SCIENCE EDUCATION
FOR URBAN THIRD GRADERS, CONTINUED

An Interactive Qualifying Project
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Submitted by:

Krystal A. Talbot

Approved by:

Prof. L. Schachterle
Advisor

PREFACE

This project is somewhat unique. It is a continuation of an Interactive Qualifying Project that was conducted in the late fall of 1996 into the winter of 1997. The project team of the original project consisted of three members, Adam Gross, Joseph Plunkett, and myself, Krystal Talbot. The project, Science Education for Urban Third Graders, dealt with the question of how to best teach science to urban third graders, and was conducted by presenting a unit on magnetism to the third grade class at Elm Park Community School. Different forms of evaluation were designed to attempt to answer the question, and their effectiveness was compared and contrasted. Results showed that the children learned most from the factual and process knowledge, but enjoyed hands on experimentation the most. The continuation of the project was to develop an analysis of the unit on magnetism and make recommendations and conclusions based on that analysis.

Some of the content of this report is work that was accomplished in common with the initial IQP. The works done in common are sections 1.1 through 1.2.1, and all lesson plans and surveys.

ABSTRACT

This Interactive Qualifying Project was a continuation of a previous IQP performed at a local public elementary school. This project involved developing an analysis of the lesson plans and subject matter implemented in teaching a unit on Magnetism to a third grade classroom. The analysis confirmed that the best way to teach science is through traditional lecture style, hands-on experimentation, and group learning. With additional recommendations of how elementary school teachers can educate themselves to advance their teaching approaches in science education.

ACKNOWLEDGEMENTS

I would like to first thank my original IQP partners, Joseph Plunkett and Adam Gross for participating in this project with me. Secondly, I would like to thank Mrs. Erma Merrill of Elm Park Community School for allowing us to present our lesson plans to her class. Thirdly, I want to thank Pat De Santis and Mrs. Jacqueline Bonneau for their time and input. Finally, I want to thank my advisor, Professor Lance Schachterle for his encouragement and guidance.

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1. Introduction

This Interactive Qualifying Project addresses the education of science to elementary school children, specifically grades three through six. The goal of this project is to evaluate teaching approaches, such as traditional lecture style, hands-on experimentation, and group learning.

Determination of the effectiveness of these approaches was carried out through the analysis of previous Interactive Qualifying Projects and interviews with Pat De Santis, science coordinator of the Worcester Public Schools, and Mrs. Bonneau of the Math and Science Department from Mass Academy of Math and Science. The previous IQP's implemented a cooperative science curriculum involving a hands-on approach to science education for third graders at Elm-Park Elementary School. One project entailed meeting for one hour three times a week for approximately six weeks. The topics covered were the Earth, the solar system and space travel. These main units were broken down into daily lessons that included investigations of the sun, planets, atmosphere, gravity, moon, shuttle, launch and satellites. Another project focused on giving the third graders a feeling for science, which they could take with them from Elm Park Elementary School, and carry with them for the rest of their lives. To do so, a single subject was presented that could provide children with many hands-on experiments, and a greater understanding of how the world and modern technology work. Classroom lessons were held for one hour once a week for seven weeks.

Both projects and interviews dealt with issues on classroom diversity, co-operative learning, teacher-student diversity, presenting science to children, and the necessity of teacher's science education background.

1.1 Problems With Elementary Science Education

1.1.1 Educator's Science Background

Many blame the teachers' lack of science background for their inadequate presentation of science to children. In 1983, the National Science Teachers Association (NTSA) set a standard for the minimum amount of science education that elementary school teachers should have in order to be well prepared to teach science to children. Their recommendation was one course in the subjects of biology, physics, and earth science. By 1989, only 34 percent of all elementary school teachers had met this standard. In 1992, NTSA revised their guidelines for the quantity and diversity of the science courses elementary educators should complete as a part of their teaching education. In the new standard, prospective educators are recommended to take courses including: biological, earth/space, environmental, life and physical sciences. These courses were also specified to pursue topics through laboratory and field experiences.[1]

These guidelines have a two-fold purpose. The first and most ostensible purpose is to expose the future educators to a more diverse science background. This increased experience in science will give teachers the confidence they need in their science knowledge to teach the subject well. Additionally, the wider range of topics will give the educator a broader framework of scientific understanding. An extended framework will allow the teacher to put the complex dynamics of the physical world into perspective, and make assimilating new information easier. Also, knowing the interconnectedness of a large variety of topics in science can allow for a more dynamic learning environment since the connections between topics can be more readily explored. The second motivation behind NTSA's recommendation is to help teachers think about science more like scientists and less like non-science majors. Students who become teachers are rarely science majors and often have the disadvantage of only having didactic experiences with science. They are taught science in a manner that is suitable for adults, who have more experienced views of the world. Adults are taught science in abstract terms, a series of physical laws and rules that are absolute in nature. This mode of thinking about science is often mistakenly applied in the education of children. In fact, many experts in the area believe that the key problem in making science more pedagogically successful is the actual method used in teaching.[2]

Although some science teachers actually meet the NTSA standards, often the science courses they take are not of high caliber. About half of all elementary candidates took their science requirements at a community college.[3] Unfortunately, this kind of exposure to science often does not leave the teachers prepared to teach science in a way that will adequately prepare today's children to deal with tomorrow's science.

Even when teachers have an acceptable science background, often they have not kept their knowledge updated. One half of all elementary school teachers took their last science course more than ten years ago. Thirty percent have not taken a science course in the past five years.[4] While the bulk of the information may not have changed, the teacher taking the class certainly has. It is important for teachers to continually re-expose themselves to science so that their own personal understanding may grow as they do. A maturity in specific topics will allow the teachers to present science with a wider variety of styles. This breadth in teaching styles will allow the teacher to make more effective presentations to students with a wider variety of learning styles.

