues related to student explanations. They explain that both everyday and scientific explanations must have a certain degree of precision to answer a question, which Hawkins and Pea label "pragmatic precision." Pragmatic precision depends on the norms of the specific community to which the explanation is addressed. Likewise, the range of variables that should be considered varies with the purpose of an explanation. Students may have difficulty crafting sufficient scientific explanations since they often require much more precision than everyday reasoning.

Results & Discussion

Before using the CoMPASS hypertext system or completing the hands-on investigation, students were asked to predict the length and surface of board that would best complete the challenge of getting the pool table into a van. Students were able to discuss their predictions with their group, so we present the ideas expressed by the majority of students in a given group (Figure 2).

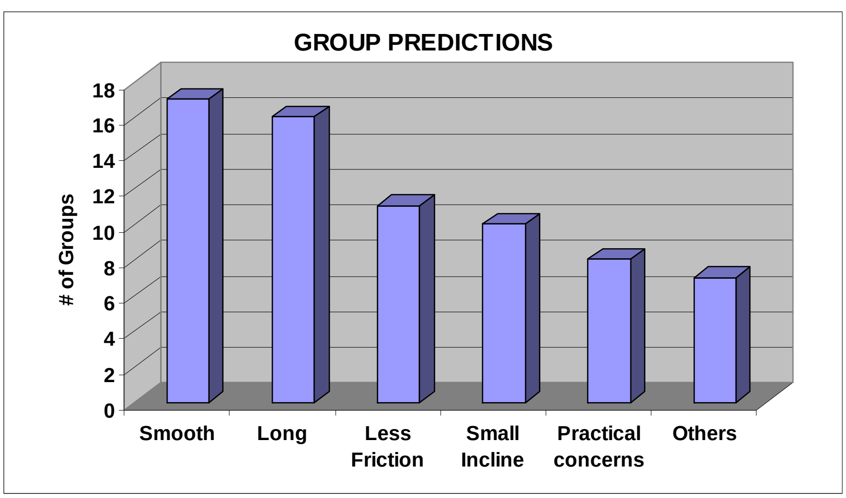

Figure 2. Group predictions about the "best" ramp

Many groups correctly predicted that a “*long*” (16/24) and “*smooth*” (17/24) board would be the best. For example, one student predicted, “We all think that the length has to be long and that the surface has to be smooth.” The next most popular predictions involved the ideas of “*less friction*” (11/24) and “*small incline*” (10/24). Some of the groups in these categories were also able to link the ideas of “*long*” and “*less incline*” (6/24) or “*smooth*” and “*less friction*” (5/24). For instance, one student wrote, “Long and smooth board because it is less of an incline and less friction.” Some groups’ predictions (8/24) included practical concerns such as the sturdiness of the board.

Students then came up with a list of questions or ideas they would like to know more about in order to best complete their challenge (Figure 3). As before, the students’ responses were analyzed for the ideas that were expressed by a majority of group members. Similar to their predictions, the majority of students focused on the ideas of “*surface*” (17/24) and “*length*” (14/24). For example, one student wrote, “Long board versus short board, which one is easier to get item up? Smooth versus textured board-how does the difference affect the item’s movement up the ramp?” The ideas of “*friction*” (8/24) and “*incline*” (5/24) were again popular. In developing their questions, however, many groups focused on practical concerns (14/24), such as the number of people available to push the pool table, and other aspects of the board (7/24), like its width.

