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ABSTRACT

In science education there is a general agreement that instruction should be sensitive to students' everyday science knowledge. This paper reports on a study investigating the effectiveness of the Multiple Resonance Reflection Tool (MRRT) which is an aid for teachers that reflects students' everyday science knowledge. Two main focus points of the study include development of a prototype based on another study, and evaluating preservice teachers' perceptions of the MRRT. (Contains 14 references.) (YDS)

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DEVELOPING THE MULTIPLE RESONANCE REFLECTION TOOL: MAKING EVERYDAY SCIENCE USEFUL TO TEACHERS, MAKING SCHOOL SCIENCE USEFUL TO STUDENTS

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Developing The Multiple Resonance Reflection Tool: Making Everyday Science Useful to Teachers, Making School Science Useful to Students

The importance of students' everyday science knowledge has taken a prominent role in science education as constructivist learning theory has become widely accepted among educators (e.g. Tobin, 1993). The National Science Education Standards (National Research Council, 1996) stresses the importance of selecting curricula and instruction that builds on students' questions and ideas (p.31). To do this requires an understanding of students' knowledge prior to instruction. Similarly, Trowbridge and Bybee (1996) reiterate the importance of everyday science knowledge by quoting Ausubel, "If I had to reduce all of educational psychology to just one principle, I would say this: The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly" (p.3).

Prospective and practicing science teachers are often encouraged to consider students' everyday science knowledge when designing and delivering instruction. Although there is general agreement *that* instruction should be sensitive to everyday science knowledge, the challenge of *how* to make instruction sensitive to everyday science knowledge remains. This paper moves towards development of the Multiple Resonance Reflection Tool (MRRT), as a tool that teachers can use to aid in their reflection on students' everyday science knowledge. The tool is intended to assist teachers in hypothesizing about (a) potential points of resonance between students' everyday science knowledge and school science that may exist prior to instruction; (b) desirable connections that students should make between everyday science and school science after instruction; and (c) curricula and instruction that draws from students' everyday science knowledge in teaching school science.

Theoretical Underpinnings

The bulk of science education research dealing with students' everyday science knowledge is found in misconception (Chi & Slotta, 1993; Driver, 1985) and conceptual change (Posner, Strike, Hewson, & Gertzog, 1982) literature. In this literature the primary prescription for science instruction is to identify everyday science knowledge as an early step in the process of eradicating students' non-scientific understanding and replacing it with scientifically accurate conceptions (e.g. Bar, Sneider & Martimbeau, 1997; Liggitt-Fox, 1997). We do not accede to this approach. Rather than seeing everyday science knowledge as something that must be rooted out and replaced, we view students' knowledge from a worldview perspective (such as that articulated by Kearney, 1984 and Cobern, 1991). In this way everyday science knowledge becomes a foundation and a resource for building more formalized science knowledge. We regard students' everyday science knowledge as valid inasmuch as it has been useful for them as they interact with their world. While the body of scientific postulates has great usefulness for scientists, its counterintuitive nature may render it useless in the opinion of some students. "Useless" science leads to what Cobern (1996) refers to as cognitive apartheid,

> Many students, in other words, practice cognitive apartheid (Fig. 1B). Students simply wall off the concepts that do not fit their natural way of thinking. In this case, the students create a compartment for scientific knowledge from which it can be retrieved on special occasions, such as a school exam, but in everyday life it has no effect (Cobern, 1993a; also see Scribner & Cole, 1973). (Cobern, 1996, p. 588)

Consequently, our immediate concern is less with students' *articulation* of scientific postulates, more pressing is their *disposition towards these postulates*. The task for science educators then is to present school science as useful, and to draw from students' everyday science knowledge in doing so. We believe that one way to accomplish this task would be to obtain an overview of students' everyday science knowledge; and from that overview to identify points of *resonance* between everyday science knowledge and planned science instruction. Settlage (personal communication, July 1998) explains the notion of resonance as a metaphor.

> The manner in which we imagine teaching science is analogous to the resonance of tuning forks, a common physics image. In texts, the illustration of resonance commonly depicts two tuning forks on either end of a tabletop. At the outset, one tuning fork is caused to vibrate, transmitting its movement to the air particles surrounding it. The alternating compactions and rarefactions eventually cause the second tuning fork to vibrate... Applying resonance to the issue of scientific versus home cultures, we are advocating the idea of seeking means whereby the two domains can remain distinct yet modified and adjusted to become more harmonious. Instead of viewing the space between the cultures as a gap that begs to be closed, the resonance image is intended to honor the differences while allowing us to create and sustain constructive associations.

This paper presents the findings of a study on the effectiveness of the Multiple Resonance Reflection Tool as a tool that teachers can use to aid in their reflection on students' everyday science knowledge. The study progressed in two phases. The first phase involved drawing on data from another study (Lewis, 1998) to develop a prototype of the Multiple Resonance Reflection Tool. The second phase involved setting up a controlled experiment, to assess patterns in preservice teachers' responses to an open-ended course creation exercise. Findings indicate that, in the three-part course creation exercise, teachers using the MRRT (a) were more successful at brainstorming everyday science knowledge that students might have prior to instruction, (b) proposed more student centered teaching objectives (as opposed to content centered objectives), and (c) drew more on students' everyday knowledge when designing activities than did the control group. The paper concludes with suggestions for further research and also identifies implications for applying the model to practice.

Model Development

Source of Data

The model presented in this paper is drawn from data from an ongoing three-year ethnographic study of how middle-school girls understand science. That study takes place at Laurel School for Girls[1] – a well respected, affluent, private, girls' school in Pittsburgh. The learning environment and experiences provided at Laurel are very rich. Students come from families of white-collar professionals (accountants, bankers, city government officials, doctors, professors, etc.). They are high academic achievers; there is great concern from faculty, parents and students if a student earns a grade lower than "B" (for additional information on Laurel see Lewis, 1998).

Fifteen girls are participating in the three-year study. However, the Multiple Resonance Reflection Tool discussed in this paper is drawn from data from four students. The data includes photographs, and student-researcher interviews discussing the photographs. Students were given 24-exposure, disposable cameras and were asked to take seven photos of their favorite things, seven photos of "things that make you think of science," and one photo of themselves. Students were instructed to use the remaining film to take pictures at their discretion. Student-researcher interviews, conducted individually and in groups of two, fit Bogdan and Biklen's (1992) description of "a purposeful conversation." While reviewing the photographs students were asked, "Is that one of your favorite things or something that makes you think of science?" Follow-up questions were "What do you like about [object]?" for favorite things; and "How does [object] remind you of science?" Additional follow-up questions varied greatly as they were

[1] Pseudonyms are used throughout this manuscript to maintain anonymity.

responsive to and dependent primarily on students' statements. The reader should note that the initial purpose of the photographs was to provide an avenue whereby students could speak freely about things of interest to them and about science. For this reason, follow-up questions were open-ended and there was little attempt to limit or direct a response.

