Students' Ideas of a Blender and Perceptions of Scaffolding Activities

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Abstract. Research has shown that students can be motivated to learn science by demonstrating its connection to everyday life. We investigated students' understanding of an everyday blender. We have previously reported on students' progression through a series of hands-on activities designed to facilitate learning about how the blender works [1]. Here, we report on the ideas about the blender expressed by students after completing the sequence of activities and the students' perceptions of the activities themselves.

Keywords: electricity, motors, everyday context, students' conceptions, physics education research
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INTRODUCTION

Studies have shown that students are motivated to learn when they see a connection between learning and everyday life and that student learning is enhanced by real-life contexts [2]. However, there typically is a gap between educators' learning goals and students' perceptions. We investigated students' ideas of a blender after completing a sequence of scaffolding activities and their perceptions of the activities. Our research questions are:

- What are the ideas about the blender expressed by students after completing a sequence of hands-on activities about electromagnetic motors in an interview setting?
- How do students perceive the value of these demonstrations in relation to the blender?
- Are there significant differences in the ideas or perceptions expressed by students enrolled in various levels of introductory physics?

THEORETICAL FRAMEWORK

In this pilot study, we were interested in examining what students transfer from either their previous knowledge or knowledge constructed while interacting with hands-on activities during the interview to the context of the blender. We adapted Lobato's [3] actor-oriented perspective, examining everything students transfer, including spontaneous intuitive knowledge [4] and attunement to affordances [5]. This perspective on transfer of learning was consistent with the idea that learners construct their own knowledge. The teaching interview was based on Vygotsky's social constructivism by which learning occurs within a Zone of Proximal Development, in which the learner can learn with the assistance of a more knowledgeable individual. [6].

METHODOLOGY

We conducted semi-structured, individual teaching interviews with 12 students. The participants in this study came from three different introductory physics courses: conceptual-based, algebra-based and calculus-based. Four students, two male and two female, were randomly selected from a pool of volunteers from each course. The teaching interview is a mock instructional setting during which students interact with a sequence of activities to facilitate learning [7]. The phenomenological approach was used to analyze the students' ideas about the blender after they had completed the activities [8].

First students saw a household blender with the back carved out and motor visible. Next, they saw individual pieces of the blender motor to help activate their prior knowledge. In the first activity, a rail gun (RG) was used to help students realize that motion results from a magnetic field and current. Next, students interacted with a permanent magnet board motor (PMB), shown in Fig. 1.

The PMB consisted of a rotor, two moveable permanent magnets and copper strips that served as brushes. Students connected a battery to the brushes

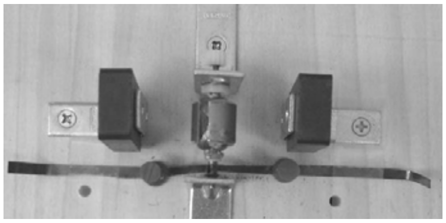

FIGURE 1. Permanent Magnet Board Motor (PMB)

and examined the effect of various orientations of the magnets. The PMB was designed to help students see the necessity of magnets in the motor since the permanent magnets were easily identifiable and could be entirely removed. Next, students were given an electromagnet board motor (EMB), which was similar to the PMB, except the permanent magnets were replaced with coils to which students needed to attach batteries in order to produce electromagnets. The EMB was included to help students identify the electromagnets in the blender. Last, students explored the effect of a permanent magnet and an electromagnet on a compass in the electromagnet coil activity (EC). The EC was included to assist students unable to identify the electromagnets in the EMB. All four activities were used both as motors and generators; however, the focus was on motors alone.

RESULTS & DISCUSSION

At the end of the teaching interview, the students were asked a series of wrap-up questions designed to elicit their ideas about the blender and their perception of the activities. The results are presented below.

Ideas About the Blender

At the conclusion of the teaching interview, most students (11 out of 12) were asked to explain how they thought the blender worked after having completed the preceding activities. Since the activities focused on what caused the motor to spin and what created the magnets, we analyzed their responses in terms of their descriptions of the mechanisms for producing (a) magnets or magnetic field and (b) spinning in the blender. In addition, we identified the key words that students used in describing how the blender worked.