1.1.2 Presenting Science to Children

The crux of the issue seems to be in a misunderstanding, by the teachers, of how children perceive science.[5] As stated previously, many teachers try to teach children "our" science of physical laws and facts. In teaching science as fact, many children simply cannot comprehend what is being told to them. They then resort to memorizing the facts and garner little understanding or belief of what they are being told.[6] It is critical to realize that children, especially at the third grade level, understand science in a very "common sense" manner. Their knowledge and ability to understand stems from what they have observed in the world around them.[7] This makes it very important for children to experience for themselves what they are being taught. Without this experience, it is very easy for children to take what they have been told and draw false conclusions. These misconceptions are fostered because children like to fit what they have been taught into the framework of what they have previously experienced. Pre-instructional misconceptions are also a barrier to children understanding science. These misconceptions are formed when children have observed a certain phenomena in their every-day lives then make a casual link that is incomplete or inaccurate. Either way, misconceptions are a barrier that must be surmounted of learning is to take place. If the misconceptions are not overcome, children will persist in their mistaken belief. Often, they are told two inconsistent beliefs, one intuitive and one formal. This problem is compounded by children's total lack of understanding of science as a series of laws (the way it is often presented). It is easier for children to simply store the facts they have been told for use in school, and to operate with the understanding that they have formed based on their observations.[8]

If observation formed the incorrect belief, then observation should be able to resolve the belief. Thus displays and demonstrations are critical to resolving inaccurate beliefs about science. It is suggested that arrays of demos that children can play with be used not only to illustrate the underlying principles, but also to give the children novel experiences. A topic's newness can often determine the amount of motivation that a child will have to pursue understanding in that area. An element of surprise in the demonstration can also greatly augment its overall effectiveness.[9]

Once an interest in the sciences has been established, teachers must nurture the sentiments and encourage children to continue in their growth. Growth can be stimulated if teachers provide children with the opportunity to think critically about science. One good way to do this is through free response exercise. Asking a child an open-ended question opens a number of doors to learning. It gives the student a chance to think aloud and sort through the confusion that may be hindering understanding. Also, the answer given by the student can give the teacher a good insight into the child's misconceptions or insights on any topic. Feedback from the children gives the teacher an opportunity to restructure his or her presentation of the concept and make the process more effective.

Learning the process of science is paramount to imparting to children the desire to learn more about science. If children are taught science the way scientists learn science, they will gather the confidence to answer their own questions in science. Children must follow the process of an idea as far they can, like a scientist. Then the child must be directed further in the process by the guiding questions or experiments as posed by their teacher. Teachers must allow children to evolve their ideas through time in a spiral approach. As the ideas come around anew in the spiral, there will be a new "spin" on the idea. This will allow the child to revise their previous interpretation of the idea, and gain a deeper understanding in the principles involved.

As children build a deeper understanding, they will begin to see the connections between various topics in science. It is important to seize the momentum of these intuitive leaps, and follow them to wherever they may lead. These unexpected paths can often prove to be the most beneficial to a student's learning. Little adventures in science also give children a good opportunity to apply the process that they have been learning to a new situation. Once again, success in these serendipitous pursuits will build the confidence that children need to continue to pursue science in their adult lives.

1.1.3 Student-Teacher Diversity

A second problem in science education at the elementary level is classroom diversity. There exists a great disparity in the percentages of the ethnic groups and genders represented by the teachers and their students. Several problems arise from the fact that elementary teachers are predominately white females. In 1992, ninety percent of elementary teachers were women and 88 percent were white. Commonly females and minorities receive less scientific education than white males.[10] This automatically puts women at a disadvantage when teaching elementary science. The mostly white teachers of America also make it more difficult for minority children to become interested in science. If a child's teacher is of the same ethnicity or gender, the child may very well be more likely to view their teacher as a role model, and become more interested in the subject their teacher is teaching. Increased attention to science over time will lead to increased confidence in children.

Unfortunately, this confidence does not seem to develop in minority children with the same frequency that it develops with others. This is evinced by the number of minorities entering the scientific job market. Indeed, this shortage in confidence is thought to come directly from the fact that minority students do not pay enough attention to science or to school in general. This attention deficit is not caused by lack of intelligence. Rather, it is caused by stress. Stress is often generated by student teacher cultural mismatch. One of the greatest sources of stress for minority students is when a teacher adopts the practice known as differential treatment, an activity that can send a student on a deadly downward spiral. Differential treatment occurs when an educator expects a quality of work and progress that is variant based on gender or culture.

Differential treatment is most visible in an area such as reading. A slow reader is usually never asked to read for meaning. Instead, they are asked to read for phonics. Thus they never develop the skill of reading for comprehension, only hone their phonetic skills. As time goes on, students learn to expect less of themselves. Especially when their cultural experience tells them that they can expect to accomplish less that those of other races as evinced by the numbers of minorities entering scientific and technical fields.

One of the most significant reasons for the poor initial performance of lower class and minority children is the lack of a level playing field. Often this type of student has two major disadvantages. The first is in the frequency of quasi-academic activities. This type of activity includes asking "known answer" questions to re-enforce a child's knowledge. This is often done when more advantaged parents read to their children, an activity that not many of these less privileged children enjoy. The second and more damning area of inequality is in the reading levels. A lower reading level can give children a feeling of inadequacy and also cause stress which lowers attention levels, as stated previously.

One of the most promising solutions to the problem created by disparity in the initial condition of students is pre-school. It was created to offset early negative imprints, and appears to work. Although pre-school does not yield the results it was expected to render, it does hold some interesting promises. Pre-school seems to give children an initial gain in school. However by second grade, this difference seems to equalize and disappear. This amazing result does not come until high school when former pre-school students tend to do much better than their peers of similar background who did not attend pre-school. In addition, this confidence will allow them to attack more and more difficult problems in science. Thus, student teacher homogeneity could then become a very effective tool in motivating a more diverse population to pursue a future in science.

1.1.4 Co-Operative Learning

Another element of children's education that has serious flaws is the focus on individual learning. One of the best ways for children to learn is through social interaction with their peers. This practice is known as co-operative learning because it allows children to help each other to understand concepts.[11] When children are allowed to discuss their theories about science with other children, many benefits are derived. Foremost, the discussion of ideas allows the children to hear what the other believe, but also allows the presenter an opportunity to think through their ideas. Children are humans too, and possess the powers of logic. They can see when their ideas do or do not hold up to the scrutiny of others. This external examination of their thoughts allows them a chance to restructure or re-emphasize their ideas.[12]

Even when children's theories about science are wrong, they can still benefit from trying to support their ideas. When children's ideas are challenged, it is important that the child does not just desert their ideas for the majority opinion.

Every time a child has an opportunity to support their idea, right or wrong, they get a chance to exercise critical thought processes. Since they will be growing up in a time when science surrounds them, thinking scientifically will be a definite advantage to them. Perhaps the most important part of the whole co-operative learning experience is the fact that this type of activity force children to develop social skills. In a world where there are more and more different kinds of people, it is increasingly important to be able to communicate ideas to a diverse group. Exposure to diversity at such a young age could also help children to be more willing to accept and understand diversity throughout their lives.

1.2 Objectives

1.2.1 Magnetism

This IQP was took place in a third grade classroom at Elm Park Community School. The first objective of this project was to develop a unit on magnetism suitable for presentation to a third grade class. The unit's aim was to do more than to force children to memorize terms relevant to studies in magnetism. The goal was to also provide motivation for further studies not only in magnetism, but in science as a whole. The science unit consisted of lectures, demonstrations and hands on experiments.

