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ABSTRACT

Museums are the fastest growing educational institutions in the United States. They provide the introduction to science for many children and are a major source of continuing education for adults. This paper discusses cooperative programs between The Children's Museum (Indianapolis) and the Indiana University School of Education. These programs are built around a series of open-ended, Piagetian type interviews of visitors conducted by preservice teachers. The interviews are aimed at determining a visitor's perceptions and scientific explanations of the exhibits. Beginning with a history of the museum and the development of its hands-on, interactive Science Spectrum (an 11,000 square foot exhibit of physics and chemistry for children), the paper considers variables critical to designing the museum environment. Several questions about adult/parent affects upon learning in museums, children's learning, and items for future research are raised. Field experiences of the preservice teachers, goals of their activities, and course requirements are described. Several examples of interview data are provided, along with a discussion of the effects of the data on the design of exhibits, the development of science objectives and curricula, and improvements in prospective teachers questioning techniques. (Author/DH)

The Mutual Benefits of Children's Museum / School of Education Cooperation

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Overview of the Museum and Science Spectrum

I. The Children's Museum

Founded in 1925, The Children's Museum is the fourth oldest museum for children, and the world's largest. Each year more than 1.2 million children and families visit the museum's new 230,000 square foot building, making it one of the most popular museum's in the nation. Admission to the museum is free.

Unlike other well-known youth museums which are primarily experience centers, The Children's Museum's purpose is to use its collection as a basis for interpreting the past and present. The museum diffuses knowledge through exhibits, programs and activities, providing academic enrichment and quality leisure educational experiences. More importantly, the museum strives to encourage an appreciation and understanding of history, natural and physical science, and people of other cultures.

While it is considered a general museum, The Children's Museum is the major science-technology center in Indiana. Participatory exhibits in physics and chemistry, natural science, geology, paleontology, archaeology and computers are the most popular areas of the museum. Other major exhibit areas include one of the world's largest collection of model trains, a turn-of-the-century Denzel carousel (reconstructed on the museum's fifth floor), Mysteries in History (opening in June), Pastimes, a locomotive and train exhibit, and Playscape, a gallery just for children ages two to seven.

In spite of its appellation "The Children's Museum," the name "family museum" might better describe the museum's audience. Over 50 percent of its visitors are adults (children of course usually come with an adult). The museum's attendance-by-age curve decreases sharply with increasing age. The museum's slogan states its appeal and perhaps best sums up its philosophy: "for anyone who is or ever was a child."

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II. Science Spectrum

In December of 1979 The Children's Museum opened Science Spectrum, an 11,000 square foot exhibit of hands-on physics and chemistry for children. The museum unabashedly "borrowed" exhibit ideas from two ground breaking science centers, San Francisco's Exploratorium and Toronto's Ontario Science Center.

Science Spectrum is a smorgasbord of science. Exhibits include giant parabolic dishes that focus a child's whisper to a listener 100 feet away; wildly spinning angular momentum platforms; pulleys, levers and gears; batteries bulbs and wires; a 5-meter air track; an inverted hyperbolic cone (which children call the black hole) where pennies are launched into "orbit"; and much more.

The philosophy driving the development of Science Spectrum was one of children manipulating objects, apparatus, light and hopefully their own conceptions of science, to help them understand and enjoy science. Museums have an important role in developing science attitudes in young learners, a role which is considered by many to be more important than any cognitive impact the museum experience might have. I might ask you as science teachers to consider what impact having a class full of young people who spend Saturdays at the local science museum, might have on the quality of your science teaching experience.

Science Spectrum's success in the affective domain is not difficult to substantiate. Even the casual observer can sense the excitement and unabashed enjoyment experienced by Science Spectrum visitors. But what evidence of cognitive gains are there? How are children's concepts of science altered by the museum experience? If the informal learning experience is to be accepted by educators as a valid cognitive intervention, research will have to substantiate its effectiveness. But there are problems. Traditional research methodologies may not apply to the informal museum environment. Further, even our notions of what we want the research studies to hypothesize and test must be reconsidered. Perhaps museum research should not seek to substantiate that what the exhibit planners hoped visitors would learn is actually learned, rather a more important objective might be to simply determine what is learned. The very nature of informal learning suggests that every learner has a different agenda, and a different set of conscious or unconscious objectives.

Enter the museum-university relationship! My colleagues will raise more important questions, and discuss one program which tries to answer at least some of these questions.

MUSEUM NEEDS
OUTLINE
NSTA, CINCINNATI 1986

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I. Variables to consider when doing a study in a museum environment:

A. Pleasurable, leisure-time experience.
B. Multiplicity of ages, backgrounds, cultures and education.
C. Inability to pre- and post-test.
D. Data collection has an impact upon the museum learning experience.
E. Data collection has an impact upon the data collected.
F. Difficult to conduct longitudinal studies.
G. Many different exhibit variables: graphics, location, labels, interpretation and lighting.
H. Exhibit variables are hard to isolate.

II. What does the museum need? Considerations which have no answers.

A. Does an adult or parent have an affect upon learning in a museum environment. If so, what effect?

- Recently, a parent approached a computer exhibit about vectors. The child immediately rushed forward to touch the computer keyboard. The parent rushed over to the child and pulled her away from the computer saying that she had one of these at home and that she should play with some other exhibits instead.

