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ABSTRACT

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ED 396 913

CAN PARENTS EFFECTIVELY ASSESS THEIR CHILDREN'S IDEAS ABOUT SCIENCE?

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ABSTRACT: The purpose of this study was to determine parent/care giver effectiveness at finding out their child's ideas about sinking, floating, and displacement. The quality and richness of responses obtained by the parent/care giver were compared with responses from interviews of the same fourth grade students conducted by project staff. Twenty–four students completed a unit-related activity and answered questions at home with their parent/care giver before beginning a science unit at school. Science educators interviewed these same students after the home activities, but prior to instruction. Findings indicated that both parents/care givers and science educators can elicit student ideas about specific science topics, however, the data obtained by the parent/care giver was less informative. We speculate that this is a result of inadequate questioning strategies. Specifically, the parents/care givers failed to ask follow-up questions when the child gave an incomplete or irrelevant response. This article provides a series of potential follow-up questions, ideas for helping parents/care givers develop better questioning strategies, and outlines how these will be tested later this spring.

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Introduction

This study was conducted to ascertain the effectiveness of parent/child interviews as a means of assessing fourth grade student ideas about sinking, floating, and displacement in conjunction with the Science PALs unit, *Floating and Sinking*. Science PALs (Parents, Activities and Language arts in science) is a teacher enhancement project funded by the National Science Foundation. PALs project goals include enhancing the science background of elementary teachers by focusing on student ideas about science, using science-based stories to interest students and teachers in doing hands-on science, and involving parents to help teachers collect initial student ideas about science topics prior to a unit which addresses these concepts. The purpose of this study was to validate and enhance the information collected by parents.

Parent involvement is often cited as the single best way to improve student achievement and interest in school (Riley, 1994; Rillero, 1994). The Children's Defense Fund (Daisey and Shroyer, 1995) stated that students learn best when parents actively monitor and support their school work. In addition, students benefit from the interaction provided by parents and guardians because hands-on science experiences, together with conversations about what is occurring, are the best methods for developing children's science process skills (Rillero, 1994). Making parents productive partners in education benefits teachers and parents, as well as students. Teachers value parent involvement at school in both instructional and noninstructional capacities (Fullan, 1991) and frequently have the opportunity to communicate with parents about students and school events. Through involvement with school, parents gain first-hand information about what their child is experiencing and learning. In a study (Daisey and Shroyer, 1995) conducted about parent roles in education, 62% and 52% of parents, respectively, named *helping children with homework* and *reinforcing school instruction* as their most important roles. These were closely followed, at 48% of parents each, by the roles of *doing home activities* and *relating learning to everyday life*. Consistent evidence exists to show that parent encouragement, activities and interest at home and parent participation at school affect children's achievement even after the student's ability and family socioeconomic status is taken into account. (Epstein in Fullan, 1991)

Therefore, asking parents to play a role in gathering information about student ideas will likely be viewed as important by all involved but this task needs to provide an opportunity for parent/child interaction that is welcomed by both participants and useful to the teacher in order to be most effective. Requirements for the parent role must also take into account time constraints on the part of the parent/care giver and the teacher must be able to easily convey the purpose and expectations associated with the task to the parent.

The PALs project has created opportunities for parent involvement that address these needs and are extremely well-received by parents and students. Nearly 1,000 students participated in the PALs project science units in the fall of 1995. Of these students, 86% completed the bookbag home science activity with their parent/care giver. Of the parents/care givers who participated, 89% reported that the experience was of significant educational value and 86% were very positive about the interaction and experience overall (PALs project documentation, 1995).

The purpose of collecting student information does more than give parents and children a chance to interact about what is happening at school. This information is a valuable and necessary resource for the constructivist teacher. The constructivist approach to teaching science (Brooks and Brooks, 1993; Yager, 1991) takes into account the learner's ideas prior to the start of instruction and uses these ideas to inform instructional decisions. Research has shown that students have ideas about the world that differ considerably from those held by scientists (Stepans, 1994; Osborne and Freyberg, 1988). These ideas take the form of well-developed explanations that are often resistant to change. For teachers, addressing these resistant student ideas begins with understanding what the child thinks and providing thought-provoking activities and other challenging discrepant events (Driver, et. al., 1985).