The unit was designed to expose the children to co-operative learning, and begin to teach them how to beneficially utilize group dynamics to help them learn. The group incorporated the use of hands-on experimentation to show the children that many problems in the world can be solved through experimentation and observation. The most important objective was to allow the children to experience science as scientists so they can begin to experience the world around them with a more developed reference frame. The overall objective was to develop the lesson plan, which would be modified upon completion of the project, and presented to Mrs. Erma Merill for future use in her third grade class.

1.2.2 Earth, Solar System and Space Travel

The Interactive Qualifying Project (IQP) that involved a unit on The Earth, Solar System and Space Travel that was taught in a third grade classroom at Elm Park Community School, Worcester, Massachusetts. The project group developed their lesson plans after gathering and studying teaching techniques, assessment techniques, cooperative learning, and multiculturalism in the classroom. The project's goal was to incorporate the techniques and teaching styles to teach the students facts about the universe and stimulate the students interest in science.

1.2.3 Interviews

The purpose of the two interviews was to get a realistic view of the obstacles that teachers and school coordinators face in teaching science to children. Interviewing Pat De Santis, science coordinator of the Worcester Public Schools and Mrs. Jacqueline Bonneau, Math and Science Department of Mass Academy of Math and Science gave insight on the types of science education for elementary school children. These experienced sources can offer their opinion and recommendations on the subject at hand.

2. Methodology

2.1 The Unit on Magnetism

The lesson plan for the unit on magnetism involved the three teaching styles: lecture, demonstrations and hands-on experimentation. Each day's lesson had a distinct and clearly defined motivation for study. The idea was to create a motivation for study and some sort of novel experience with each lesson to make it easier to maintain the children's interest in the subject. Additionally, each day's lesson was to also incorporate some sort of hands-experience, a co-operative learning experience and some practice with critical thinking.

The lesson plans were formed on a rolling basis. This was to allow each lesson to be formed on the progress of the previous lesson, and to give a more timely focus on issues.

Written surveys were conducted daily as the main source of feedback from the children. These surveys were used in place of traditional exams and quizzes. Typically, exams and quizzes are used to gauge the progress of the class as a whole, and to rate the achievement to the individual. This project used the less rigorous surveys to make daily observations of the students. These observations helped give the group an idea of where the class was at as a whole and was crucial in developing the succeeding lesson plan.

In order to make an evaluation of the child's knowledge of the concepts and principles of magnetism, and to try and find out which method of teaching worked best a final exit interview was conducted with each child. Having oral interviews avoided the barrier some of the children with reading or writing problems may have had. Also, conducting the interviews individually left no chance of the students relying on their peers for help.

Determination of the success of the lesson plan and which teaching method worked best was based on the oral interviews that were conducted one month after the teaching unit was complete.

2.2 The Earth, the Solar System, Space Travel

The design of the lesson plan was created around the break up of the unit into three sections: the Earth, the solar system, and space travel. The section on Earth was covered first because the students were most familiar with this topic than the others. The solar system was covered second, in hopes that a connection between the Earth and the planets would be made easily, by both the students and the teaching group. The last topic, which was only brushed upon, was space travel.

The format of this teaching unit was similar in many ways to the unit on magnetism. The success of this unit seemed to outweigh the success of the other. This particular unit incorporated the same methods of mini-lectures, hands-on demonstrations, co-operative learning , and daily evaluations, but this unit had additional methods that would have benefited the unit on magnetism.

This unit issued a pre-test on the first day of class to serve as a basis for evaluating the students' overall performance. This gave the teaching group an idea of what the students already knew before the lesson unit began. This pre-test was compared to a nearly identical post-test that confirmed what knowledge the children gained throughout the unit.

The teaching group used the product of the hands-on activities to create a portfolio for each student. This enabled the group to track each student's progress throughout the entire unit. This also gave the students the opportunity to track his or her own accomplishments.

Another idea that proved to be very beneficial and incorporated co-operative learning was breaking the class into groups, giving them a project, and having them present it to the entire class. This method encouraged the children to work together towards a common goal. It also provided an opportunity for the student groups to compare their results to other students in the class, as well as proving the teaching group to evaluate the teaching methods they employed.

3. Recommendations

3.1 The Lesson Plans

Both lesson plans were successful in different ways. The unit on magnetism was successful in determining the methods of teaching that were most beneficial in teaching science to children. The final oral interviews proved that either the student acquired most of the knowledge that was presented to them or hardly any at all. This may in fact be due to the nature of the subject itself. Pat De Santis agreed that the concept of electricity and magnetism was too abstract to present to third graders. Although he did not disagree that some of the lesson plans were teachable lessons, but should have been carried out in a different manner.

One suggestion he had was to re-do an entire lesson plans if survey results proved the students did not understand the lesson. Repetition of such a plan may have given the teaching group a better idea of the potential learning ability of the class. From there they could have re-vamped the succeeding lessons accordingly.

Another issue that was discussed with Mr. De Santis and Mrs. Bonneau both was that in order for co-operative learning to be effective the teacher must have already developed a relationship with the students. A relationship where the teacher is aware of each student's level of ability and class behavior can enable effective grouping of the students.

The teaching group was at an unavoidable disadvantage with this issue. The only option the group had was a random selection of grouping. Usually grouping was accomplished by having the class call out numbers, 1, 2, and 3 and group up accordingly. Problems with co-operative learning also arose because the class behavior would often get out of control. Children would get overly excited about many of the experiments that they performed. Having to constantly control these behavioral outbursts would distract the rest of the class interfering with the lesson as a whole. Suggestions were made by Mr. De Santis to avoid grouping the class when these behavioral problems occur. The teaching group should have addressed the issue to the class, letting them know that insubordinate behavior would not be tolerated. The group should then have proceeded with only mini-lectures and demonstrations.

The method of co-operative learning has proven to be very beneficial in a variety of ways, as stated previously. The teacher must be aware that methods of teaching and the results that they have a direct correlation of the control and relationship the teacher has with his or her students.

3.2 Redesign of Lesson Plan

The purpose of first lesson plan on the unit on magnetism was to introduce the students to the project group and the concepts of magnets. The concept of magnetism was simplified at this point to the idea that a magnet "sticks" to certain objects rather than attracts (see Appendix A Lesson Plans). Attraction and repulsion is addressed later on in the unit. The group first introduced themselves to the class and explained to that they were there to teach the students about magnets. The group emphasized to the students that all class rules still apply. Then the students introduced themselves to the group.