B. Do parents or adults convey misinformation? If so, is that bad?

- Another parent was overheard to say while standing at the Bernoulli blower:"The balloon is being heated by the blower and that causes it to rise. It doesn't want to fall because the air around it is cooler."

C. What constitutes effective teaching?
D. Can we help adults or parents to be more effective teachers? If so, what should we provide?
E. Should each child be accompanied by an adult?
F. How do adults learn? Is it different than how children learn?

- The museum has a doll collection which is arranged by

date. Adults go through the exhibit in a linear fashion and like to look at the clothing styles. Children, on the other hand, look at the dolls they like and create a play fantasy which usually includes story telling.

G. What is a child's concept when approaching an exhibit?
H. How does the museum reinforce or alter that concept?
I. When a child is presented with a conflict, how is it resolved? Is it resolved?

- During an interview on the focussed sound exhibit, an exhibit that uses two large parabolic dishes to focus the visitor's voice across a large exhibit hall, the interviewer found that most children come to the exhibit with the concept of wires, speakers and microphones. When confronted with the question, "How does it work?" children usually respond with an explanation that incorporates the above concepts. When asked to find the microphone, wires or speaker a child does basically one of three things to reslove the conflict between the concepts.
    1. Alters concept to fit new circumstances and begins to ask more questions about the phenomenon.
    2. Remains dogmatic about original concept and refuses to recognize other ideas or possibilities. However, a process of thinking about the new ideas may be started internally that may lead to a later alteration of their concept.
    3. Creates a fantasy to explain their own concept. They may never alter their concept if the fantasy is well constructed. One child said, "Look at the ceiling. See those sparks! That's where the sound goes!" When the interviewer said that they could not see the sparks the child said, "Well that's your problem!" and then walked away.

J. Does the content presented in an exhibit transfer to other settings?
K. What are the effects of labels, graphics, exhibit location and interpreters upon the learner in an exhibit environment? How can we be more effective?
L. Is learning the same for each person and the environment the difference?
M. What effect does the collection of data have upon the visitor's experience?
N. What effect does a particular data collection method have upon the validity of data?
O. Do formal research techniques apply to a museum?
P. What is the goal of evaluation and data collection in a museum? To have every visitor appreciate every exhibit? To understand how children learn?

III. The museum is a rich environment in which to study life-long learning. It presents many problems as well as

questions for the person doing the study. But given the fact that most of us will spend our lifetime learning in non-formal settings, it is so important that this research lead to a greater understanding of how people learn in non-formal settings.

TEACHER EDUCATION IN MUSEUM SETTINGS

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This section will describe the activities of our undergraduate students at the Children's Museum. For several years, as part of their science methods course, our students have been conducting individual interviews with children and adults in classroom and non-classroom settings. These interviews have usually revolved around topics introduced by the interviewer. The results of these interviews have been very useful in helping us learn more about how different people gain and maintain science concepts. Several of these student projects have been published or presented at professional meetings (Bourke, 1984; Carter et al, 1981; Fuson, 1981; Orem, 1980; Truax, 1981).

In 1983 we moved this interview study part of our courses to the Children's Museum of Indianapolis. This created several changes. First, the topics selected for the interviews were now determined by the exhibits in the gallery. Our students had to be ready to consider topics that might not be their particular favorites. Unlike many teacher education activities where the teacher in training can select topics of interest, our students faced the situation of most teachers who have to become interested and knowledgeable about the topic in the syllabus or textbook. Second, the museum environment is unstructured and built on enjoyment. Because it was unstructured individuals could walk away from the interviews whenever they wished. Motivation became not only more important, but took on an entirely different form. Our students really had to "grab" the visitors attention. Third, our students were able to interact with a wider variety of age and interest groups. This was very useful in helping the students think about the grade level they wished to teach as well as providing an opportunity to compare and contrast the content and processes used by individuals at different age levels and backgrounds. It is important to note that our students are usually surprised by the similarity between children's and adults responses. Finally, our students worked in groups. They could watch each other conduct the interviews, collect additional data for each other, and help each other with interview questions. Cooperation of this sort is critical if teachers are to continue to grow and develop. We need to get into the habit of sharing with our colleagues.

The fact that several of the students' interview studies conducted in the science methods course were published has always been an important part of the assignment. It increased the credibility of the assignment. Here was an opportunity to create knowledge and ideas for others. But there was always a delay between the time a paper was finished in class and published in a journal. Often students were not aware their colleagues had published the results of our class projects. With the museum studies the results were immediately reported to the museum staff. In all cases the students were able to see the importance of their "research." And for the typical elementary education major, who is not yet sure of the power they have to change or improve an educational setting, this is an important lesson.

THE CLASS PROJECT FORMAT

The project includes several stages. First the students visit the gallery to see what the exhibits look like, try out the activities at several exhibits, and select one or two for further, in-depth study. The class then selects one exhibit where every student will collect interview data. So each student is responsible for two exhibits, one that the whole class studies and one that only a small group studies.