Practically, the logistics and time needed for a teacher to collect the initial ideas of each student in the class is daunting and in many cases, impossible—especially if this method is meant to accompany all science units throughout the year. Using parents as resources to gather information about student ideas is an important way to overcome many of the obstacles, while still providing a benefit for parent and student. Research has shown that given clear expectations from teachers, parents can become effective partners in the education of their child (Fullan, 1991). Parents do not have to be science experts or even feel comfortable with science concepts to be effective. "Through the effort to communicate, children are forced to construct thoughts, form concepts and examine interrelationships among ideas. The measure of a good discussion is not how much an adult explains to a child, but how much a child is induced to think." (Rillero, 1994, p. 2) The bookbag activities used by the PALs project provide a well-received example of how parents can help teachers collect these initial student ideas.

The purpose of this study was to determine parent/care giver effectiveness at finding out their child's ideas about sinking, floating, and displacement using the PALs bookbag activity. This paper will detail the method of comparison used to determine the effectiveness of parents/care givers in this capacity. Our findings indicate that both parents/care givers and science educators can effectively elicit student ideas about specific science topics and that the bookbag activity provides an accepted and efficient method for both the teacher and parent.. However, the bookbag responses can be enhanced by providing the parent/care giver with information and examples of potential follow-up questions that can be used to obtain more in-depth and complete responses from students about their science-related ideas.

Methods

Twenty four students who completed the bookbag activity at home with their parent/care giver were interviewed by project staff who were familiar with the unit and interview strategies. The student responses from the bookbag activity and the interviews were compared in order to determine the effectiveness of parents/care givers at determining their child's ideas. Activity and interview protocols were completed prior to any classroom instruction of this district/PALs project modified National Science Resource Center (NSRC) unit about sinking, floating and displacement.

At the start of a PALs unit, a bookbag activity is sent home with each student. The bookbag contains a story, an activity and a set of questions. Parents/care givers also receive instructions describing their role in collecting the child's ideas, examples of student/adult dialogs, and some tips on how to engage their child in the activity. The bookbag activity takes approximately 30 minutes and the responses are returned to the teacher so that s/he can reflect on the information when preparing for the unit. The interview questions and the activities were designed by the teachers and project staff to address specific concepts related to each science unit. As a result, each unit has a different activity, story and set of questions.

The story selected for the *Floating and Sinking* unit bookbag was Aesop's fable, *The Crow and the Pitcher*. In this story a thirsty crow finds a pitcher half filled with water. Unable to reach the water, the crow drops small rocks into the pitcher until the water level rises, enabling the crow to get a drink. After reading the fable, the parent/care giver asked the child questions about the story and recorded the responses. Bookbag questions were constructed to deal with different aspects of sinking and floating (see the Bookbag Instructions and Activity Sheet in Appendix A). The child and parent/care giver completed the activity which required the child to partially fill a vial with water and watch the water level while dropping small pebbles into the vial. This activity mimicked the actions of the thirsty bird in the fable.

Project staff conducted individual student interviews using questions and activities that paralleled the purpose of the *Floating and Sinking* unit bookbag. The interviews were completed in the school on a single day after the parent/care giver activities but prior to the start of science instruction for this unit. Interviews were recorded and later transcribed for analysis. The interview protocol and activities were carefully designed to elicit the same understandings and ideas covered by the bookbag while posing the questions in a novel setting. Appendix B shows the protocol for the staff interviews and a comparison of how the items from bookbag activity and the interview questions relate.

A qualitative approach was followed for the interpretation of both sets of student responses (Glasser and Strauss, 1967). Conceptions and misconceptions relating to the *Floating and Sinking* unit were noted and a comparison between the two data sets were made. Thirty three different types of responses were given by the students. The interviews were coded according to these 33 statements. The statements were later condensed to six clusters representing the major themes which emerged as a result of data analysis. The topics represent two broad areas: student explanations for sinking and floating and student understanding of displacement. Within these two broad topics, six subgroups emerged. Appendix C shows the original 33 categories as well as the subsequent coding clusters.

Raters were trained to score parent/care giver recording sheets and staff interview transcripts using data from a different fourth grade classroom. These earlier interviews and the misconception literature about density and displacement generated an initial list of sample student responses. The actual transcripts yielded the 33 response types shown in Appendix C. Moderation between raters took place to resolve differences in scores. All bookbag responses were scored by two raters. Three-fourths of the staff interviews were scored by multiple raters.