Photography as a method of data collection

The use of student generated photographs, as a tool for assessing students science knowledge, has not enjoyed widespread use in science education. Settlage (1998) is the first to use this method in soliciting children's ideas of science. Among the advantages, Settlage points out that students are not limited by their artistic ability, as is the case with the "draw-a-scientist" protocol. The photographs produced also have the capability of revealing much more than can be communicated by a child through writing or even the spoken word, as photographs can capture images for which no words exist. We would add to these advantages that student generated photographs engage students in data collection making them co-owners of the data. In previous work (Lewis, 1998) I have found the use of photographs to be more motivating for students than observations or interview protocols. The photographs also encourage student creativity and make it acceptable where creativity might otherwise be limited by observations or interviews.

Description of MRRT

The Multiple Resonance Reflection Tool (MRRT) used in this pilot study is a photo album that consists of samples of student generated photographs, as well as researchers' summaries of the photographs. The pages of the photo album are pictured in Appendix A. Students took a total of 103 photographs 45 of these were of things that make them think of science. To develop the MRRT we took the 45 science photographs, analyzed them for content, and sorted the objects in the pictures into six categories. The six categories are nature; technology; people; doing science; science content; and abstractions. The *nature* category consists primarily of photographs of trees and plants, there are also pictures of the sky, bird houses, and other nature items usually depicted among trees and plants. The *technology* category includes photographs of household appliances, and electronic devices. The *people* category consists of candid shots of teachers and classmates in non-science settings. There were several other pictures of people taken by students but they were usually identified as "favorite things," rather than things that make you think of science.

The *doing science* category contains photographs of settings where science is done and people in those settings. Among these are photographs of friends, teachers and others in science settings. These photographs of people differ from the people category in that it is the people *and* the setting that "makes me think of science." For example the first author appear in a few photographs because he is "…the science professor, the one who tapes science class." Science *content* photographs include pictures where factual science information is represented. This includes science textbooks, students' notebooks, notes and formulae on the chalkboard, etc. The final category, *abstractions* consists of photos that could not be placed in the other categories but which students report make them think of science. The only photograph that fell into this category is of a bulletin board containing images of fractals.[2]

Table 1 summarizes the distribution of student photographs across the six categories. The majority of photographs are of nature (16 images) followed by technology (11 images) and

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[2] A fractal is a rough or fragmented geometric shape that can be subdivided in parts, each of which is (at least approximately) a reduced-size copy of the whole (Bourke, 1991).

doing science (10 images). One unexpected result is the low number of content images. There were only four of these photos and all four content pictures were taken by one student. Other interesting trends appear when looking at the number of photos taken by individual students. For example, student #3 had seven photographs of doing science (far more than any other student), five photos of technology (more than any other student), and only one photo of nature (far fewer than other students). Student #2 had three photos of people whereas no other students had photos in that category. She also had one abstract photo where again no other students had any in that category.

	Nature	Technology	People	Doing Science	Content	Abstract
Student #1	6	3		1		
Student #2	5		3	1		1
Student #3	1	5		7		
Student #4	4	3		1	4	
TOTAL	**16**	**11**	**3**	**10**	**4**	**1**

Table 1 – Distribution of Student Photographs

These trends suggest a couple of things. First, this simple categorization provides a succinct overview of how these students' view science and what ideas about science they might be more ready to receive. For example student #3 (who had seven doing science photographs) might be more receptive to learning about the inquiry aspect of science than the other students. Or she may more easily accept the idea that science is a human endeavor. In contrast student #4 may be more amenable to learning science postulates or to understanding science as an authoritative body of factual information. Second, the stark differences in the students' photographs reemphasizes the importance of not drawing broad conclusions about students' views of science from this data. Only four students from very similar backgrounds evidenced notable differences in their views of science. The addition of more students and students from more diverse backgrounds would likely result in many unexpected categories and possibly very unpredictable distributions.

The MRRT photo album consists of 21 pages. There is an introductory statement on the importance of students' prior knowledge followed by a description of the photo album and an explanation of how the photographs were generated. For each category there is a heading and a description of the pictures that comprise that category. This page is followed by one to three sample photos from each category. The next section describes the pilot study wherein the MRRT was used.

Description of Research

Methods

How could a pictorial summary of students' science knowledge serve as a reflection aid for teachers working to present school science that is resonant with students' everyday science knowledge? To explore that question we first developed the Multiple Resonance Reflection Tool as described in the previous section. We then enlisted eight preservice teachers to complete a three-part task on course creation. Four of the students used the MRRT to complete the task while the other group completed the task without the MRRT. Of the eight preservice teachers participating in the study six earned their BS degree in biology and are seeking certification to teach high school biology. Of the two remaining teachers one earned a BS degree in chemistry and seeks certification in high school chemistry; and the other earned a BS degree in geology and seeks certification in middle school earth/space science. Both non-biology teachers were members of the experimental group. The group consisted of six females and two males evenly distributed across experimental and control groups; and there was one African American, the remaining students were Caucasian.

Data Collection

The Course Creation Exercise (in Appendix B) opens with a *background statement* on the importance of students' everyday knowledge and a *summary explanation* of the exercise. The summary explanation given to the experimental group differed from that given to the control group in that it included a statement telling them to read through the photo album and encouraging them to use the album to complete the exercise. Following the summary explanation, the Course Creation Exercise directed teachers to complete three tasks: Brainstorming Ideas, Writing Objectives, and Developing Activities. In the first task, Brainstorming Ideas, teachers were instructed to "Make a list of ideas that students might have (prior to your course) that would help them to understand your course on Genetics." The second task, Writing Objectives, instructed teachers to "...write a list of objectives that describe how students should or could apply their knowledge of genetics, learned in your course, to their everyday lives." The third task, Developing Activities, instructed teachers to "Describe 3 activities that you could use in your course on Genetics." The entire exercise took 30-60 minutes to complete.