The group then proceeded with the mini-lecture that was performed in every lesson plan. The discussion to the entire class was approximately ten minutes long and contained the following material:

- Does anyone know what this is? (Showing a magnet to entire class)
- Can anyone tell us what makes a magnet special?
- So you know where you could find a magnet?
    - At home?
    - At school?

*Make sure students understand the concept of magnetism by answering questions and giving further explanation.

The class was then divided into three groups by a counting off method. This was the first occurrence of misbehavior, which could have been prevented. The counting off method was obviously not suitable for this group. The students could not remember what number they had counted off therefore did not know what group they were supposed to be in. Some students did not care what number they had, they chose whatever group that their friends were in. Regrouping the students caused delays, which took away from valuable experimentation time. In the redesign of the lesson plan, a color coding system may prove to be more effective. Paper squares of three different colors could be passed out, each color representing the group the students should belong to and the project team group leader. Besides allowing for more time for the lesson, this organization prevents the children from misbehaving and makes co-operative learning more beneficial.

The experimentation groups distributed the kit of 15 sample materials, one magnet, and a record sheet to note what materials the students thought would "stick" to the magnet and what materials actually "stick" to the magnet. The experiment was introduced then reiteration of the concepts presented in the mini-lecture was performed before the experimentation began. Each student selected one of the objects presented to them and predicted yes/no whether or not the object would "stick" to the magnet. Then each student in the group would give their prediction. Each student and group leader recorded all results. The magnet was then passed around the group to verify predictions. After all objects were verified, the students returned to their desks to complete the survey (see Appendix B Survey Results), given at the end of every class.

By evaluating the survey results, the students understood that what makes a magnet special is that "it sticks". The idea that all metals do not "stick" to magnets was a concept that the students did not comprehend.

The method of guided inquiry would have been most appropriate during the experimentation time. After all the predictions on whether or not the objects "stick" to magnets were complete, the project group leader should have followed up with questions for the group. Giving guided inquiries such as saying, "The magnet does not 'stick' to the penny, but it does 'stick' the paper clip." The students should then question the idea that not all metals "stick" to magnets, but some do. The group leader should continue with similar questions until the students present this concept.

3.3 Creating the Curriculum

The question that this project addresses is what is the best way to teach science to elementary school children. In order for the answer of this question to have the most significance, determination of how to teach teachers to present these methods to the classroom should be developed. Unfortunately, the development of teaching teachers the most effective methods is currently not concrete and left unanswered.

The use of teaching kits has in fact aided many teachers that do not have the educational scientific background to teach science. The use of teaching kits guide teachers with supplying them with a detailed lesson plan and teaching supplies used for demonstration and experimentation. Teaching kits are available for a variety of topics in different subjects for different academic levels. The use of these kits has given teachers a broader basis for developing skills in teaching science to children. Responses from teachers that have used teaching kits have proven that not only does it provide a strong basis for developing a science curriculum but encouraged the teachers to venture out on their own to find interesting books, experiments, etc. that the students can do. The kits provide a basis for the teachers to expand from which they may not find anywhere else. Therefore these kits can be very beneficial in giving teachers ideas on how to present certain subjects, especially science, to their students.

Not only do these kits provide lesson plans focusing on a subject matter but connect other subjects into the curriculum. For instance, connecting writing to science can be done through the following procedure. Present a problem to the class, have them write down what they think will happen, and perform the demonstration with an explanation. After the students seem to have an acceptable understanding of the concept they should then write to their conclusions on what actually happened. Compiling this information in paragraph form is the beginning of developing an analytical essay.

4. Conclusion

Both Interactive Qualifying Projects mentioned in this paper presented a scientifically based topic to third graders. One dealt with a land science while the other dealt with a physical science. Based on a comparison of the entrance and exit surveys, the project on the Earth, the solar system and space travel was a very successful unit. The students exemplified understanding and knowledge of the material that was presented to them. The material that was taught was mostly factual information. Material such as the order of the planets and how long it takes Pluto to revolve around the sun is presented to the class and reiterated through group projects and assignments which instills the material into memory.

Due to the nature of the subject of magnetism, presenting the material as factual information would have been inappropriate. Magnetism is a more abstract phenomenon. It requires observation by the students to verify the concepts and ideas that are presented by the project group. Of course, some factual memorization must occur because some vocabulary is necessary to learn the material and understand what is being presented. The difficulty arises when taking such an abstract scientific subject and making the appropriate links between experimentation and demonstration with the lectures and efficiently utilizing co-operative learning techniques.

Most teachers will opt for the easier way out. To teach the land science which is much easier to present and evaluate and ignore the more difficult physical sciences such as magnetism. It is important for teachers to learn to how to teach such subjects successfully. It is not fair to the young students to have their science education limited because the educators are not qualified or are too intimidated.

5. Future Work

During the interview with Mrs. Jacqueline Bonneau from Mass Academy of Math and Sciences, an idea for future IQP's, or possibly MQP's, was spawned. Students could organize and run a weeklong program for elementary school teachers in the surrounding area. The session could focus on one particular topic related to science that elementary school teachers and students are rarely exposed to, such as magnetism. WPI students could organize workshops that would refresh the schoolteachers with knowledge of the subject and perhaps go a step beyond their previous knowledge. Mass Academy is more than willing to assist any IQP's or MQP's with this program. It would be a great way for WPI to interact with the community and help give recognition to Mass Academy.

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[1] Senta A. Raizen and Arie M. Michelson, eds., The Future of Science in Elementary Schools (San Francisco, California: Jossey-Bass Publishers, 1994), p 14.

[2] David F. Treagust, et. al., eds., Improving Teaching and Learning in Science and Mathematics (New York, N.Y.: Teachers College Press, 1996), p. 4.

[3] Raizen and Britton, p 18.

[4] Raizen and Britton, p 21.

[5] Ibid., p 1.

[6] Eleanor Duckworth, et. al., Science Education A Minds-On Approach for the Elementary Years (Hillsdale, New Jersey. Lawrence Earl Baum, Publishers, 1990), p 6.

[7] Bess-Gene Holt, Science with Young Children (Washington, D. C.: National Association for the Education of Young Children, 1985), p 3.

[8] Treagust, p 2.

[9] Holt, p 40.

[10] Raizen, p 16.

[11] Bonnie L. Shapiro, What Children Bring to Light: A Constructivist Perspective on Children's Learning in Science (New York, New York. Teacher's College Press, 1994), p 37.