Once the exhibits for study have been selected, each student is responsible for learning the science behind the exhibit and drawing a "concept map" (Novak and Gowin, 1984) to explain the science at the exhibit. The students then use the concept map(s) to develop a list of possible questions to ask of visitors to the exhibit.

It is not possible to characterize the first visit by the students to collect interview data. Some students have exciting, productive encounters. Others are ready to drop out of our Education program. However, during group and class discussions about their initial interview experiences the class usually agrees that one can learn from all types of experiences. During the subsequent visits, between four and six, each student usually has several positive and negative experiences with the visitors. Since one of our key points is the need to learn "how to learn" from unexpected and unanticipated experiences, the negative situations are seen as opportunities for growth and not as examples of a student's inabilities.

At the end of the museum visits and interviews the students are responsible for a written report. This report usually begins with a statement of the students initial ideas and beliefs written as the project started. They then include an initial concept map developed prior to any interviews. The interviews make up the data section of the reports. An analysis and the implications for teaching and learning complete the report.

EXCERPTS FROM SELECTED STUDENT PAPERS

There are several aims for the project. But, before I provide a list of these aims, I'd like to provide a few examples of the reactions of several students. Several examples of the type of data collected by our students were provided by Mark Kesling in the last presentation (pages 3-4). There are so many examples it is difficult to select exemplars. The exhibit that mixes three colors of light which make the table top look white, and which is used to create colored shadows, is most interesting. First the students have problems with the "science." As young students they learned that mixing paint colors creates black or other muddy colors. Now they have trouble understanding how mixing colors of light can create white. That's the first problem. They seem to have less trouble with colored shadows, although even I had to think for a moment when I first observed the exhibit. During their conversations (what the interviews turn out to be in reality) with the visitors the students discovered that many people also had trouble with mixing colors of light. When asked to explain how the table top was white even though lights with three different colors were shining on it, many visitors exclaims, "Well there are white lights on the ceiling, and they shine on the table."

Several comments relevant to teaching were made by one student (Kolb, 1984) as she discussed the rotating window, optical illusion exhibit. First she comments on the variety of children's reactions. "Some children would not leave the exhibit until they had what they thought was an explanation, while others accepted it as just happening... I see teaching as having to motivate, and increase the curiosity and interest for those students who don't or won't question and allow those who do to continue to do so. This kind of an experience really shows how different children are."

Another student (Banton, 1984) worked with visitors trying to trace a star pattern by watching the image in a mirror. Her initial comments centered on the apparent simplicity of the exhibits. "There were very few children around the exhibit. From talking to the students, I found that the exhibit was too plain. There were no flashing lights or anything to get their attention. Many, who did stop, did not see the instructions, so they looked at the star - - not the reflection. They traced the star didn't see any challenge and went on to the next exhibit." She however, was interested in the exhibit, and set up a similar exhibit at home to practice. After the interviews she comments, "one of the unexpected results of my interviews was the increased interest in the exhibit." She tells how as she began to talk to one child, others would join in. "It seems that once someone explained the exhibit, a lot of the kids found it an enjoyable experiment." She has one additional observation and comment I'd like to share. First she noticed that the children missed the reason for the mirror, "In fact, most of them seemed to think the mirror was only there to show them what they were doing, like a mirror in a room would do." As her concluding statement she states, "The bottom line of this exercise seems to be: Don't take the idea that your students, or you, fully understand a concept, no matter how simple that concept may seem."

The science of one exhibit was a serious problem for one student (Abernathy, 1984). Finding a dictionary definition made her feel "overwhelmed" and she went to the library and looked through several textbooks. Finding that textbooks and encyclopedias did not agree, she asks, "...how was I as an adult, or children, supposed to know what is correct." As an after thought to her paper she adds, that "Several of them (the children) thought my questions were 'hard', when in fact it was the idea that was hard."

Language was seen as a problem by Conder (1984). "I asked them what a pulley was and they confused it with the verb pulling," she reported. In her analysis she continued, "I'm not sure (language) interferes with the children's ability to communicate with themselves and reach an understanding, but it certainly made the interviewing more difficult... There seemed to be three uses for the word weight: what they felt in their arm as they pulled the handle of the exhibit; the name of the yellow bell attached to the rope in the exhibit; and the gravitational pull on an object... You get something like, 'the weight of the weight, weighs 15 pounds'."

Summary of Aims

The goals of this project involve integrating several ideas to help our students become more introspective. We ask them, in carrying out this project, to view themselves, their ideas about learning, their science concepts and their interacting style(s). They are asked not only to learn the science behind the exhibit, but to be aware of how they go about learning. We ask them to view their own concepts by drawing concept maps. In listening to the variety of responses they can become more respectful of others, and more aware of levels of learning. Very important to our perception of the role of a teacher education program is its development of a model of lifelong learner (Cohen and Ault, 1984).

We are also aware of several changes in our students ability to ask questions. The improved questioning techniques we observe involve:

1. Better listening on the part of the students. They can discuss if the visitors were open or inhibited;
2. The acceptance of multiple interpretations of answers;
3. A look to the exhibit, not teacher or authority, to sort out questions;
4. An improved understanding about science and acceptable answers;
5. An improved understanding about learning and the idea that one doesn't learn only from correct answer. Incorrect ideas can also lead to better understanding of a concept;
6. An awareness of the fear of being wrong on an individuals ability to answer questions;
7. An acceptance that visitors often "make up" answers and that they, our students, also make up answers.