Data Analysis

Responses to each of the three tasks were analyzed by the authors working independent of one another using predetermined sorting criteria. Discrepant items were discussed jointly until we arrived at agreement on item sorting. There was over 95% initial agreement on sorting across all three tasks. All discrepant items were resolved so that there were no ungrouped responses. Any items that were not informative enough to be categorized were omitted from consideration. In the first task, Brainstorming Ideas, responses were grouped as either everyday science knowledge or school science knowledge. If (from our judgement) the response was an idea that students would likely get from everyday experiences then we rated it as everyday science knowledge. If it was more likely that the idea was one students would get from prior instruction then we rated is as school science knowledge. One guide that we used in rating these items was the source of the information. Ideas that were more likely garnered from friends and family, popular media, and students' observations were rated as everyday science knowledge. A second guide was the terminology used to express the idea. Ideas that were expressed in more scientific terms were rated as school science knowledge, whereas ideas expressed in everyday terms were rated as everyday science knowledge. Table 2 provides some examples of teachers' responses and our rating choices.

RESPONSE	RATING	REASON
"Children have similar DNA make-up as their parents (can be used for paternity tests)"	School Science Knowledge	Terminology
"Children have traits from both mom and dad"	Everyday Science Knowledge	Terminology
"There are a number of genetic mutations"	School Science Knowledge	Source/Terminology
"Sometimes a fluke can happen: two normal colored parents can have a child with albino characteristics"	Everyday Science Knowledge	Source

Table 2 – Examples of Responses to Task #1 - Brainstorming Ideas.

In the second task, Writing Objectives, objectives were grouped as either student centered objectives or content centered objectives. The Multiple Resonance Reflection Tool was intended to help teachers hypothesize about desirable *connections that students could make* between everyday science knowledge and school science. Therefore objectives which in some way sought to foster a personal connection between students and the content or which included students' everyday knowledge, or their out of school resources were rated as student centered. Objectives reflecting content knowledge abstracted from students or independent of students' everyday knowledge were rated as content centered. Table 3 provides some examples of teachers' objectives and our rating choices.

RESPONSE	RATING	REASON
"Apply information learned about genetics to interpret traits inherited from one generation to the next"	Content Centered	Abstracted from student
"Trace traits of ancestors to determine the family tree and conclude their relatives on basic traits passed along the family line"	Student Centered	Involves the students' family
"Gain deeper understanding of the Human Genome Project and its possible effects on the future"	Content Centered	Abstracted from student
"Explain how science or how 'we' can use genetics to 'our' benefit (i.e. making of insulin and making of hybrid plants...) Genetic Engineering"	Student Centered	Stresses students involvement "we" and "our"

Table 3 - Examples of Responses to Task #2 - Writing Objectives

In the third task, Developing Activities, activities that drew on students' everyday knowledge were distinguished from those that did not. The Multiple Resonance Reflection Tool was intended to help teachers hypothesize about curricula and instruction that *draws from everyday science knowledge* in teaching school science. Therefore we noted activities that required students to rely on their everyday science knowledge for completion. Table 4 provides two examples of teachers' responses and our rating choices.

DRAWS FROM EVERYDAY SCIENCE KNOWLEDGE?	RESPONSE
Yes	"Expression of Genes" Have students determine whether they have dominant (Dd or Dd) trait or recessive (dd) trait expressed - Ex crooked finger, eye color, widow's peak, etc.
No	Using jelly beans and cups, students will do 100 crosses to determine genotype and phenotype ratios. Take 4 opaque plastic cups and each cup represents an allele pair. Two cups per parent. 10 jellybeans in a cup. If the parent is heterogeneous for one trait the cup will have 2 different colors. The same colored jellybeans represent the same gene. For example, if we did a cross of RrQq X RRQq cup 1 would be 5 red for R and 5 pink for r. Cup 2 would be all red. Cup three would be five orange for Q and five yellow for q. Cup 4 would be the same. The girls would pull one jellybean from cup one, one from cup 2, one from cup 3 and one from cup 4. They then determine phenotype and genotype. Pull the jellybeans back and repeat and repeat. Each pair of girls will have a different cross. We will get ratios and talk about the ratios.

Table 4 - Examples of Responses to Task #3 - Developing Activities

Findings

Findings of teachers' responses on the Course Creation Exercise are summarized in Table 5. The table shows that in the Brainstorming Activities task the experimental group had a higher percentage of responses reflecting everyday science knowledge than the control group (73.5% compared to 32%). The table also shows that the experimental group had more total responses to the task, which suggests that they were able to conjure more ideas that students might have about genetics than the control group.

On the Writing Objectives task the experimental group had a higher percentage of student centered objectives than the control group (31% compared to 2.3%). The table also shows that for this task the experimental group identified fewer total objectives than the control group. One explanation for this finding could be that the experimental group, upon seeing and reflecting on students' science knowledge, did not view them as being deficient to the degree that the control group did. Finally for the Developing Activities task we present data on the Introductory Activity as well as a summative count of all activities. It seems reasonable to expect that a teacher wishing to build on students' everyday knowledge would be most likely to plan an Introductory Activity that draws from students' everyday science knowledge to teach new concepts. What the table shows is that the experimental group planned a greater number of activities that draw on students' everyday science knowledge when looking at the Introductory Activity (100% compared to 25%), or all activities (50% compared to 16.6%).

These findings have a number of implications for several strands of research including teachers' access to students' science knowledge, assessment studies, and studies of students' science knowledge. Science teacher educators can also benefit greatly from the development of Multiple Resonance Reflection Tool described in this paper. The following section highlights implications for research and teaching and suggests ways that the tool and research methods employed herein can be improved.

	Brainstorming Ideas			Writing Objectives			Developing Activities			
							Introductory Activity		All Activities	
	Everyday Science Knowledge	Total Number of Responses	%	Student Centered Objectives	Total Number of Responses	%	Everyday Knowledge/Total Responses	%	Everyday Knowledge/Total Responses	%
Control	8	25	32%	1	43	2.3%	1/4	25%	2/12	16.6%
Experiment	25	34	73.5%	9	29	31%	4/4	100%	6/12	50%
Total Responses	33	59	56%	10	72	13.9%	5/12	62.5%	8/24	33.3%

Table 5 - Summary of Findings

Discussion

Implications for Teaching/ Teacher Education

While the data presented in this study do not suggest a transformation in the way teachers think about students' everyday knowledge, they very clearly show that a simple tool such as the MRRT can help teachers to be more mindful of students when planning instruction. Our study explored the influence of the MRRT over a brief period of time (fewer than two hours). It might be too much for science teacher educators to expect such a brief exposure to have significant long-term impact. Another option could be to introduce the MRRT as a teaching strategy. It is a tool that could be used to design or modify instruction, to assess changes in students' science knowledge over time, or to introduce a unit or a topic of study.