6. BIBLIOGRAPHY

Chittenden E. Interim Report: Committee for Assessment in Science Education. Princeton, NJ: Educational Testing Service, 1984

Clewell, Beartriz Chu. Breaking the Barriers. San Francisco, CA: Jossey-Bass Publishers, 1992.

Duckworth, Eleanor, et al. Science Education A Minds-On Approach for the Elementary Years. Hillside, NJ: Lawrence Erlhaum Associates Publishers, 1996.

Duschl, Richard A., and Richard J. Hamilton, eds. Philosophy of Science, Cognitive Psychology and Educational Theory and Practice. Albany, NY: State University of NY Press, 1992.

Hollins, Etta R. Teaching Diverse Populations: Formulating a Knowledge Base. Albany NY: State University Press, 1994.

Hurd, Paul DeHart, and James Gallagher. New Directions in Elementary Science Teaching. Belmont, CA: Wadworth Publishing Co. Inc., 1968.

Karplus, Robert, and Herbert D. Their. A New Look at Elementary School Science. Chicago, IL: Rand McNally & Co., 1967.

Raizen, S. A., and T. Britton. "Science and Mathematics Teachers". In National Science Foundations, Indications of Science and Mathematics Education. Washington, DC: National Science Foundation, 1993.

Raizen, Senta A. and Arie M. Michelson, eds. The Future of Science in Elementary Schools. San Francisco, CA: Jossey –Bass Publishers, 1994.

Treagust, David F, et al. Improving Teaching and Learning in Science and Mathematics. NY, NY: Teachers College Press, 1996.

APPENDIX A

THE LESSON PLANS

Lesson 1

Purpose	To introduce the students to ourselves and the concept of magnets.
Materials	Several Magnets Three sets of each of the following: Paper clip, Nail, Aluminum foil Bottle cap, Wood, Top of desk Leg of desk, Spoon, Cardboard Copper strip, String, Rubber band Styrofoam, Coins What will a magnet stick to documentation sheet.
Procedure	
10 min.	Introduction • Introduce ourselves. • Explain to students the reasons for our presence. • Emphasize that all existing rules apply. • Have the class introduce themselves to us.

10 min.	Begin mini-lecture
	• Begin discussion with entire class as a group.
	• Ask the following questions in order:
	    • Does anyone know what this is? (showing a magnet)
	    • Can anyone tell me what makes a magnet special?
	    • Do you know were you could find a magnet?
	        • At home?
	        • At school?
	• Make sure students understand concept of magnetism by answering questions and further explanation.

25 min.	Experimentation Time
	• Break class into three groups by counting off.
	• Distribute materials.
	    • one kit with all 15 sample materials
	    • one magnet
	    • record sheet
	• Introduce experiment.
	    • Reiterate on concepts presented in lecture.
	    • Explain the rules of experiment.
	        • Have one student choose one sample.

Surveys	- Have them predict yes/no. - Repeat around circle. - Give magnet to first student. - Verify around circle. - Record all results. • Proceed with experiment. • Return students to desks and give survey.

What Will A Magnet Stick To?

	What do you think will stick?		What really sticks?	
	yes	no	yes	no
paper clip				
nail				
Styrofoam				
bottle cap				
wood				
elastics				
string				
top of desk				
coins				
aluminum foil				
spoon				
cardboard				
leg of desk				
copper strip				
another magnet				

Lesson 2

Purpose	Review material covered previously; introduce principles of attraction and repulsion.
Materials	6 matchbox cars 12 magnets (with pole distinction) 3 race boards with 2 tracks Tape (to tape down tracks) Diagram of magnetic poles showing opposites attract and like repels
Procedure 5 min.	Review last lesson's survey. • Read one question off at a time. • Ask class for answer. • Make sure everyone understands.

10 min.	Begin new mini-lecture.
	• Recall that magnets did stick to other magnets.
	• Show children that magnets can also push away from each other.
	• Explain that magnets have north and south poles.
	• Show diagram (from materials).
	  • Explain attraction (opposite poles).
	  • Explain repulsion (same poles).
	• Discussion question:
	If I put the south pole of this magnet next to the north pole of this magnet what will happen?

30 min.	Experiment Time
	• Break up into groups of three (having them count off, 1,2,3,1,2,3).
	Adam – Group 1
	Joe – Group 2
	Krystal – Group 3
	• Group Materials
	  • each take one race sheet
	  • two cars with magnets attached
	  • two magnets
	  • one score sheet
	  • pencil
	  • tape
	• Introduction to Experiment.

	- Reiterate attraction/repulsion. Each group member should understand concept at this point. - Ask how they think they could use a magnet to make the car move. - Unroll, tape down race sheet. - Explain rules of experiment. - Rules - Two players at a time. - Players start across from each other. - Goal is to finish line (off the paper) before the other .player. - Start when group leader says 'GO'. - Score Sheet - Mark winner in appropriate position. - Follow flow diagram.
Surveys	

Lesson 3

Purpose	Review material covered previously; (attraction and repulsion.). Introduce lines of force, magnetic strength, and magnetic force.
Materials	Demonstration bar magnet iron filings construction paper books (to elevate the paper) Experiment (for each group) 3 different magnets 50 sheets of construction paper paper clip result sheet
Procedure	
5 min.	Review last lesson's survey. • Read one question off at a time. • Ask class for answer. • Make sure everyone understands.

15 min.	Begin new lesson
	• Force
	    • Causes a push or pull.
	• Magnetic force
	    • The invisible pull that makes magnets move things .
	• Demonstration
	    • Set-up demo (place paper on books over magnet).
	    • Gather class around table.
	    • Slowly spread filings over paper.
	    • Magnetic force pulls filings into pattern of lines.
	    • Pattern runs from one pole to the other.
	    • Pattern of lines called "lines of force".

25 min.	Experiment Time • Reiterate new ideas - lines of force, magnetic strength. • Show class three different magnets. • Demonstrate with one sheet how magnetic force will hold a paper clip through the paper. • Have the class guess how many pieces of paper they believe

Surveys	each magnet can hold the paper clip through. • Tally results on the record sheet. • Assign specific task to each student. • Secretary: keeps track of record sheet. • Magnet keeper: holds magnet for experiment. • Paper clip tester: tries to make paper clip stick. • Paper holder: stacks paper and keeps count. • Counters: all other students will also help count. • Have students test each magnet with as little guidance as possible. • Have students determine strongest / weakest magnets.