It is clear that schools have never had exclusive control over what is learned within a society. However, learning "Beyond the Classroom" has taken on new meaning (Fiske, 1985). "New types of schools would only represent a threat if they came up with a good model that the public schools couldn't match. I wouldn't mind a few schools that would show us how to teach" (Shanker quoted in Fiske, 1985). This program has provided one part of that new model that is quite easy to replicate.

References cited

Abernathy, K., Roll a Coin. Unpublished term paper, Indiana University, Indianapolis, June, 1984.

Barton, J. L., Interviews at the Children's Museum Exhibit. Unpublished term paper, Indiana University, Indianapolis, June, 1984.

Bourke, W. D., Confused Children: Do We Teach Misconceptions? The Hoosier Science Teacher, 10, (2), p37 - 41, 1984.

Carter, J., Cohen, M. R., Flick, L. B., Rice, J. R. and Truax, C. J., Why Did The Wind Stop Breathing? Children's and Teachers' Concepts of Science. Panel presented at the annual meeting of the Hoosier Science Teachers' Association, Indianapolis, Indiana, February, 1981.

Cohen, M. R. and Ault, C. R., Jr., Improving Instructional Practices for Science and Technology Education. In Redesigning Science and Technology Education, edited by Bybee, R., Carlson, J., and McCormack, A., NSTA: Washington, D.C., 1984.

Conder, E. J., Interviews at the Children's Museum Exhibit. Unpublished term paper, Indiana University, Indianapolis, June, 1984.

Fiske, E. B., Beyond the Classroom, Education Spring Survey, The New York Times, Section 12, p1, 43, April 14, 1985.

Fuson, L. I., What Happens to Stars in the Daytime? The Hoosier Science Teacher, 7, (1), p15 - 17, 1981.

Kolb, R. E., Child Views on the Rotating Trapezoid. Unpublished term paper, Indiana University, Indianapolis, June, 1984.

Lucas, A. M., Scientific Literacy and Informal Learning, Studies in Science Education, 10, p1 - 36, 1983.

Novak, J. D. and Gowin, D. B., Learning How To Learn, New York: Cambridge University Press, 1984.

Orem, J., What Ten Children Believe About the Wind, The Hoosier Science Teacher, 6, (2), p5 - 8, 1980.

Truax, C. J., Why Don't Fish Drown?, The Hoosier Science Teacher, 6, (3), p22 - 25, 1981.

Teacher Training in a Museum Setting

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The Science Spectrum Gallery of the Children's Museum of Indianapolis has provided a very special environment for helping undergraduate elementary education majors prepare to teach science. As part of a methods course in teaching elementary science, students at Indiana University must complete a field experience. Instructors have wide discretion in choosing appropriate experiences. Interaction with visitors in the museum environment furthers several key aims of the science methods course:

1. Cause students to introspect on their own understanding of particular science concepts in the context of shared experiences.

2. Become sensitive to how often people construe meaning in unanticipated and "intelligently wrong" ways.

3. Learn to ask probing questions while refraining from teaching.

4. Accept direct experiences as a form of "authority" rather than what the teacher already claims to know.

In summary, the museum gallery is a non-threatening learning environment. For visitors, recreation dominates the experience. For pre-service teachers, there is no need to feel responsible for what people are learning. Yet questioning, listening, and wrestling with the meanings of puzzling observations can occur.

The alternative to the museum early field experience is small group teaching in an elementary classroom. The insights from the museum project may counter the often conservative, "right answer," vocabulary centered style of instruction students often gravitate towards when placed prematurely in a classroom setting.

In the museum setting, elementary education majors can "dispense with the dispensing model of teaching." They are free from the constraints of believing that they have to know "all"

the answers before teaching a subject. However, the preparation for the museum field experience demands thorough study and reflection on the exhibit topics of interest to the student.

The museum field experience assignment

Students visit the museum twice. On the first visit interaction with visitors is casual and undirected. Students are expected to become aware of just what interpretations visitors are making of exhibits and what kinds of background knowledge they bring to bear on their experiences.

On the second visit students ask several visitors -- child and adult -- to join them in a simple experiment related to a particular exhibit. Students are instructed to carry on a dialogue in the style of a "modified clinical interview" and reconstruct the dialogue immediately afterwards from memory. The museum publishes exhibit guides with simple science experiments and these guides are the primary source for the "interview tasks" and student background knowledge on the topic of the exhibit.

One very important activity prepares students for their dialogue and experiment: they prepare a concept map of the topic. Mapping serves two purposes. First, it cause students to reflect on what they truly know and how it is connected to the exhibit and simple related experiment. Secondly, they map reveals promising channels of questioning -- for relationships, meanings, and causes. Figures 1-4 depict maps drawn by students who participated in the museum project.

Insert Figures 1-4 about here

Maps help students look at science concepts in interesting ways and find alternative pathways to making connections among ideas. Maps are most useful when tied to direct experience -- they help bring about an "event sense" of the subject and the confidence that meaningful understanding of science is possible without mathematical formula.