Findings

Both parents/care givers and project staff elicited student ideas about science concepts related to sinking and floating. However, the data obtained by the parent/care giver provided less rich information about student understandings. The difference in the abundance and richness of data collected by the staff and parents/care givers can be explained because the project staff asked more follow-up questions based on students' initial answers. This resulted in a greater frequency of responses generated from the interview data when compared to the responses generated by the bookbag questions and activity. The difference in the average number of responses generated by the bookbag activity and the interview is not statistically significant. However, the interview data was more likely to confirm student understanding than was the bookbag data because staff were more likely to ask follow-up questions. This meant that students gave more complete answers about their understandings of sinking, floating and displacement, thus informing more cells in the matrix.

Table 1, below, represents the number of different cells informed for the 24 students in this study. This table shows the breakdown of responses for the bookbag activity (parents), interview (project staff) and those cells informed by both activity and interview. Cell frequency refers to information that informs a given cell but it is not a measure of the number of times a given cell was informed for a particular student. It might be assumed that staff data informed more cells simply because there were multiple opportunities to discuss similar ideas. This is not the case because when a student repeated his/her understanding of a concept it would not be counted again. It would, however, tell the interviewer how strongly a student held a particular idea.

TABLE 1

Total Number of Cells Informed

	number of data cells informed from parent bookbag activity	number of data cells informed by both parent bookbag activity and staff interview	number of data cells informed by staff interview
Student explanations for sinking and floating	29	24	77
Student understanding of displacement	35	18	18

Table 2 provides a summary of average, per student data generated by the parent/child bookbag activity and the staff interview. While the number of cells informed by each type of information varies, the categories of information collected is consistent across both types.

TABLE 2

Data Generated per Student via Interviews

	Mean number of cells informed	Standard Deviations
Bookbag Responses	4.417	1.692
Staff Interview	5.708	2.136

$t=2.32$, $\alpha = .05$ Retain the hypothesis that parent and staff means are equal.

Rater reliability showed 71% agreement between raters using all 33 categories. Several of the categories related to similar kinds of explanations for floating/sinking and displacement. When the categories were grouped to reflect these similarities, the recalculated reliability was 85.7%. The groupings used to combine categories are based on conceptions/misconceptions associated with floating and sinking (Biddulph and Osborne, 1984; AAAS, 1993) and displacement (Stepans, 1994; Piaget and Inhelder, 1974). These groupings are also logical from the perspective of classroom applications, because grouped student responses for the same concept are usually addressed by the same activity in the unit. This finding was reflected by the PALs teachers use and grouping of the student idea data obtained by parents (PALs Documentation, 1993-1996).

Implications and Recommendations

While multiple benefits of parent/child interactions about science at home are also supported by the PALs project, this study has shown that parents/care givers were also effective at obtaining useful information about their child's ideas. Differences that exist between the quality and quantity of information collected by parents/care givers and project staff can be explained by the follow-up questioning strategies adopted by both groups of adults.

Staff members asked follow-up and clarification questions when necessary, as indicated by an unclear or unfocused student response. Parents accurately recorded what their child said but they were unlikely to ask questions that pushed the student to elaborate or clarify an idea. For example, many students responded to the bookbag question about dropping pebbles into the water by saying "the pebbles sank". Although the question protocol prompts the parent to ask "why do you think that would happen?", this question frequently remained unanswered. This leaves the teacher uninformed about student understanding of why things sink. Another problem with parental questioning skills seems to be in their attention to detail. For example, when asked about the *pebbles* as they are dropped into the water, several students responded with observations about the water *level*. Rather than acknowledge the observation and reiterate the question about the pebbles, the parents recorded the response and moved on to the next question. We speculate that parents don't realize the care with which questions were worded for inclusion in the bookbag. Nor are they aware of the importance of follow-up questions. For this reason, they are not successful at using the given general follow-up questions or at generating other specific questions to hone in on student reasoning.

In contrast, staff follow-up questions allowed students to give more complete answers. Asking students to elaborate on their answers and checking to see if there were other reasons why the students gave an answer, produced a more complete picture of student understanding. In addition, students gained practice with clarifying and expressing their thinking.