Lesson 4

Purpose	Review material covered previously;(force/lines of force.). Introduce principles of making temporary magnets.
Materials	21 nails 63 paper clips 21 magnets
Procedure	
5 min.	Review last lesson's survey • Read one question off at a time. • Ask class for answer. • Make sure everyone understands.
10 min.	Begin new lesson • Magnets are made of many tiny magnets that all point the same way. • Show on chalkboard a magnet with arrows going all in the same direction. • The metals that magnets are attracted to are also made up of millions of tiny magnets that are not lined up. • Show on board a nail with arrows going in all different directions. • If you swipe a magnet across a nail all the tiny magnets will line up and the nail then becomes a temporary magnet. • Show on chalkboard a nail with arrows going in the same direction. • Label the un-magnetized nail and the magnetized nail on the board.
20 min.	Demonstration time • Have entire class gather in group in area with plenty of room. • One student is the magnet. • Other students are the tiny magnets that make up the un-magnetized metal. They are facing in various directions. • Walk magnet student around others and make them face the same direction. • Emphasize that the students are now a temporary magnet.
10 min.	Experimentation time • Each student will have one magnet and three paper clips.

Surveys	• Make temporary magnet . • Try to attract the paper clip to the temp. magnet. • Allow students to freely experiment and discuss ideas with their piers.

Lesson 5

Purpose	Review material covered previously; special attention to temporary magnets and North and South pole, attraction/repulsion..
Materials	5 sewing needles 5 pieces of Styrofoam 5 shallow plastic containers 1 compass 5 pieces of construction paper
Procedure 5 min.	Review last lesson's survey • Read one question off at a time. • Ask class for answer. • Make sure everyone understands.
10 min.	Begin new lesson Discuss compasses. • The biggest magnet on earth is the earth. • The center (or core) of the Earth is one big magnet; it's a molten metal core made of iron that creates a huge magnet. • Since the earth is one big magnet, are other magnets attracted to the earth's magnet? (YES). • Hang magnet from string to show how North pole of magnet points north. • The needle of a compass detects the earth's magnet. • The north pole of the earth is magnetically speaking, a south pole. (the red end of your magnet, marked North, used to be called the North Seeking Pole, but over time people started calling it simply a North pole).
30 min.	Experiment Time • Break up into five groups. • Distribute group materials. • Groups work together following instructions to build a compass.
Surveys	

Lesson 6

Purpose	Review material covered previously; allow students to complete an activity by him/herself.
Materials	21 magnets (one per student) paper clips 21 rulers (one per student)
Procedure	
5 min.	Review last lesson's survey • Read one question off at a time. • Ask class for answer. • Make sure everyone understands.
10 min.	Review all material • What makes a magnet special? • What will a magnet stick to? • What is attraction/repulsion? • North pole, South pole • Whit is force? Lines of force? • Magnetic strength; are all magnets the same strength? • If you break one magnet in half , will you have two magnets? Will they both have a North and South pole? • What's a temporary magnet? • What's the biggest magnet? Why? • How does a compass work?
30 min.	Experiment Time • Break up into groups of three . • Have students put paper clip on one end of ruler magnet on other. • Move magnet towards paper clip until paper clip is attracted to magnet. • Have students record the distance of the effect.. • Try with different magnets.
Surveys	

Lesson 7

Purpose	Review all material covered previously; discover what students did with their magnets over the week..
Materials	None
Procedure	
10 min.	Review last lesson's survey • read one question off at a time • ask class for answer • make sure everyone understands
10 min.	Begin new lesson • Ask children what they did with their magnets. • Get children to demonstrate that their knowledge influenced their experimentation. • Discuss other uses for magnets.

30 min.	Experiment Time
	• Break children up into three groups to review all topics covered. During discussion, aim for participation of all students.
	    ◦ What makes a magnet special?
	    ◦ What will a magnet stick to?
	    ◦ What is attraction/repulsion?
	    ◦ North pole, South pole?
	    ◦ What is force? Lines of force?
	    ◦ Magnetic strength; are all magnets the same strength?
	    ◦ If you break one magnet in half, will you have two magnets? Will they both have a North and South pole?
	    ◦ What's a temporary magnet?
	    ◦ What's the biggest magnet? Why?
	    ◦ How does a compass work?
	• Ask children to draw a picture about what they learned about magnets and how they work.
	    ◦ Encourage creativity.
	    ◦ Allow focus to be on one topic or many.

Surveys	

APPENDIX B

SURVEY RESULTS

Survey #1 Results

1. What makes a magnet special?

   ✓It sticks: 15
   Incorrect or no answer: 3

2. Circle all the things a magnet will stick (attract) to.

Object	# circled	# not circled	Object	# circled	# not circled
penny	*0*	*18*	leg of chair	*18*	*0*
bolt	*12*	*6*	fork	*15*	*3*
string	*0*	*18*	crayon	*1*	*17*
paper	*7*	*11*	your shirt	*1*	*17*
copper	*2*	*16*	refrigerator	*18*	*0*
nail	*14*	*4*	another magnet	*18*	*0*
pencil	*13*	*5*	chalkboard	*18*	*0*
popsicle stick	*2*	*16*			

3. Do all metals stick to magnets?
   Yes: 8 ✓No: 6 No answer: 4

4. Do you know any place where a magnet is being used?
   At home? Most common answer: refrigerator
   Unique answer: speakers
   At school? Most common answer: chalkboard, chair leg

Comments: The results of this survey imply that the children respond well to this type of testing. Most of the incorrect answers came from ESL students. Also the students seem to rely heavily on their piers for answers. Question 3 seems to have presented some problems. This is most likely due to the wording of the question.

Good

M..rkett

End of Class Survey #1

Remember: Keep your eyes on your own paper.

1. **What makes a magnet special?**

it sticks on

2. **Circle all the things a magnet will stick (attract) to.**

A penny	A bolt	Some string	Paper
Some copper	A nail	A pencil	A popcicle stick
Leg of you chair	A fork	A crayon	Your shirt
A refrigerator	Another Magnet		The chalk board

3. **Do all metals stick to magnets? Yes or No.** (Circle One)

4. **Do you know any place where a magnet is being used?**

At your house?

on your refugerator

on your speakers

At school?

on the leg of your chair

on the chalk board

on your side of your desk

Bod

[illegible]

Jonathan

End of Class Survey #1

Remember: Keep your eyes on your own paper.

1. **What makes a magnet special?**

2. **Circle all the things a magnet will stick (attract) to.**

A penny	A bolt	Some string	Paper
Some copper	A nail	A pencil	A popcicle stick
Leg of you chair	A fork	A crayon	Your shirt
A refrigerator	Another Magnet		The chalk board

3. **Do all metals stick to magnets? Yes or No.** (Circle One)

4. **Do you know any place where a magnet is being used?**

At your house?