Pre-service elementary teachers do not realize that the children can change the teacher's understanding of the subject. "How could they?" ask some students rhetorically, "We know more -- or at least we're supposed to." A child who states, "In order to time something you have to compare it to something else that always goes at the same speed, but you can't tell if something goes at the same speed unless you time it," has some very

profound thinking to share with grownups. Think also of how children might interchange "melting" and "dissolving." Does salt melt ice or ice dissolve salt? Does water melt salt? Lastly, remember that science seldom has absolute criteria for defining class membership. Are birds special reptiles or are some dinosaurs poorly formed birds? Is a stool a chair without a back or a chair a stool with a back? It takes a kind of playful courage to explore the limits -- as well as consequences and arbitrariness -- to how we organize meaning. The museum environment provides the support and stimulus for this kind of intellectual playfulness. Teachers should learn to import such playfulness into their classrooms.

Visitor conceptions

The dominant theme of student observations of visitors has been the "inhibition" and "fear of being wrong" primarily characterizing adults. One student wrote, "The next step is to help students realize and believe that it's ok to make guesses even if they might be wrong." Modelling the message might help. As another student observed, "Parents amazed me because most of them refused to do any of the experiments themselves."

Another student became "frustrated that so much of the experimentation is accepted by the kids as 'magic' or 'tricks' and they are not looking any further for an explanation that helps them to see that the happening is the result of real life forces or situations over which they can exert some control and have some understanding.

Often visitors do tie exhibit events to other contexts -- they see analogy even when the jargon of the labels remains mystifying. Roll-a-coin is sometimes compared to amusement park rides or a velodrome -- "the bicycle is held up by the same force as the penny."

Specific misconceptions challenge probing skills. A nine year old boy explained "one end of the magnet sticks and the other end doesn't -- it's probably not magnetized at that end." Along a similar vein, an eleven year old child reasoned, "One end of the magnet has a stronger pull than the other end. There's a crack at one end of the plastic covering and the magnetic stuff can creep through the crack." The student working at this exhibit tried to explain "polarity" with little success. What kind of interaction and exploration of the magnet concept should occur given the understandings revealed above?

Very productive observations occur when just listening to how one person attempts to explain an exhibit to another. When watching the rolling coin, one boy said to his friend, "Oh yeah, now I know! Remember that guy's law that says something moving always needs to go straight? Well, this curve is keeping it from going straight." His friend responded, "Yeah, and the bottom is curved down to that hole so the coin goes down too." A good interview question often has the form, "How would you explain XYZ to someone aged _____?"

Students who spend sufficient time at one exhibit can describe visitor conceptions along a spectrum of understanding. At the optics exhibit a pre-service teacher set up a "disappearing coin" experiment. A penny under a glass appears to disappear from the observer's line of sight as water is added to the glass. Three basic divisions characerized visitor understanding of the disappearing penny. At one end was an acceptance that this was, indeed, a trick. "Something in the water is blocking the view of the penny." In the middle level were people who had a notion about refraction and its importance to explaining the penny's disappearance but were unable to express themselves clearly. At the high end of the spectrum were those who understood light was being refracted, which direction it was going, and what was causing the refraction.

Age was not necessarily an important factor. A 25 year old woman hypothesized that "some chemical was in the water to keep it from being transparent." A nine year old boy exclaimed, "The water is fooling my eyes cause the light is still there to show me the penny and that's only water in there."

It does not seem important, concluded the student conducting this study, that people possess the scientific labels to correctly label their reasoning. A man of 55 "took cover behind a very tidy, 'It's just an optical illusion.' That summed it up to him. -- optical illusion was, as far as he was concerned, a complete explanation in itself." Optical illusion removed the mystery -- reduced the trick to common expectation.

The refraction conception study ended on an optimistic note: initial hypotheses even when not correct did not deter learning. A young girl who believed, "The white paper is magnifying too much light and is keeping me from seeing the coin," was later heard explaining how "refraction" bends the light and sends it in a different direction.

The obstacle to understanding identified in this study -- and generally corroborated by most of the students experiences -- was a "closed mindset that chose not to attempt understanding. Perhaps the reason for a closed mind was that the person felt uncomfortable examining a lack of knowledge in from of another. Each visitor reacts according to previous personal experiences.

The visitor's past may make the exhibit intriguing, threatening, boring, challenging, or overwhelming."

Exactly this kind of sensitivity to learning is needed among elementary education majors. The museum setting has proven fruitful for such training.

Discussion questions

1. Can informal learning "do the job"?

2. How can informal science learning and school science help each other?

3. Should museums do the bidding of the schools or something else entirely?

4. How do you take a museum trip?

5. Can kids be curators? (Mathers museum example -- exhibit being prepared over 10 weeks in the summer by children on Monroe County geology and limestone industry.)