Causes of Magnets or Magnetic Field

Students' ideas about the source of the magnetic field in the blender varied. The most common response, given by four out of 11 students, was that the magnets were a result of "current." For example, one student stated, "You've got your current running through these coils setting up a… magnetic field." This response was given by three students enrolled in the calculus-based physics course, but only one other student overall.

The other responses included "charge," "electricity," the blender being "powered up" and having "oppositely charged bundles of wire." Three students did not discuss the mechanism for creating electromagnets in their ideas about the blender.

Causes of Spinning of Blender

Students also offered a variety of ideas as to what caused the blender to spin. Six students attributed spinning to something to do with magnetism, such as the magnetic field, magnetic force or oppositely poled electromagnets. For instance, one student explained, "that causes a magnetic force within and because this [rotor] is inside here [electromagnets] that magnetic force gets this [rotor] spinning which in turn gets the entire blender spinning." All four calculus-based physics students attributed spinning to magnetism, as did one student in each of the other courses.

Two of the above students also included a role for current in their mechanism for spinning. One student pointed to the rotor and stated that the current was always in the same direction through it and the other attributed spinning to currents trying to align.

Other reasons given for the blender's spinning included "electricity," "metals reacting upon each other," "charge," "electrons moving," the switch connecting the blender's parts with the outlet cord and the "power source." Two students, both from the calculus-based class, specifically mentioned that the blender worked in the same way as the EMB activity.

Keywords Used by Students

In describing their ideas about the blender, students used the following keywords or phrases. The keywords were identified by searching the transcripts of students' responses for commonly occurring words. Table 1 indicates how many students in each course used each keyword or phrase. Here, the keyword "magnetism" includes all references to "the magnets," "magnetic force" and "magnetic field."

TABLE 1: Keywords Used by Students

Keyword	Concept-based (N=4)	Algebra-based (N=3)	Calculus-based (N=4)
Charge	2	1	0
Electricity	2	1	0
Magnetism	3	3	4
Electromagnetism	0	0	1
Source/Supply	0	1	2
Current	0	1	4

Several trends were noticeable from the table. The term "magnetism" appeared in nearly all the students' responses. Only one student (who was enrolled in the conceptual-based physics course) did not use this term. The term "current" was used by all four students in the calculus-based course, but by only one other student. Additionally, the term "electromagnet" was only used in one student's description of how the blender works.

Students in the algebra-based course used the largest variety of keywords, with at least one student mentioning five of the six identified keywords. The terms "source" or "supply" and "current" were not mentioned by any of the conceptual-based students, while the terms "electricity" and "charge" did not appear among the calculus-based students' responses.

Perceptions of the Activities

At the conclusion of the teaching interview, 11 of the 12 students were asked a series of questions designed to assess their perceptions of the activities that had been used. To determine which activities the students felt were similar to the blender, they were asked to identify the activities most similar to and most different from the blender. To determine which activities the students found to be most useful in thinking about how the blender worked, they were asked to identify which was the most useful and which activity, if any, they would leave out of the sequence of activities. Finally, students were asked if they would change anything about the order of the activities.

Most Similar or Most Different

The EMB was chosen by nearly all students (10 of 12) to be most similar to the blender. The remaining two students could not decide between the EMB and PMB, or the EMB, PMB and RG. The students were more divided on which activity was the most different from the blender. Four students each selected EC or RG, and three students cited both as the most different.

Table 2 displays the reasons given for choosing an activity as most similar or most different. The category "spinning" includes references to both "spinning" and "motion" and the category "magnets" includes any reference to magnets or magnetism, but not "electromagnets," which was a different category. The most common reason given was the presence of spinning or motion. For instance, one student said, "I would choose this one [EC] as the uh, the most different simply because there's no motion involved." The second most common reason had to do with magnets, such as the student who stated, "I think this one [PMB] helped me a lot because um I didn't really see where the magnets were and so once I saw that these were magnets and it was causing it to spin I could see the magnets were being produced here [coils in blender]." We labeled the categories as to whether they referred to structural or functional connections and found nearly equal references to both.