To assist parents/care givers to collect more complete information about their child's ideas, teacher expectations and directions should be provided along with information about questioning strategies. Minimally, this should include a request that each question in the current interview protocol be answered completely. This will require the parent to ask a series of general and specific questions until they exhaust novel explanations from their child. Parents/care givers will need to be informed that repetition is okay and that it yields thoroughness of results.

Optimally, parents/care givers will receive information about wait-time and follow-up questioning strategies. Care must be taken not to substantially increase the size of the task for parents/care givers and students to complete. With this in mind, we provide a list of potential follow-up questions that can be incorporated into parent directions (see Appendix D).

For example, general follow-up questions that can be used to enhance student explanations include:

> Is there any other reason? (What are the other reasons?)
> What do you mean by that?
> Why do you think that?
> Give an example of what you mean.

The first question in this list may seem awkward as a two-part question, but, asking just the second half may lead the student to believe that s/he needs to have other reasons, or that the reason given is not correct. By giving the student an opportunity to answer yes or no first, the questioner is less likely to influence the student response. (See Grossier in Good and Brophy (1991) for a discussion of why yes/no questions alone are not desirable.)

Follow-up questions can be used to define the categories used by students. For example questions like *what if I had a smaller . . .?* or *what if I had a larger . . .?* help to clarify the conditions under which the student uses certain categories.

Definitions of words can also be misleading without follow-up questioning. Asking students to define, using examples or descriptions, the critical words in their explanations sheds light on the depth of their understanding. For example, we determined that some students used the word *bigger* to mean *heavier*. It changed our understanding of what they thought of weight/size relationships in terms of sinking and floating once it became clear that they did not distinguish between the two properties.

We also found it helpful to ask questions about the six categories of explanations for sink/float phenomena. This focused the discussion and shed light on one characteristic at a time, allowing students to elaborate on their ideas. The teacher was then able to determine the properties the student uses to predict whether an object will sink of float. This series of questions is designed to be purposeful and sequenced (Good and Brophy, 1991), and it can be modified for use with several parts of the bookbag and the *Floating and Sinking* unit. For example, concerning floating:

Student: It floats because it is light.
Interviewer: Do all light things float?
Student: Yes (or no).
Interviewer: Give me an example.
Student: Like wood, it floats.
Interviewer: Do all wooden things float?
Student: Yes (or no).
Interviewer: Give me an example.
Student: *Gives example*
Interviewer: What about wood makes it float?
Student: *Tells what about wood makes it float*
Interviewer: If something floats and I push it under water and let it go, what will happen to it? (to distinguish between surface tension and floating)

Increasing awareness about questioning strategies and the outcomes they generate will result in even more useful information from at-home parent/child activities. Increased awareness could be achieved by a sample protocol, a list of common follow-up questions with the typical responses, a role play at a parent meeting, information at a parent conference, a discussion about interviewing, or a video of a sample interview. Ultimately, the teacher knows the parents of his/her students best and can adopt a method for informing them about questioning strategies that will be most successful.

We are piloting follow-up questioning strategies as part of the bookbag instructions to parents for the Floating and Sinking unit this spring. This will enable us to obtain information about the effectiveness of this method as well as gauge parental receptivity to this new element of an already successful bookbag activity.

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APPENDIX A

Parent/Guardian Bookbag Instructions and Activity Sheet

Science PALs: Parent Instruction Sheet

As a parent/guardian, you are an essential key to the success of the Science PALs project. Your primary role will be to interview our child and collect his/her initial ideas about the science topic through discussion of a story and a simple hands-on activity. These student ideas are then used by the classroom teacher to gauge where your child is in his/her level of understanding of the science topic before the unit begins. Your enthusiasm to listen to your child's science ideas and your interest in the science topic will stimulate your child to become a more active learner in the classroom. As your child's teacher, I greatly appreciate the effort you will be making in assisting in this collaborative approach to science. Your specific instructions are as follows.

Approximately one week prior to the start of the science unit, you and your child will receive a Science PALs Bookbag at the Parent Training Workshop containing:

1) a copy of the Aesop's Fable *The crow and the pitcher*
2) materials for the hands-on activity (vial and pebbles)
3) Parent Instruction Sheet (this page)
4) Student Response Sheet
5) Parent Response Sheet

*please return both the Student and Parent Response Sheets with the Bookbag to me by the due date listed.