At school? Oh the Days of the week

Ugly

Rohaud

itsticto gatr

End of Class Survey #1

Remember: Keep your eyes on your own paper.

1. What makes a magnet special?

2. Circle all the things a magnet will stick (attract) to.

A penny	A bolt	Some string	Paper
Some copper	A nail	A pencil	A popcicle stick
Leg of you chair	A fork	A crayon	Your shirt
A refrigerator	Another Magnet	The chalk board	

3. Do all metals stick to magnets? Yes or No. (Circle One)

4. Do you know any place where a magnet is being used?

At your house? athouse arefrigerator a tosagr

At school? a Zepe afosit

Gina

Good

Survey #2

1. Circle ALL the things a magnet will stick (attract) to.

Nail	Spoon	Penny
Paper	Chalkboard	Shirt
Wood	Another Magnet	Leg of Chair

2. Circle what the two poles of a magnet are called:

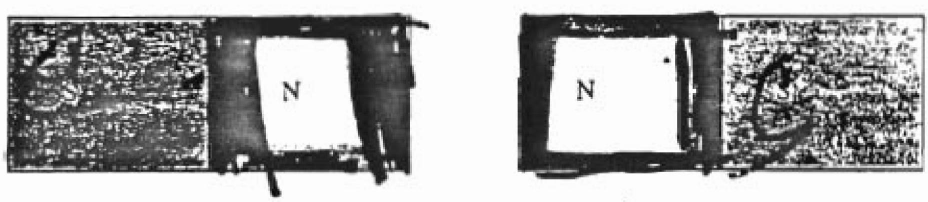
Left Pole and Right Pole

North Pole and South Pole

Up pole and Down Pole

Fishing Pole and Telephone Pole

3. Will these magnets ATTRACT or REPEL ?



4. Opposite sides attract and like sides Repel.

5. Did the magnets used for the car races repel or attract each other?

Repel

[redacted]

Survey #2

1. Circle ALL the things a magnet will stick (attract) to.

Nail	Spoon	Penny
Paper	Chalkboard	Shirt
Wood	Another Magnet	Leg of Chair

2. Circle what the two poles of a magnet are called:

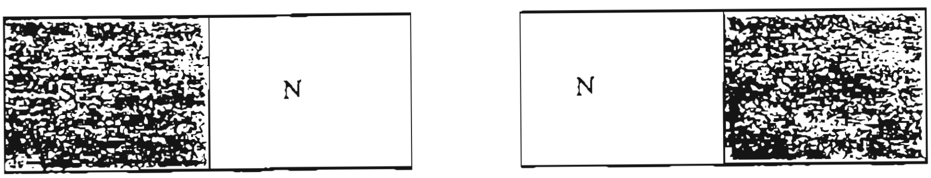
~~Left Pole~~ and Right Pole

North Pole and South Pole

Up pole and Down Pole

Fishing Pole and Telephone Pole

3. Will these magnets ATTRACT or REPEL ?



4. Opposite sides attract and like sides They ripel.

5. Did the magnets used for the car races repel or attract each other?

repel

Survey #2 Results

1. Circle all the things a magnet will stick to.

Object	# Yes	# No	Object	#Yes	#No
Nail	21	0	Chalkboard	21	0
Spoon	18	3	Shirt	0	21
Penny	1	20	Wood	0	21
Paper	5	16	Magnet	21	0
Chair Leg	21	0			

2. Circle what the two poles of a magnet are called.

   Left pole and Right pole: 1.
   ✓North pole and South pole: 19.
   Up pole and Down pole: 1.
   Fishing pole and Telephone pole: 0.

3. Will these magnets attract or repel?

   Attract: 3. ✓Repel: 16. Both: 2.

4. Opposite poles attract and like poles ________.

   Attract: 0. ✓Repel: 21.

5. Did the magnets used for the car races repel or attract each other?

   Attract: 0. ✓Repel: 19. No answer: 2.

Comments: It is becoming more clear that the students rely on each other for the "correct' answers. Also the ESL students require special attention for each question. Again they constitute the majority of incorrect answers.

Survey #3 Results

1. Like poles repel and opposite poles ____________.

✔Attract: 18
Repel: 2

2. The iron filings made lines around the magnet. What were these lines called.

✔force/lines of force: 20
other: 0

3. Do all magnets have the same strength?

✔no: 19
no answer: 1*

4. The poles of a magnet are called the ___________ pole and the __________ pole.

✔north/south: 20
other: 0

Comments: The results of this survey seem to show that the class has a good understanding of the material presented thus far. The fact remains that they are good at "acquiring" the answers from their piers.

** ESL student

Good Jmanyra

Survey 3

1. Like poles repel and opposite poles repel.

2. The iron filings made lines around the magnet. What were these lines called? ~~[illegible]~~ force

3. Do all magnets have the same strength? no

4. The poles of a magnet are called the north pole and the south pole.

3ad

Elvis Elvis

Survey 3

1. Like poles repel and opposite poles attract.

wni of Jcu

2. The iron filings made lines around the magnet. What were these lines called?

3. Do all magnets have the same strength?

4. The poles of a magnet are called the moth pole

and the axill pole.

Survey #4 Results

1. What are there millions of in every magnet?

    ✓tiny magnets: 18
    other: 1

2. What did you have to do to make the nail into a temporary magnet?

    ✓rub with magnet/align magnets: 16
    other: 3

3. Will these magnets ATTRACT or REPEL ?

    ✓repel: 16
    other: 3*

4. Iron filings made lines around the magnet. What were these lines called?

    ✓lines of force: 16
    other: 3

Comments: The results of this survey are more than satisfactory considering the fact that the concepts in this material are more abstract than the students are used to. Again ESL students made up majority of incorrect answers.

*All three answered "both" to the question .

Good

Anh

Survey #4

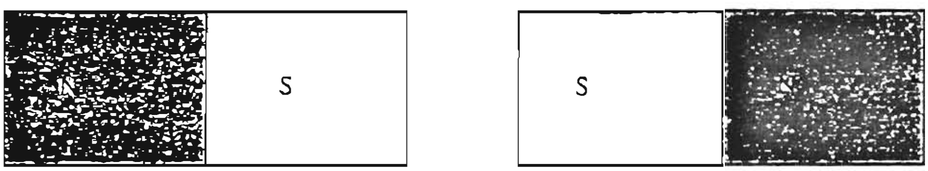
1. What are there millions of in every magnet?

little magnets

2. What did you have to do to make the nail into a temporary magnet?

you have to make all the magnet in the same direction

3. Will these magnets ATTRACT or REPEL ?



4. Iron filings made lines around the magnet. What were these lines called?

lines of force

Alexander Hogan

Survey #4

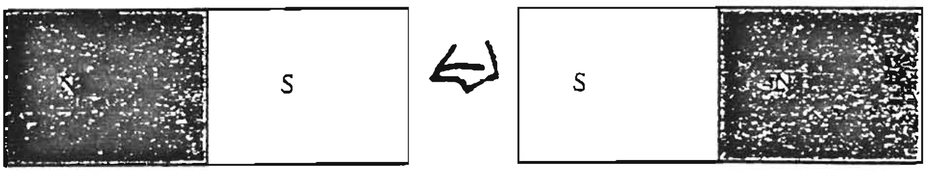
1. What are there millions of in every magnet?

litles magnut

2. What did you have to do to make the nail into a temporary magnet?

you have to get a magnit and rubble it on the nail.