TABLE 2: Reasons for Similar/Different (S= Structure; F= Function)

Reason	S or F	Concept-based (N=4)	Algebra-based (N=3)	Calculus-based (N=4)
Same pieces	S	2	3	0
Coils	S	1	2	1
"Motor"	S	0	1	4
Spinning	F	4	2	1
Magnets	F	2	1	3
Electromagnet	F	0	0	1
Works same	F	1	1	0

The only obvious difference between groups was that all of the calculus-based physics students cited the presence of a "motor" (by which they meant rotor) as a reason for choosing an activity as the most or least similar to the blender.

Most Useful or Least Useful

The students were again divided on the topic of which activity was the most useful. Four students stated that the PMB was most useful, while three chose the EMB and another four could not decide between the two.

Many of the students (5 out of 12) stated that they would remove the EC from the sequence of activities. Three more students said they would leave out both the EC and the RG. One student said he would choose not to show the EC used as a generator and three stated that they would not remove any of the activities.

The most common reason given for eliminating the EC was that the knowledge it helped them gain was repeated or redundant. For example, one student stated, "It just seemed like it was added information that I already learned from all this [previous activities]." Interestingly, this reason was given even by some students who needed the EC to recognize the electromagnets in the EMB or the blender.

Another common reason, given by four students, for choosing an activity as most or least useful again had to do with magnets. For example, one student said, "This one [PMB] was useful just in knowing that, okay, they're blatant magnets here." There were no obvious differences between the groups in choosing which activities were most or least useful.

Order of Activities

All but three students chose to alter the order of the activities in some way. Table 3 below shows the various orders suggested by students, as well as the frequency with which they were suggested. The most common reason for changing the sequencing was that the EC would assist the transition from the PMB to the EMB, as suggested by one student who said, "I kind of see how the transition from the magnet to the coil wires would work."

TABLE 3: Preferred Sequence of Activities

Sequence	Frequency
RG, PMB, EC, EMB	4
RG, EC, PMB, EMB	1
PMB, EMB	3
RG, PMB, EMB	2
Do not change	2

CONCLUSIONS

After completing the sequence of scaffolding activities in a teaching interview setting, the most commonly given mechanism for creation of the magnets or magnetic field in the blender was current. The most commonly given mechanism for the creation of spinning was the magnetic field. Both of these responses were given most frequently by students enrolled in the calculus-based introductory physics course. There was no evidence that students knew the meaning of these terms or their function in a blender.

The largest variety of keywords was used by students in the algebra-based course. Students in the calculus-based course were more likely to use the terms "current" and "source" or "supply," probably because they had covered the material related to these terms recently in their course. On the other hand, students in the conceptual-based course had not yet covered this material and were more likely to use common terms such as "electricity" and "charge." The term "magnetism" was used by all but one student.

In deciding which activity was either most similar to the blender or most helpful in understanding the blender, students tended to focus on the presence of spinning and magnets in the activity. If we look again at Table 2, we see that students in the conceptual and algebra-based courses were more likely to focus on structural or low-level functional (i.e. spinning) similarities and differences. Finally, most students chose to alter the sequence of activities, moving EC earlier in the sequence or removing it entirely. Students commonly reasoned that this change was necessary because the EC provided redundant information as the final activity.

LIMITATIONS & FUTURE WORK

Due to the small size of this sample, we should be cautious in drawing generalizations from the data presented. In the future, we plan to interview more students to see if the observed trends still hold.

In this paper we have focused only on analyzing students' responses after they have completed the entire sequence of activities. Our next step will be to analyze students' ideas as they progress through each activity and to map out their learning trajectories. Additionally, we will consider students' suggestions gathered from our data and implement some of them, such as the preferred sequence of activities, and examine the effect on students' learning trajectories. Finally, we will also connect the learning activities with material already covered in introductory physics courses to determine where these learning experiences should optimally be placed to help students learn.

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