One problem we had when sorting through the photographs was that we weren't always sure what students' intended the subject of a photo to be; and without the interviews we would not have known why students took many of the photos they took. An idea that occurred as we assembled the MRRT was to have students take the pictures and create their own photo albums. This would add another dimension of creativity and would provide teachers with a great deal more insight into students' thinking. In student created photo albums, students could create a compelling title for each photograph and also write a one or two sentence summary description of the photograph. The summary might answer "Why did I take the photo?" or "Why does it make me think of science?" Student created photo albums would also be an aid to researchers using this method, in that it would reduce the need for interviews and transcribing.

One drawback of this method for research and teaching is that it is costly. In the study from which the photographs were generated each student received their own camera at a cost of

\$8.00/camera and \$3.00/roll for film development. For one class of 30 students this cost exceeds \$300.00. Costs could be reduced by having students work in groups or share cameras. If used to design and modify instruction teachers could select a representative sample of students to take photos rather than work with an entire class. A second drawback is that students may be limited in the types of pictures they can take by time, space, and access. This could skew results. For example, a student who views a laboratory as being synonymous with science might not take a photo of a laboratory if they don't have access to one. Or if they visit the lab on Saturday and the film is due to the teacher on Friday. One way to minimize this effect would be to allow students an extended period of time to take photographs, to also have them take photographs at different times throughout the year, or to ask "Are there any photos that you wanted to take but were not able? What were they?"

Implications for Research

One limitations of the current study is that it relies on an extremely small, homogenous sample to develop the Multiple Resonance Reflection Tool. As a result of the small sample the tool may be limited in the types of pictures that were presented as representative of science. It is likely that a broader sampling of students' from more diverse backgrounds would have produced a more varied set of photographs. It would also be interesting to see similarities in photos across a larger population. This limitation does not invalidate the current study, as the goal was to see *how teachers would respond* to a pictorial summary of students' science knowledge even if those students were a homogenous group.

There were two other drawbacks of the study all of which relate to the Course Creation Exercise. First, the choice of genetics as the topic of the Course Creation Exercise, may have posed a problem in that a few of the teachers participating in the study spent a semester in a methods course designing units on genetics. The experience of designing a genetics course over a four month period may have had an unexpected influence in the completion of the Course Creation Exercise.

Second, some teachers in the experimental group suggested that the MRRT would have been more beneficial had the photos been targeted to the subject of Course Creation Exercise. So, students could have taken seven photos of "things that make you think of genetics." Future research using the MRRT should consider topic specific photographs. There are several research issues raised by this study which could be explored in future research. One would be to explore teachers thought process as they reflect on photographs in designing or redesigning instruction. A second would be to study the impact of the MRRT over a protracted period of time, perhaps for the duration of a methods course or throughout a certification program. It would also be interesting to explore how the task of taking photos of "things that make you think of science" influences students' reflection on science.

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BACKGROUND

Students begin school with a tremendous amount of scientific knowledge. They do not always realize that their knowledge is about science and they may not be able to articulate scientific principles. However, successful science instructors use this knowledge as a resource for introducing new science concepts.

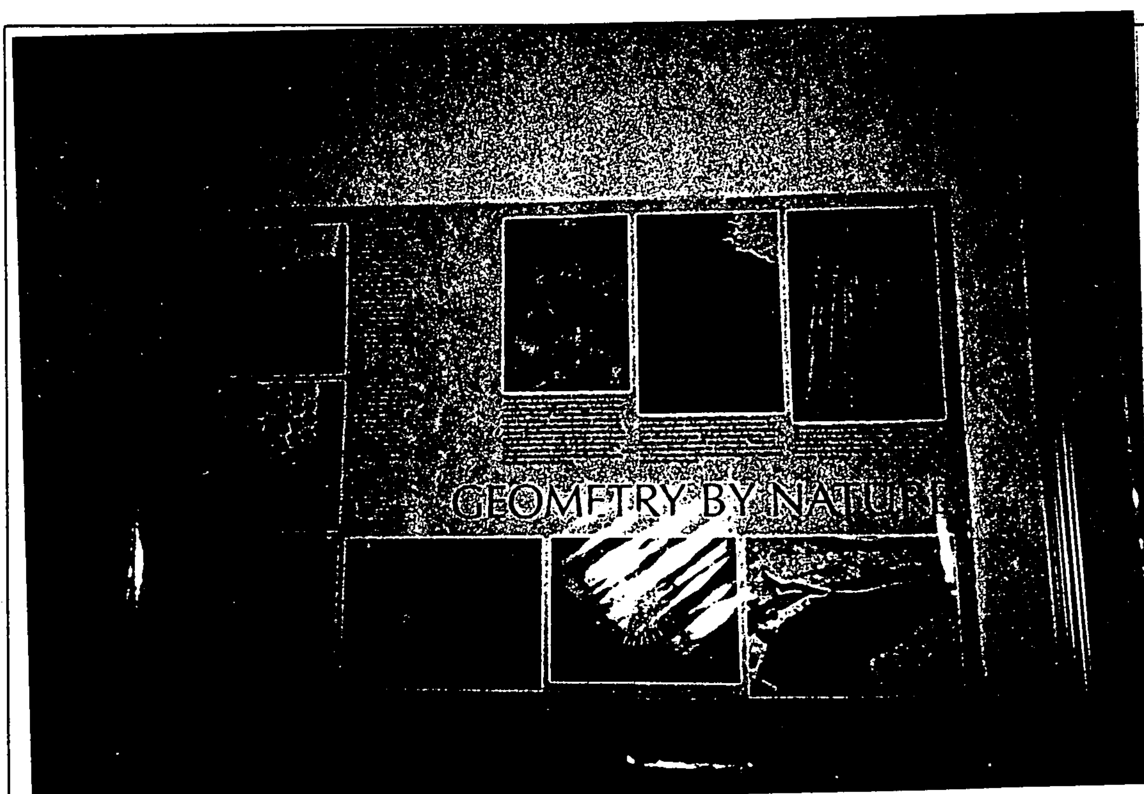
Description of Album

The pages that follow include photographs taken by middle/upper class, 6th-grade girls and is intended to give you information on their science knowledge.

The students were instructed to "Take 7 pictures of things that make you think of science." The result was a wide variety of photographs that are organized into 6 categories: nature, technology, people, doing science, science content, and abstractions. On the page opposite each photograph is a label indicating the category to which the photograph belongs and a brief explanation of why the object in the photograph pictured made the student think of science.