You will need to find an appropriate time and place to spend about thirty minutes reading and discussing the above story with your child and doing the activity together. The story has a science-related theme. We are asking that you specifically **do not** try to explain the science behind any of your child's questions concerning the science phenomenon. Rather, we would like for you to interview your child about his/her ideas. Discuss with her what she's thinking. Please record your child's ideas on the Parent Response Sheet as your child completes his Student Response Sheet. Then relay both to me.

An example of a parent/child interview might be . . .

Parent: What happened to the water level when the pebbles dropped into water?
Child: It rose up higher in the pitcher.
Parent: Why would that happen?
Child: I don't really know.
Parent: That's okay if you don't know for sure, can you tell me what you think?
Child: Well, it could be that air came in the water with the pebbles and air can make the water go up.
Parent: Let's write down your ideas so your teacher can read about what you're thinking.

Guidelines for interviewing your child:

1. Use an appropriate location isolated from the flurry of everyday activities.
2. Read at an appropriate time. Make certain that you and/or your child are not tired. It's hard to devote your attention to anything if you're sleepy.
3. Try to make the reading session a one-on-one time for you and your child. Reading time should be quiet (no t.v.), relaxed, and uninterrupted. Find a room and close the door.
4. Regardless of time and place, the most important thing you'll want to do is create a pleasant, happy, comfortable atmosphere. Let your child know you like being with him/her doing this science reading and activity.
5. Being in close physical contact with your child during the reading helps hold her/his attention. Sitting side by side perhaps with your arm around your child conveys a strong positive message.
6. Talk about the reading and activity as something both of you will be doing. Let him/her know that science is exciting and important to both of you.
7. Remember to be kind and non-threatening to your young child. Its' very important for your child to feel comfortable for him/her to be able to express an idea.

Please remember that when your child asks questions about the scientific nature of the story, its' up to you to give your child the opportunity to stretch his/her mind by not giving answers or explanations to the questions.

Science PALs Parent Response Sheet

In the activity bag you will find a clear, plastic vial filled with approximately 99 tiny pebbles. After reading The Crow and The Pitcher, use the pebbles and the vial to act out what the crow did in the story. The vial is marked with two lines. Fill the vial with water up to the black line. Ask you child to add pebbles one at a time. After about 10-20 pebbles, ask your child the questions. Your child does not need to add all of the pebbles unless he or she wants to do so.

Please record below your child's response to the three interview questions and the activity you have discussed with her/him.

Question #1: What happened to the pebbles when they were dropped into the pitcher or container? Why do you think that happened?

Question #2: What happened to the water level when the pebbles were dropped into the pitcher or container? Why would it do that?

Question #3: What if the crow had dropped small pieces of wood into the pitcher? What would happen to the wood? to the water level? Why do you this that?

Parent Survey:

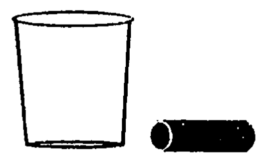
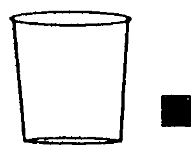
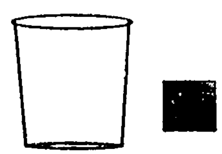
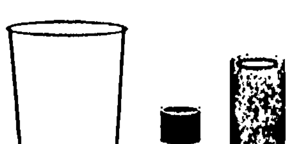
	Strong Yes	Yes	Neutral Feelings	No	Strong No
1. Have you enjoyed this science interaction with your child?	____	____	____	____	____
2. Do you feel that this experience has been valuable for your child?	____	____	____	____	____
3. Do you receive sufficient instruction to understand your role?	____	____	____	____	____
4. Do you feel that there is significant educational value in having parents involved as an integral part of the school district's science program?	____	____	____	____	____

Comments:

Science PALs Student Response Sheet

Draw a picture and/or describe what happened to the water when the crow dropped the pebbles into the container.