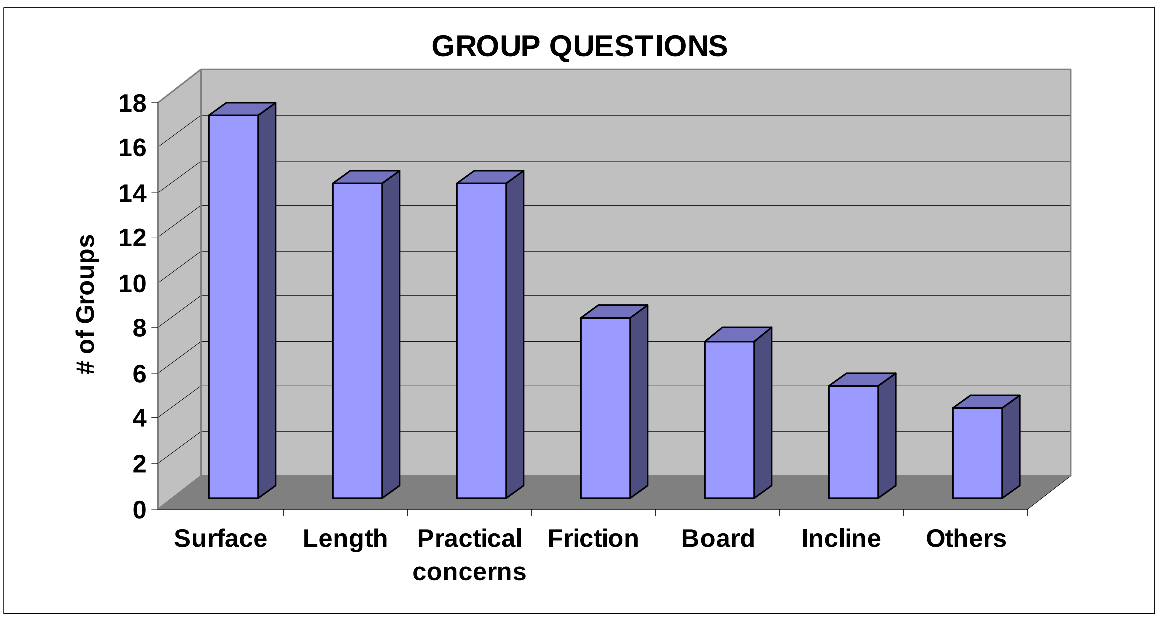

Figure 3. Group questions about inclined planes

Log files stored data on how long students spent on various concepts on the CoMPASS online system. The results compiled for all 24 groups are shown below (Figure 4). Students spent the most time on the topic “*distance*” (19%) followed closely by “*friction*” (16%). These topics match the most common ideas from the groups’ predictions and questions. Many groups also explored the idea of “*mechanical advantage*,” which is one of the target concepts of the curriculum.

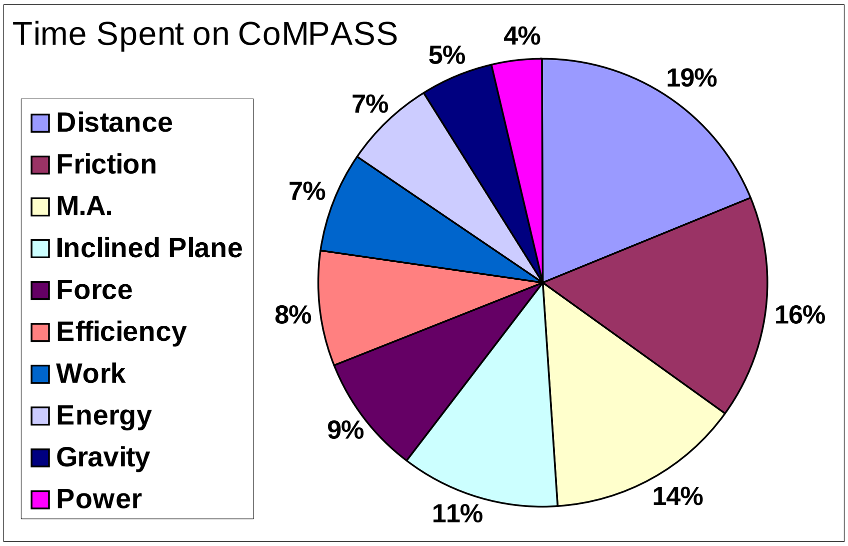

Figure 4. How students spent their time in the compass hypertext system

Students were encouraged to take notes about the important ideas while they explored the CoMPASS hypertext system. Upon analyzing students' notes (Figure 5), we see "*friction*" (22/24) and "*distance*" (21/24) stand out as the most commonly noted concepts, followed closely by *"mechanical advantage."* This observation is consistent with students spending the most time in CoMPASS on those concepts.