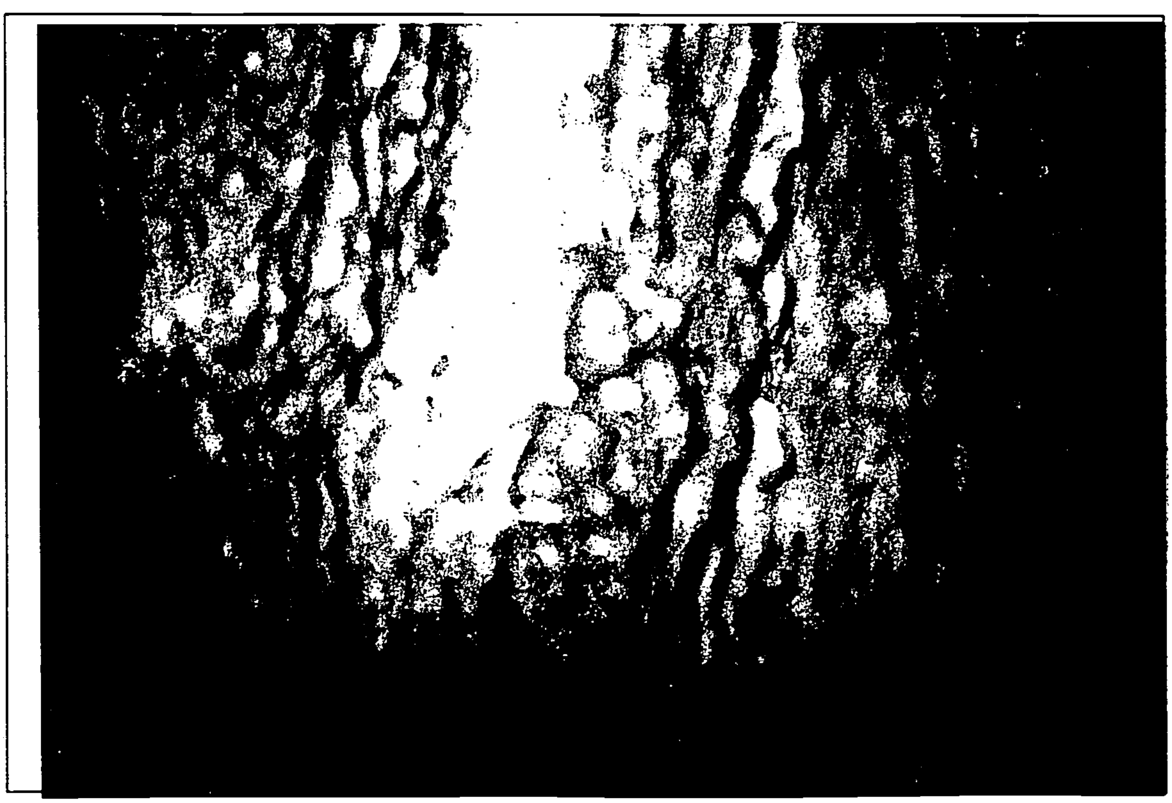
CATEGORY: NATURE

Student pictures contained several photographs of nature. These mostly included panoramic pictures of trees although there were also pictures of plants and flowers.