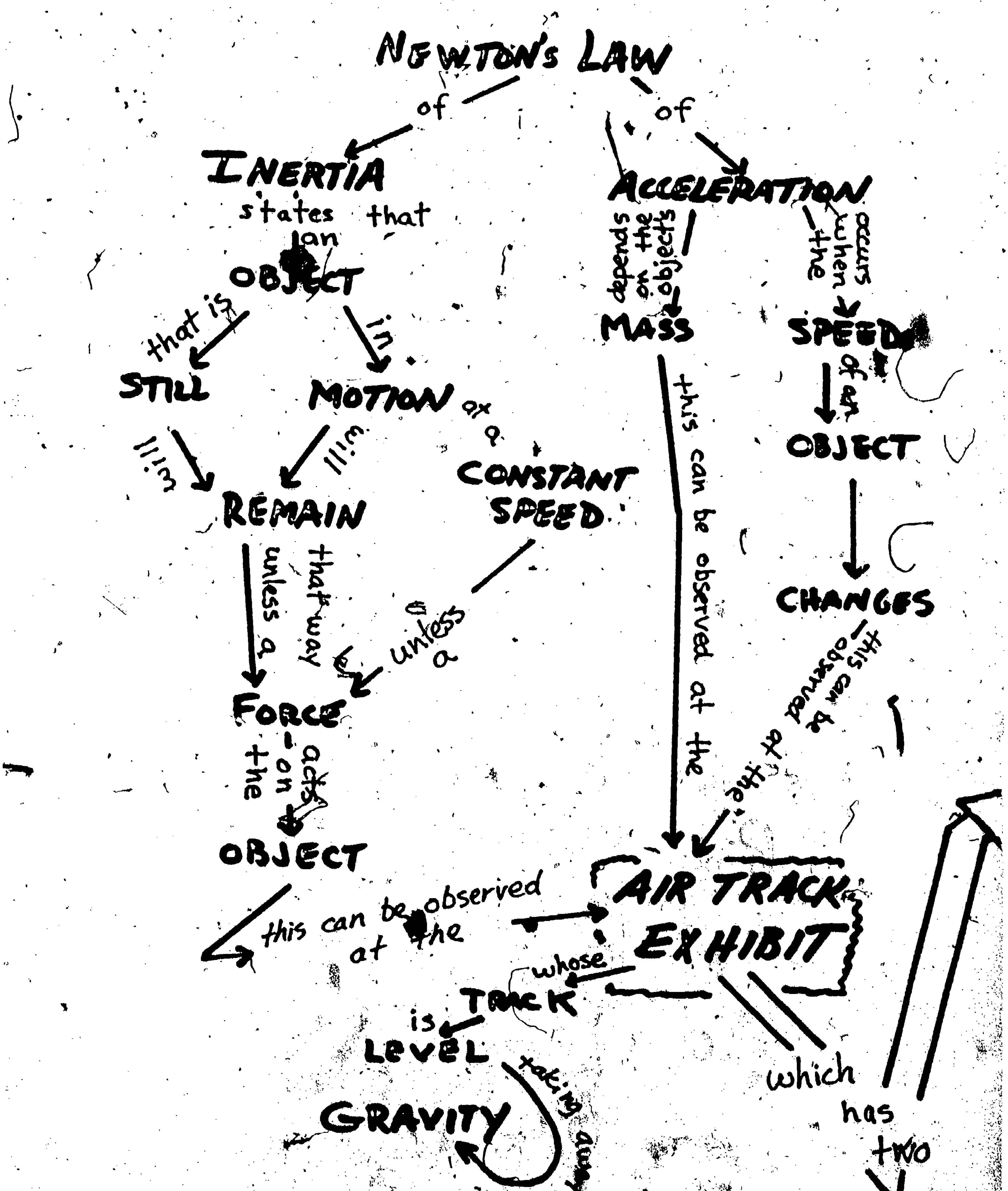


Figure 1: Student developed Concept Map of Science behind museum exhibit

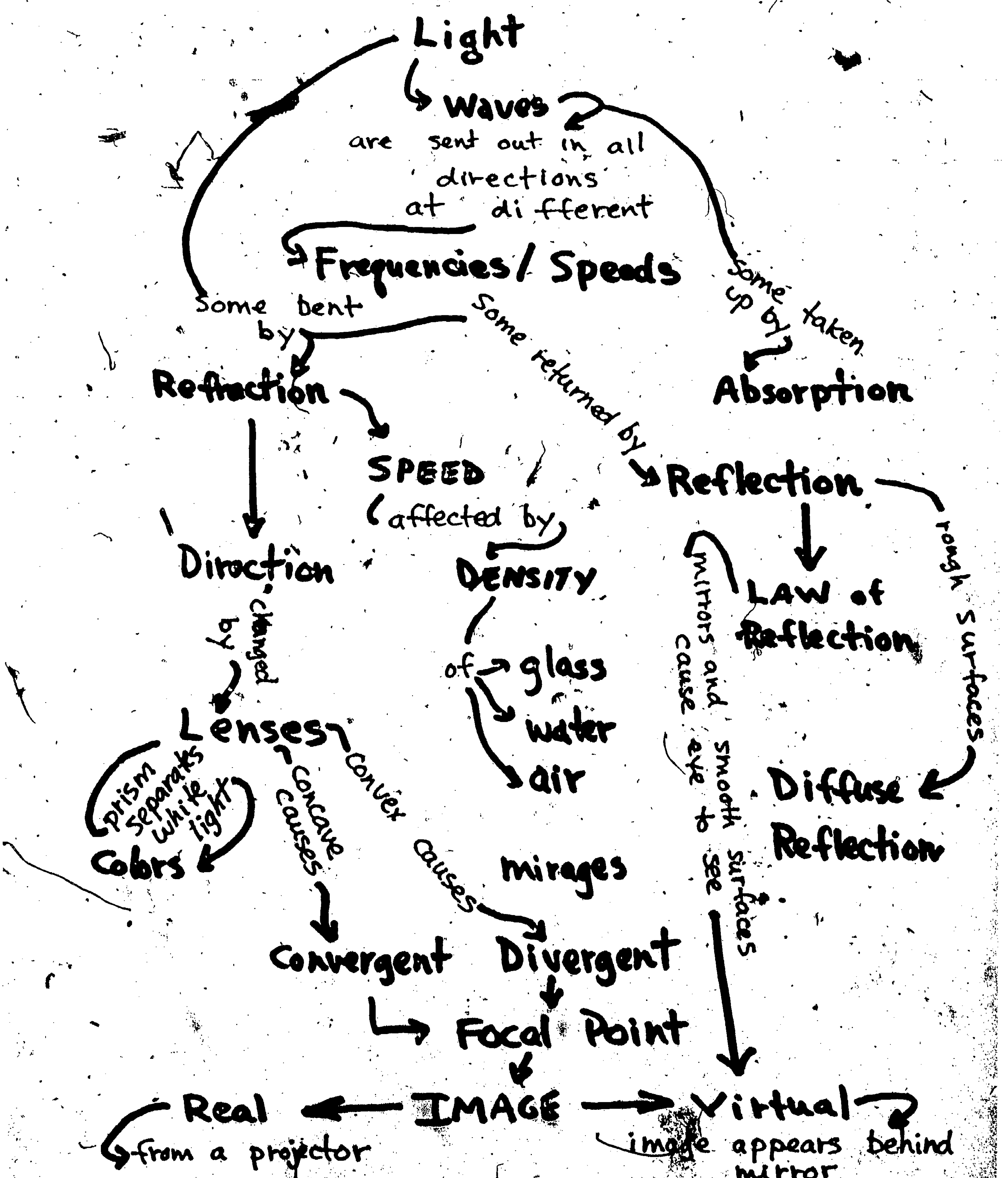