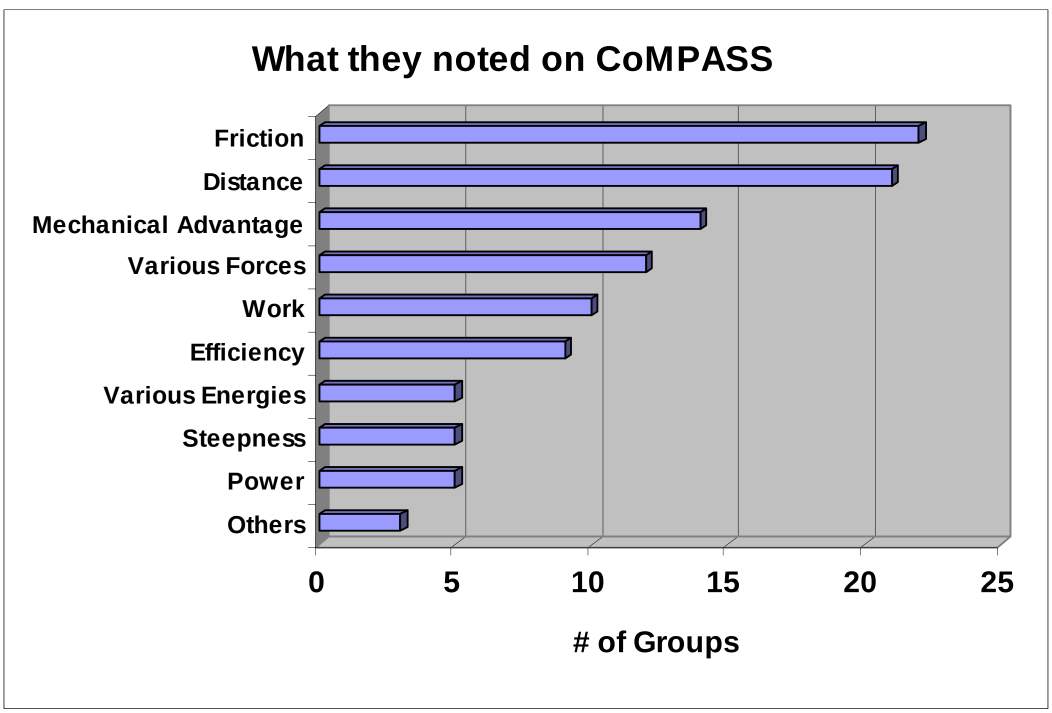

Figure 5. Students' notes while using the ComPASS Hypertext System

At the end of the unit, students were asked to individually explain why the design they chose was successful. Nearly all students chose a "*long*" (66/85) or "*smooth*" board (55/85) as the best way to complete the challenge (Figure 6).

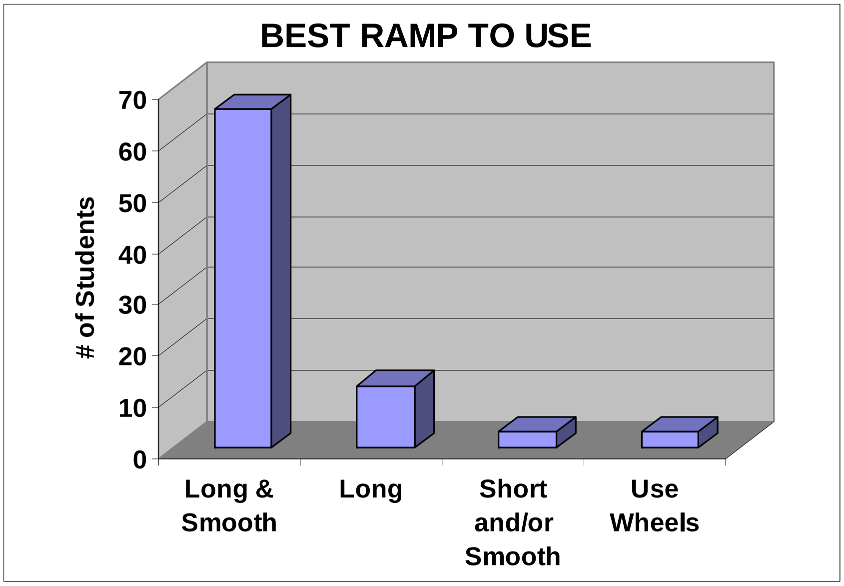

Figure 6. Students' choices for the best way to complete the challenge

Their reasons for these choices are shown in Figure 7. The most common reasons given were that we would need "*less effort*" force than a short or rough board. For example, one student wrote, "Using a long ramp with a smooth surface required the least amount of effort force." Again, some students related the idea of a "*long board*" with "*less incline*." For example, another student wrote, "We had less effort force applied because we used a longer board. The longer distance to travel created a smaller angle to go/push up, making it easier."