BEST COPY AVAILABLE

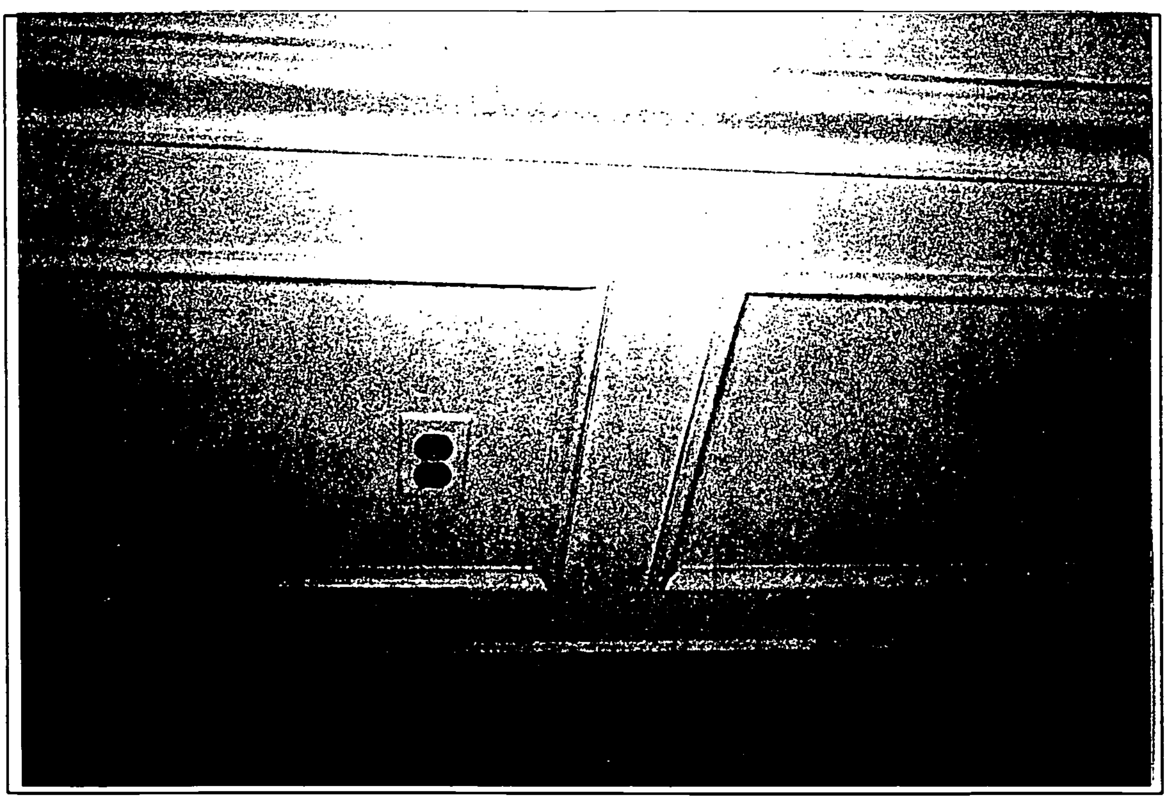
Nature Photos



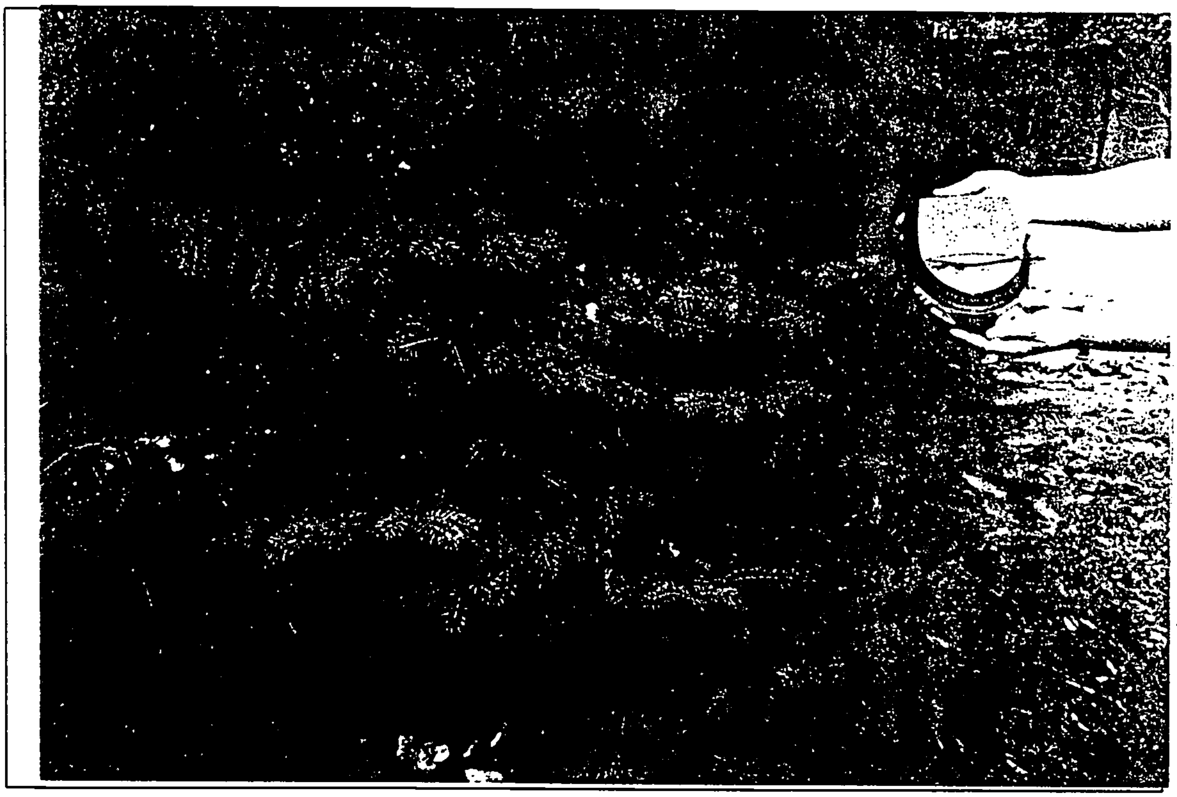
CATEGORY: **TECHNOLOGY**

Student pictures contained several photographs of technology.

When asked how the object in these photographs "make you think of science" students' response was generally "it uses heat/electricity and you study heat/electricity in science."



Technology Photos



CATEGORY: PEOPLE

Some student pictures contained photographs of people.

When asked how the person depicted in this photo "makes you think of science" the student's response was "Because she's weird."

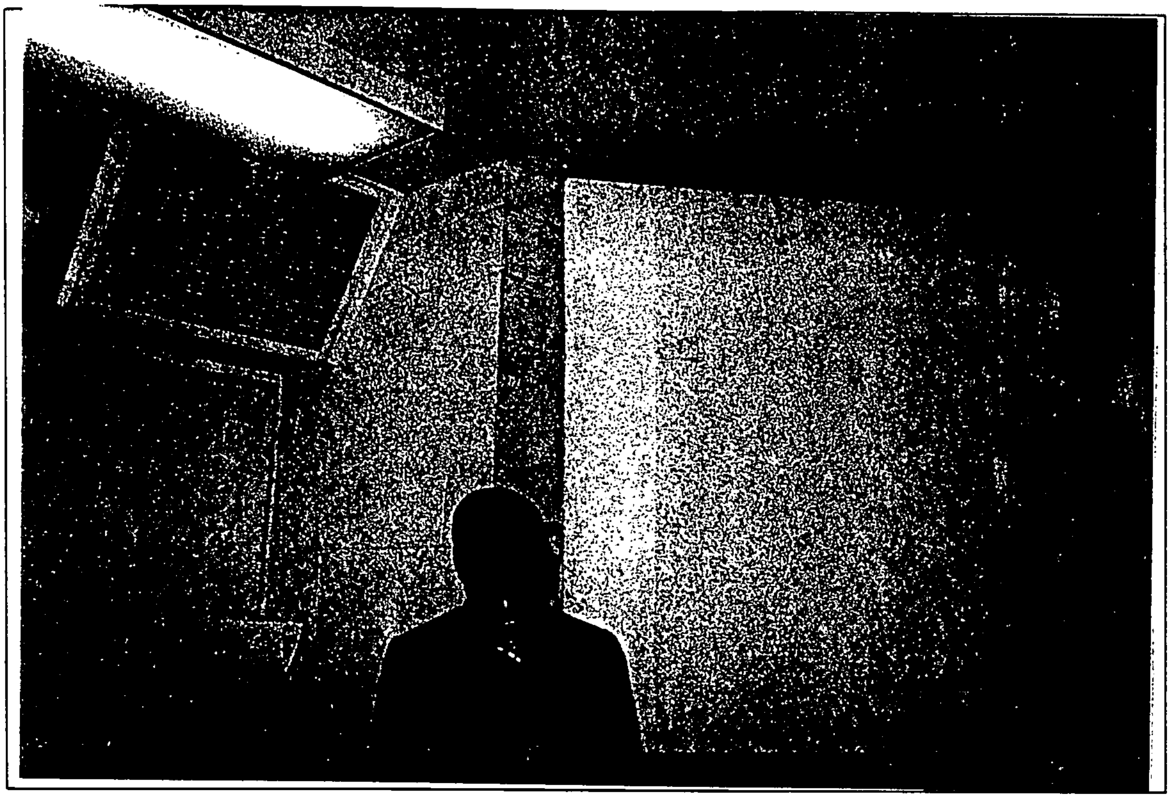
Note: The photo used in this section of the MRRT is not included to protect the students' anonymity.