Figure 2: Student developed Concept Map of Science behind museum exhibit

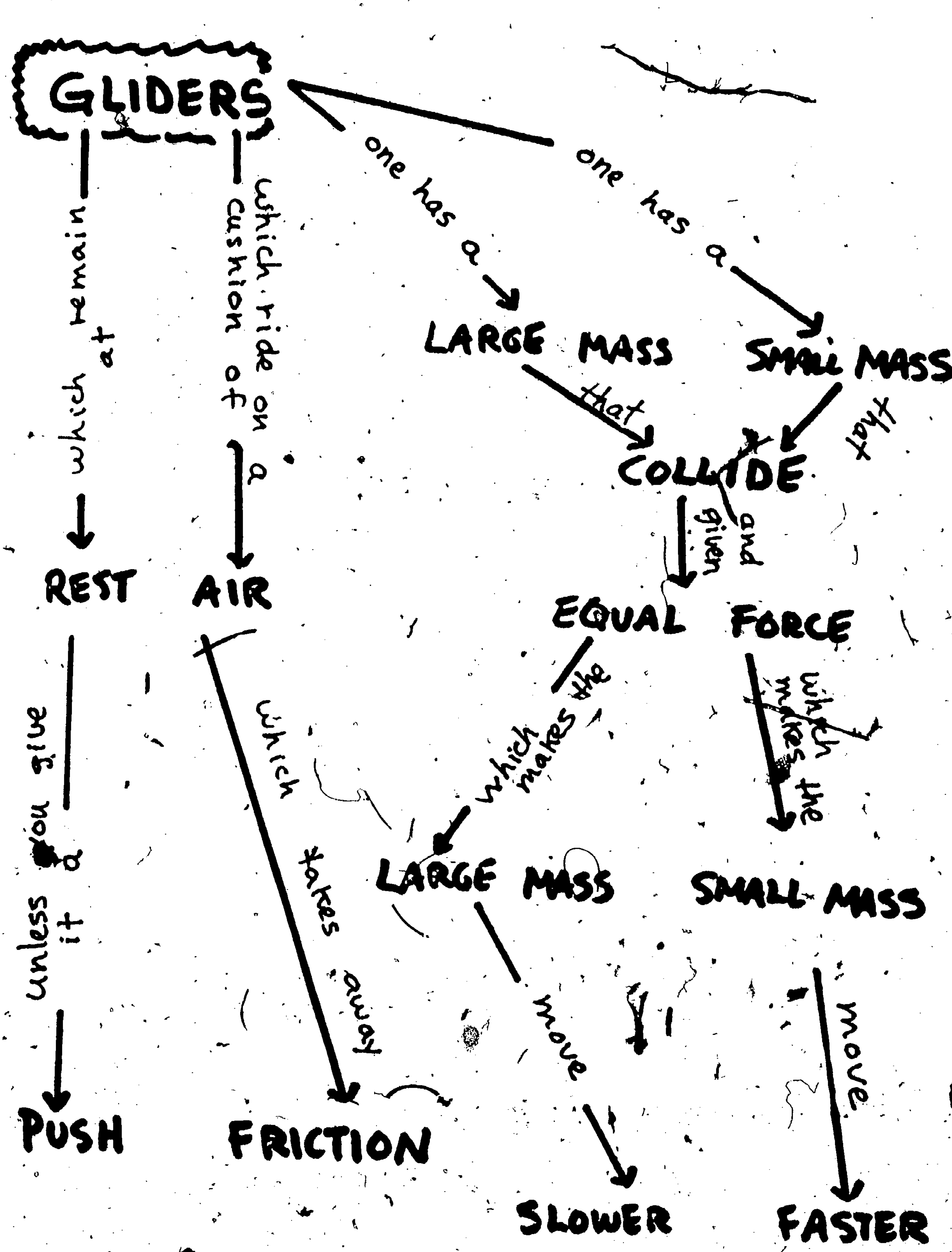
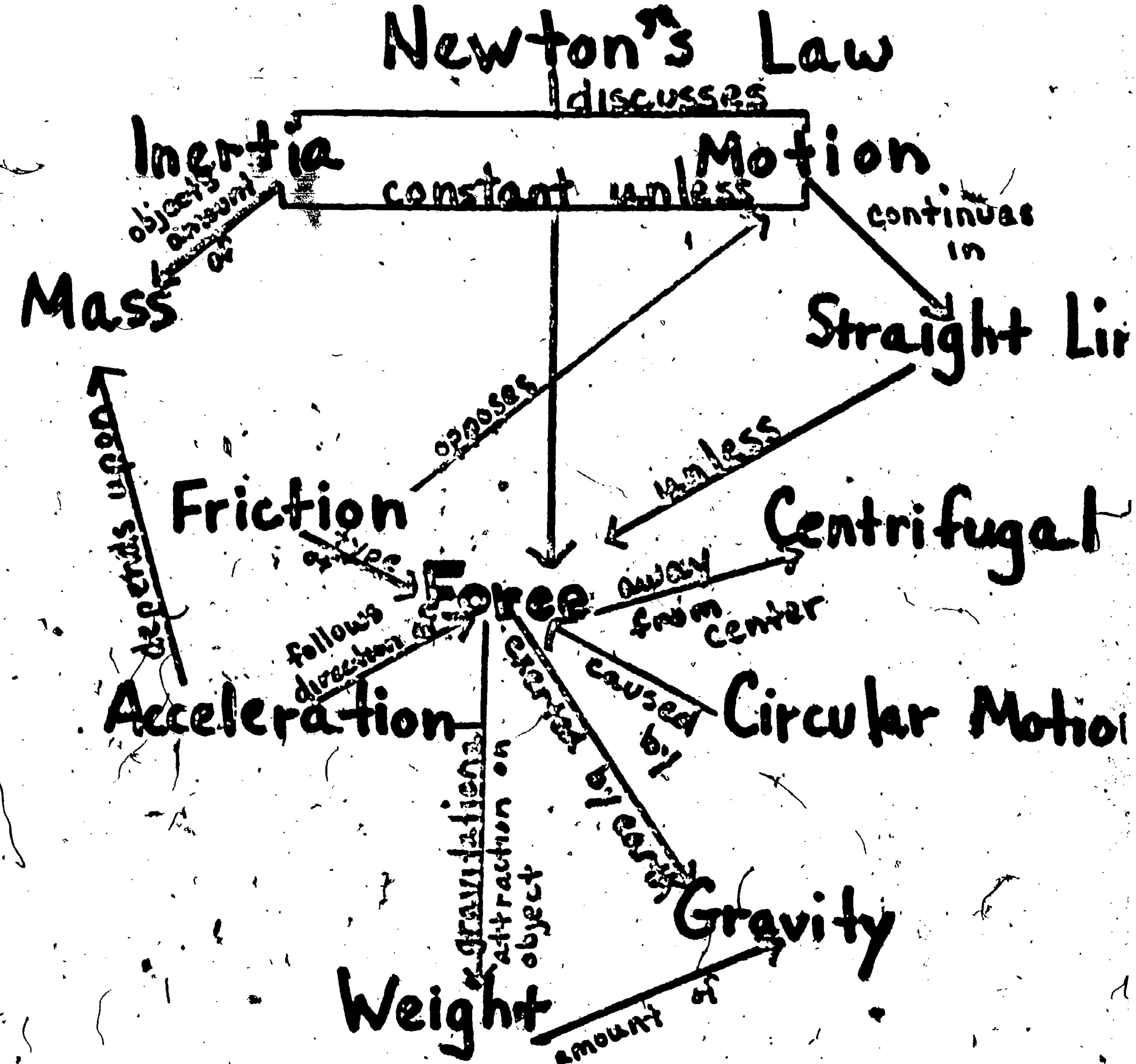


Figure 3: Student developed Concept Map of Science behind museum exhibit



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ure 4: Student developed Concept Map of Science behind museum exhibit