3. Will these magnets ATTRACT or REPEL ?



4. Iron filings made lines around the magnet. What were these lines called?

lines of force

Ugly

Survey #4

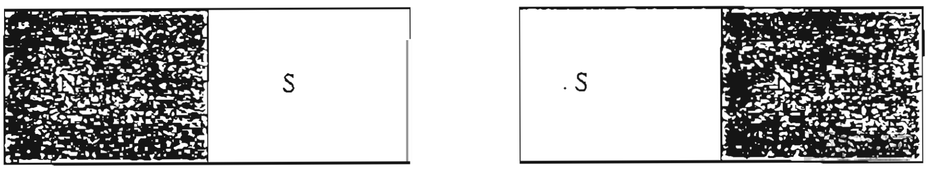
1. What are there millions of in every magnet?

magnet

2. What did you have to do to make the nail into a temporary magnet?

Streat the MOut

3. Will these magnets ATTRACT or REPEL ?



4. Iron filings made lines around the magnet. What were these lines called?

Nouth and South

Survey #5 Results

1. What is the biggest magnet on the Earth?

✓ the Earth: 18
other: 2

2. What does a compass tell you?

✓ north/directions: 19
other: 1*

3. Like poles repel and opposite poles ____________?

✓ attract: 20
other: 0

Comments: ESL students required extra help. Overall results are very good. This is due to the ease of the survey. The survey was made to be easy so as to make up time for the long experiment.

* Student answered in his native language

Good

Pauline Parmutti
Elm Park

Survey #5

1. What is the biggest magnet on Earth?

earth?

2. What does a compass tell us?

it tells us Noth and south?

3. Like poles repel and opposite poles

attract

Dad

Shannia

Survey #5

1. What is the biggest magnet on Earth?

biggest magnet on Earth

2. What does a compass tell us?

North

3. Like poles repel and opposite poles

attract

Survey #6 Results

1. What is force?
   a.) **a push or pull** 11 *
   b.) **lines drawn around a magnet** 10 *
   c.) **I don't know**

2. Magnets are attracted to things made out of:
   a.) **iron** 17
   b.) **copper** 4 **
   c.) **wood**

3. What could you use to find the North Pole of the earth?
   ✓ Compass/magnet: 20
   other: 1 ***

4. If you had two magnets to bring home what would you do with them?
   The nature of this question resulted in a variety of responses, as follows:
   8 students: 'put them on my refrigerator'
   7 students: 'play with them'
   4 students: 'stick on metal'
   3 students: 'have car races with them'
   3 students: 'see if they attract or repel'
   2 students: 'move stuff with them'
   1 student: 'make magnets by rubbing a magnet on a nail'
   1 student: 'do science with them'
   1 student: 'make stuff'
   1 student: 'put on a pencil and attract and repel'
   1 student: 'attract to things made of iron'

Comments: The results of this survey and previous ones, exemplifies that the students have retained material taught to them. The variety of responses to question 4 shows that the hands on experiments have influenced their knowledge of the subject. Next lesson will truly exhibit how creative the students got with their knowledge.

*This question is a bit two-sided, both a) ans b) are correct. The responses show us how the class conceptualizes force.
**Most of the class answered this correctly. Confusion may be results of the lack of experience with metals.
***The one student that answered incorrectly answered 'north'

Good

Survey #6

1. What is force?

   a.) a push or pull
   b.) lines drawn around a magnet
   c.) I don't know

2. Magnets are attracted to things made out of:

   a.) iron
   b.) copper
   c.) wood

3. What could you use to find the North Pole of the earth?

   a Con[illegible]

4. If you had two magnets to bring home what would you do with them?

   I would play with them and
   stick them on my refrigerator.
   I also would [illegible] if they attracted
   to things made of iron.

Tra Tanga

Survey #6

1. What is force?

   a.) a push or pull
   lines drawn around a magnet
   c.) I don't know

2. Magnets are attracted to things made out of:

   a.) iron
   copper
   c.) wood

3. What could you use to find the North Pole of the earth?

   campest

4. If you had two magnets to bring home what would you do with them?

   atica is am
   metal or mare
   atufe with it !!

[illegible]

Survey #6

1. What is force?

   a.) a push or pull
   ~~b.) lines drawn around a magnet~~
   c.) [redacted]

2. Magnets are attracted to things made out of:

   a.) iron
   ~~b.) copper~~
   ~~c.) wood~~

3. What could you use to find the North Pole of the earth?

   a compass

4. If you had two magnets to bring home what would you do with them?

   Tri to Repel and attract the magnets. Stik the magnets whit another things.

Final Survey Results

1. What is the special metal all magnets attract to?
   a) Wood: 0
   b) Chair leg: 1
   c) Paper: 0
   d) Iron: ✓17
   e) Chalkboard: 2

2. Will these magnets ATTRACT or REPEL ? Circle one.

✓attract: 19
repel: 1

3. Which magnet is stronger and has more force? Magnet A or Magnet B.

✓magnet B: 20
magnet A: 0

4. What does a compass tell you?

✓north/directions/NSEW: 18
other: 2

5. Do you think learning about magnets was fun?

✓yes: 20
no: 0

6. What part of learning about magnets did you like the most?

Most common answer: The race cars: 16
Other answers: 4

MAKING A COMPASS

1. Do you have everything you need? (bowl, needle, magnet, Styrofoam, construction paper, and a marker)

2. Have one of the teachers put some water in your bowl.

3. Make needle into a temporary magnet. To do this swipe the needle with the magnet 20 times (swipe in one direction).

4. Stick needle (now a magnet) through Styrofoam.

5. Float Styrofoam in water and wait for it to stop moving. Try to keep the needle from touching the side of the bowl.

6. Raise your hand to have a teacher check if the needle is pointing north.

7. Label North, South, East, and West on paper.

Good Job! You made a compass!