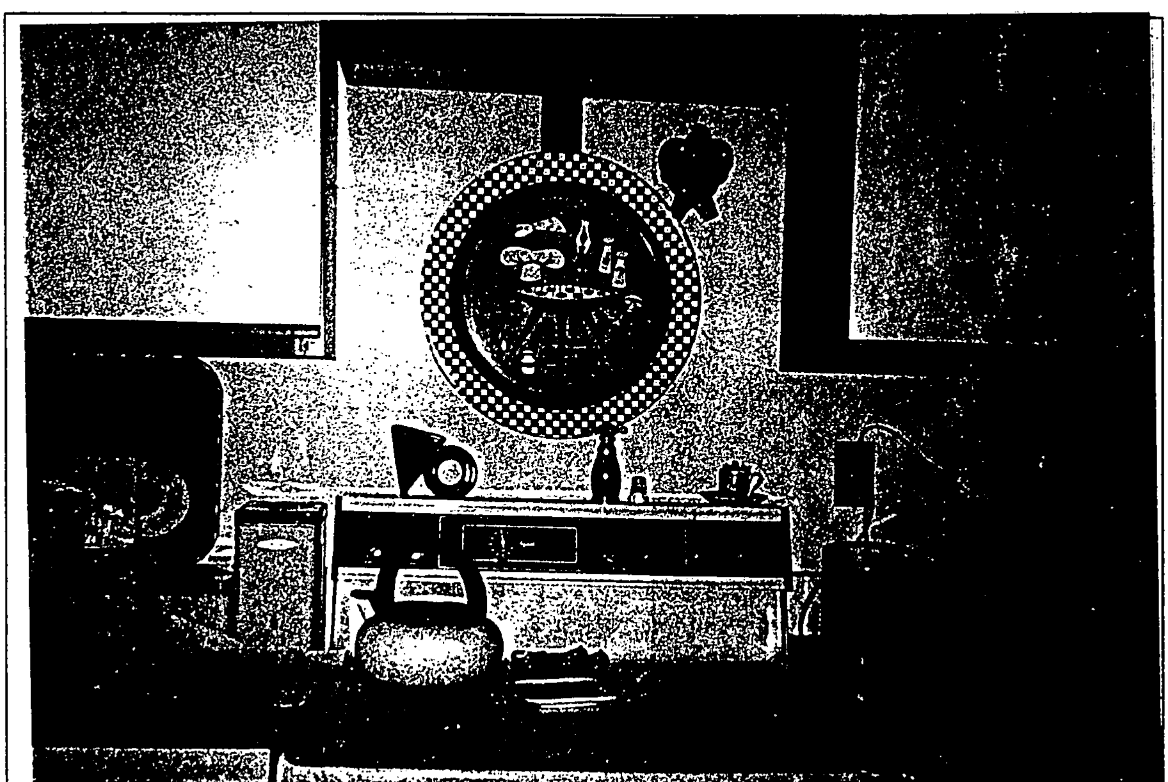
CATEGORY: DOING SCIENCE

Student pictures contained several photographs of the science classroom, science teachers, and science classmates.

When asked how the settings and people depicted "make you think of science" students explained that these are settings where science is done and people with whom science is done.