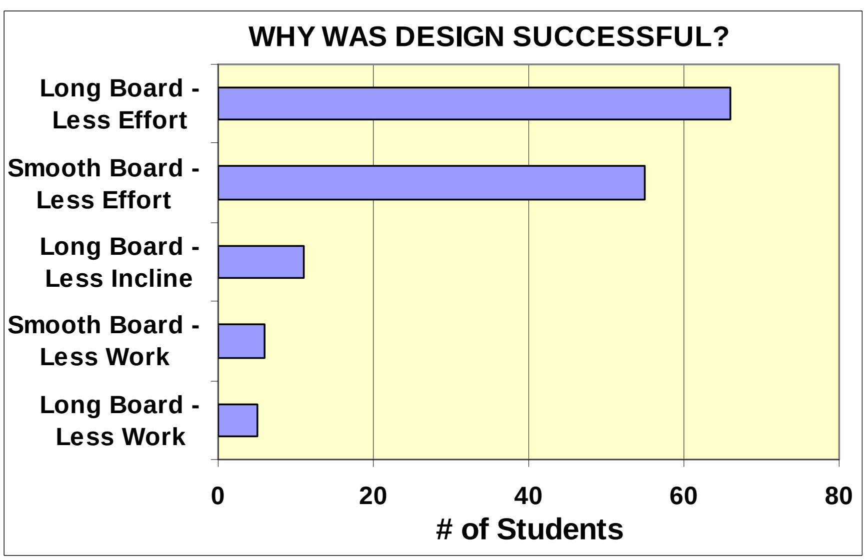

Figure 7. Students' reasons for why their ramp was successful

Some students associated the "*smooth*" (6/85) or "*long*" (5/85) board with "*less work.*" For instance, one student wrote, "A longer board (distance) provides a less steep incline, so it takes less work." The latter students appear to confuse "*work*" with "*effort force,*" as noted in previous studies (Leornard & Rebello, 2007; Haynicz, Rebello, & Puntambekar, 2008). The idea of work must be handled carefully because whether the work needed to lift an object to a given height changes based on the ramp's length depends on whether the ramp has friction (as a real-life ramp would) or is frictionless.

Students were asked to include specific information in some of the summary questions. In one question, students were asked to include the terms "*distance,*" "*friction,*" and "*effort force*" in their responses. The majority of students (66%) included all three concepts, but a significant proportion only included a subset (Figure 8).

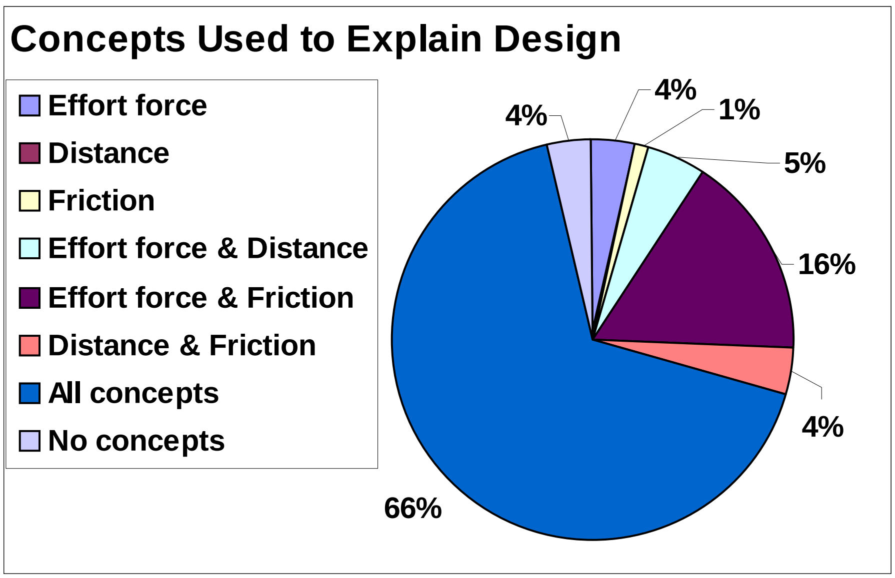

Figure 8. Concepts students used to explain their ramp design

In some cases, students made statements about the board being "*long*" or "*smooth,*" but did not relate these ideas to the science concepts of "*distance*" and "*friction.*" In a second question, students were asked to use data from their experiments to support their reasoning. The majority of students (62/85) did not include any data in their response (Figure 9). For example, one student wrote, "To get the pool table into the van I would use a long ramp so that I would have to apply the least amount of force. I would also make sure the ramp was smooth." Some students did include adequate data to show that the effort force was least for their chosen length (15/85) or surface (10/85). For instance, one student wrote, "Our experiment showed the longer the ramp the less effort needed (1.4 N for long, 2 N for short). The ramp needs to be smooth and our experiment with the rough surface required 3.4 N when the smooth surface was 2 N." In an attempt to include data, some students reported only the effort force for their "best" trial (4/85), which is not sufficient proof that they selected the trial with the least effort force.