APPENDIX B

COMPARISON OF PROJECT STAFF INTERVIEW AND PARENT/CHILD BOOKBAG QUESTIONS			
Interview		Purpose of Questions (interview and bookbag)	Related *Parent/Child Bookbag* Questions
Set-up	Initial Interview Questions		
Use the beaker of water and the large, solid, metal cylinder. 	What will happen to the metal cylinder if I put it in this beaker of water? Why do you think that will happen?	To determine student explanations for why objects sink and float. Involves type and structure of material, weight, size and shape.	1. What happened to the pebbles when they were dropped into the container? Why do you think that happened?
Use the beaker of water and the small cube of wood. 	What will happen to the small wooden cube if I put it into this beaker of water? Why do you think that will happen? Note: be sure to allow the student to put the cube in the water and then remove it before asking the next question.	To determine student explanations for why objects sink and float. Involves type and structure of material, weight, size and shape.	3. What if the crow had dropped small pieces of wood into the pitcher? What would happen to the wood? What would happen to the water level? Why do you think that?
Use the beaker of water and the large cube of wood. 	What will happen to the large wooden cube if I put it in this beaker of water? Why do you think this will happen?	To determine student explanations for why objects sink and float. Involves type and structure of material, weight, size and shape. Note: this question was asked to determine if size of the material changed the outcome.	3. What if the crow had dropped small pieces of wood into the pitcher? What would happen to the wood? What would happen to the water level? Why do you think that?
Use the beaker of water, the short, solid metal cylinder, and the tall, hollow, brass cylinder. 	Which of these two cylinders weighs more? Note: Allow student to hold the cylinders to determine this.	To assure that the student knows which cylinder is heavier and does not answer based on what they assume.	Not required by the bookbag questions but addressed in the parent/child situation because students handled the pebbles which were not of uniform size.

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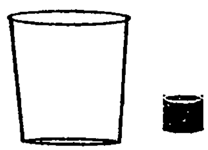
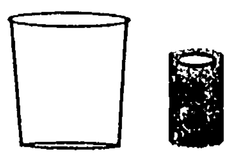
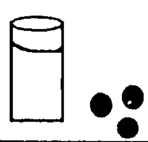
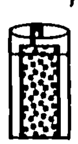
Interview Set-up	Interview Initial Questions	Purpose of Questions	Related *Parent/Child Bookbag* Questions
Use the beaker of water and the short, solid metal cylinder. 	What will happen when I put this short, solid metal cylinder in this beaker of water? Why do you think that will happen?	To determine student explanations for why objects sink and float. Involves type and structure of material, weight, size and shape. Note: This question was asked to determine if size of the material changed the outcome.	1. What happened to the pebbles when they were dropped into the container? Why do you think that happened? 2. What happened to the water level when the pebbles were dropped into the container? Why would it do that? Note: This question is similar to parent question 1 except that it allows students to talk about explanations for sinking and floating and/or their ideas about displacement.
Use the beaker of water and the tall, hollow metal cylinder. 	What will happen when I put this tall, hollow, metal cylinder in this beaker of water? Why do you think that will happen?	To determine student explanations for why objects sink and float. Involves type and structure of material, weight, size and shape. Note: This question was asked to determine if holes in the material changed the outcome. The significance of holes was often mentioned by students when they talked about wood.	1. What happened to the pebbles when they were dropped into the container? Why do you think that happened? 2. What happened to the water level when the pebbles were dropped into the container? Why would it do that? Note: This question is similar to parent question 1 except that it allows students to talk about explanations for sinking and floating and/or their ideas about displacement.
Use the plastic vial filled to the line with water and the marbles. 	What will happen to the water when I place this/these marble(s) in the vial of water? Why do you think that will happen?	To determine student understanding of displacement. Involves categories based on characteristics of the object and characteristics of the medium in which the object is placed.	2. What happened to the water level when the pebbles were dropped in the container? Why do you think that happened? 3. ...What would happen to the water level? Why do you think that?
Use the plastic vial full of water and a metal cylinder with a hook in the top. 	What will happen to the water level in the vial when I remove this cylinder? Why do you think that will happen?	To determine student understanding of displacement. Involves categories based on characteristics of the object and characteristics of the medium in which the object is placed. Note: This question verifies student ideas with a reversed example.	2. What happened to the water level when the pebbles were dropped in the pitcher or container? Why do you think that happened? 3. ...What would happen to the water level? Why do you think that?