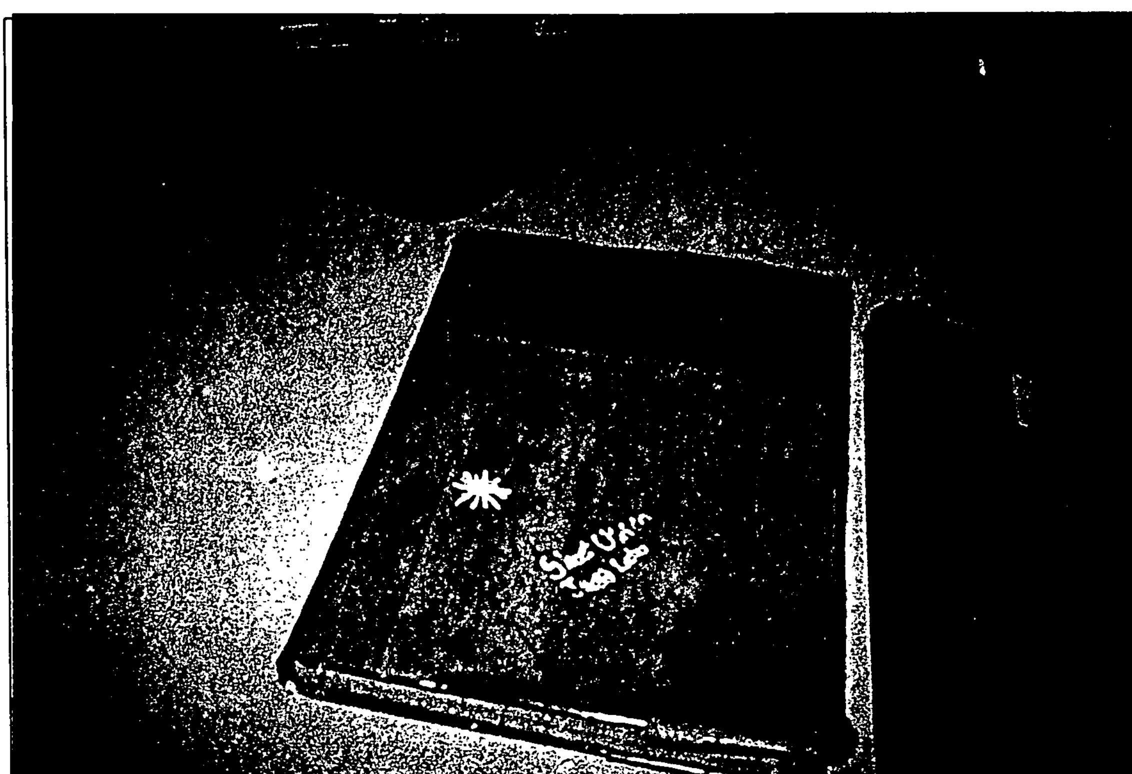
Doing Science Photos



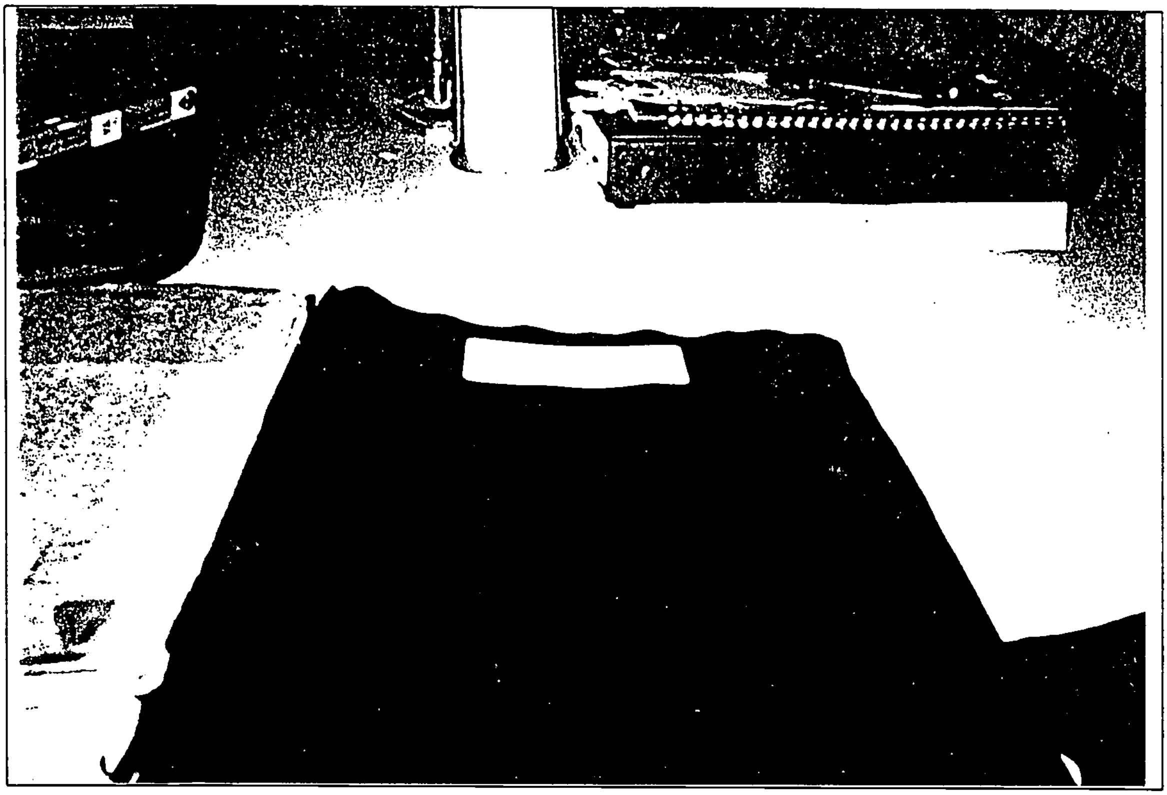


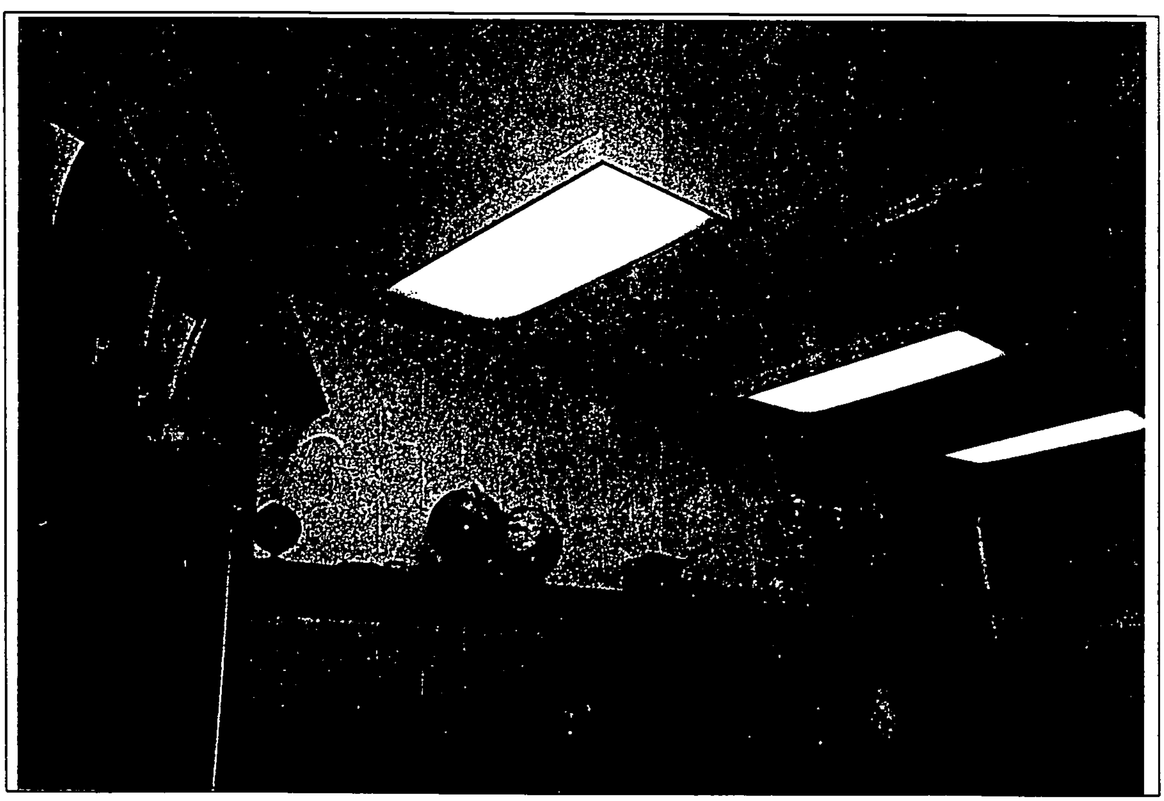
CATEGORY: **SCIENCE CONTENT**

Student pictures contained photographs of the science books, science notebooks, and artifacts from science class.



Science Content Photos





CATEGORY: **ABSTRACTIONS**

Student pictures contained one photograph of a abstract images.

The images in this photograph is a fractal. When asked how the images "make you think of science" the student's response was "it looks 'sciencey' to me. Doesn't it look 'sciencey' to you?"

COURSE CREATION EXERCISE

Background: Children enter science class with a considerable measure of science knowledge gained from previous classes and experience. Successful science instructors use this knowledge as a resource for introducing new science concepts.

Tasks: You are presented with the assignment of developing a course on Genetics for middle/upper class 6th grade girls. To begin writing your course, you will complete three tasks (a) *brainstorming ideas*, (b) *writing objectives*, and (c) *developing activities*. To complete these tasks please follow the directions given below. The photo album contains pictures of "Things that make students think of science." Read through it before beginning the exercise. You may use it as a resource to help you complete the exercise.[3]

Brainstorming Ideas

(a) Make a list of ideas that students might have (prior to your course) that would help them to understand your course on Genetics. Try to be comprehensive, your list can be as long as you wish.

(b) Place an asterisk next to the 5 most important ideas.

Writing Objectives

(a) For your course on Genetics write a list of objectives that describe how students should or could apply their knowledge of genetics, learned in your course, to their everyday lives. Try to be comprehensive, your list can be as long as you wish.

(b) Place an asterisk next to the 5 most important objectives.

Developing Activity

(a) Describe 3 activities that you could use in your course on Genetics. One activity should be an "Introductory" activity (taught at the start of the course); one activity should be an "Intermediate" activity (taught anywhere in the middle of the course); and one should be a "Concluding" activity (taught at the end of the course).

[3] The highlighted portion represents the only difference in what the two groups received (experimental vs. control).

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