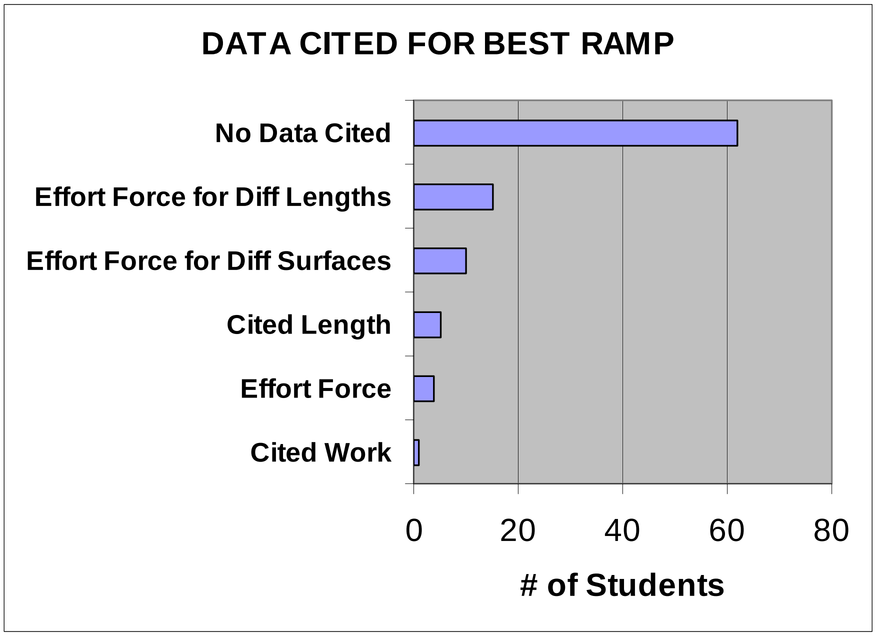

Figure 9. Data students cited to explain their choice of the best ramp

Conclusions

We will first address the research questions and then discuss how our findings fit with Hawkins and Pea's discussion of explanations. The majority of groups initially predicted that they would need a "*long*" and "*smooth*" board, although a significant number of groups also considered the factors of "*incline*" and "*friction*." Students' questions before using CoMPASS focused mostly on the "*length*" and "*surface*" of board they would need. However, a large number of groups also focused on practical concerns or other aspects of the board, such as the width and sturdiness of the ramp. When students used the CoMPASS hypertext system, they spent much of their time on the topics "*distance*" and "*friction*," which is consistent with the factors they had considered before using the system. Likewise, students' notes were focused on the same concepts. Many groups also took notes about "*mechanical advantage*," but less than half took notes on any additional concepts. At the end of the unit, the majority of students explained that a "*long*" and "*smooth*" board would be the best because it would have less "*effort force*."

Thus, we see that students' explanations focused mostly on one main idea: A *long, smooth* board will take *less effort force* to move the pool table. When students were asked to include data to support their explanations, the majority were unsuccessful. Their difficulty can perhaps be explained by Hawkins and Pea's idea of "pragmatic precision." If our students were asked by a friend how to move a pool table, a response such as "a long, smooth table will be the easiest" would be sufficient. In the science community, though, answers need justification. Some students provided the data only for their best trial, which is not sufficient to prove that trial is actually the best. In the future, we need to help students understand the level of precision required in the science community.

Hawkins and Pea also pointed out that the range of variables that should be considered differs based on the purpose of an explanation. This notion could explain why students focused heavily on practical concerns before completing the CoMPASS activities. The practical concerns they raised would in fact be important if they were using a ramp to move a pool table in everyday life, but are not usually considered in a “physics view” of inclined planes. Since these ideas came up less often after students completed the CoMPASS activities, it seems the activities helped students to focus on the variables relevant to their current task.

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