APPENDIX C

Categories of Student Responses

		STUDENT IDEAS
EXPLANATIONS OF SINKING AND FLOATING	WEIGHT	heavy objects sink
		not all heavy objects sink, but some do
		an object must be heavier than water to sink
		objects heavier than water sink and objects lighter than water float
		light objects floa;
		weight is only variable considered for why objects sink or float
	SIZE	size has nothing to do with whether an object sinks or floats
		water can hold up small objects (surface tension)
		little objects sink and big objects float
	MATERIAL	material of object is only variable considered for why objects sink or float
		all wood floats
		all metal sinks/metal can't float
	STRUCTURE	air/holes/hollow spaces make things float
		water going into the holes in objects makes them sink
		water going into holes could make things bob up and down (sink, then float, then sink, etc.)
		objects may have a delayed reaction to sinking. They may float for a time and then sink because of holes.
		air is in holes/hollow spaces in the object
		fragile things float because water holds them up
		water in holes makes things float ("water weight" in the holes makes the object float)
		holes makes things sink
	SHAPE	an object will float if the water can go around it (gets under it and holds/pushes it up)
		shape is the only variable considered for why objects sink or float
UNDERSTANDINGS OF DISPLACEMENT	CHARACTERISTICS OF OBJECTS	water rises because objects take up space on the bottom
		big things take up more space and make the water level rise more
		the object must be a sinker to make a change in water level (floaters produce no change in water level)
		must be a big object in order for water level to change
		water level changes are only based on weight of object (heavy/light) not size
		wood will "suck water into it" and sink so the water level falls
		both floaters & sinkers cause changes in the water level
		water level changes because sinking objects lift up the water
	CHARACTERISTICS OF MEDIUM	adding objects to water changes the water level - it is like adding another drop of water
		gravity pulls the water down (so water level decreases when objects are removed)
		water level rises because the water is on top of the sinking object
		water level rises causing objects to sink

APPENDIX D

Follow-up Questions for *Floating and Sinking*

Purpose	First Follow-up question*	Second Follow-up question
General questions to enhance and clarify student responses	Is there any other reason?	What is/are the other reason(s)?
	What do you mean by that?	Can you think of anything else?
	Why do you think that?	
	Give me an example?	
Defining categories of student reasoning	What if I had a smaller...?	Why do you think that?
	What if I had a larger...?	
	What if I had a lighter...?	
	What if I had a heavier...?	
	What if there was more air in the...?	
	What if there was less air in the...?	
The student says "It sinks because it is heavy."	Do all heavy things sink?	What are some examples?
The student says "It sinks because it is metal."	Do all metal things sink?	
The student says "It sinks because it is big."	Do all big things sink?	
The student says "It floats because it is light."	Do all light things float?	What are some examples?
The student says "It floats because it is wood."	Do all wooden things float?	What are some examples?
	Does the size of the piece of wood make a difference?	Do big and little pieces of wood float?
	What about wood makes it float (or sink)?	Why do you think that?
The student says "It floats because it has air."	What about air makes it help something float?	What are some examples?
	Do all things that float contain air?	
	Do all things that contain air float?	

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The student says "It sinks because it has holes."	Do all things with holes sink?	What are some examples (Why are they examples?)?
	Do some things with holes float?	
	Do all hollow things float/sink?	If I have something with holes that sinks and I plug up the holes, what will happen?
	Does the size of the hole matter?	How and why?
	Does the size of the hollow space matter?	
To determine the effect of outside influences (not associated with the object being tested) on floating and sinking	Does the amount of water effect whether an object sinks or floats?	How?
	Does the size of the container an object is in effect whether it sinks or floats?	How?
To distinguish between surface tension and floating	If something floats and I push it under the water and let it go, what happens?	Why do you think that will happen?
*To determine fluctuations in sinking and floating behavior***	Do things that sink ever float later?	What are some examples?
	Do things that float ever sink later?	Why do you think that?
To determine ideas about displacement	Where does the water go when something sinks?	What do you think that happens?
	Where does the water go when something floats?	

* Frequently the first follow-up questions can be used as second follow-up questions in other contexts. This chart is meant to represent a sample of the possible question types and a sample protocol.

** These questions also helped us determine that some students thought that all floating objects contain air.