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Fun Experiments about Properties of Air in a Teacher Education Program

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Abstract: This exploratory research has three purposes: (a) to identify which air pressure activities students (teachers and preservice teachers) find most fun and least fun, (b) to determine for these two groups of activities the likelihood that teachers will do the activities in their classroom and whether they will do them as hands-on activities or as demonstrations, and (c) to look for common characteristics and differences among the activities the students chose as most fun and least fun. Undergraduate and master students participated in hands-on learning stations and discrepant event demonstrations in the science methods course. An activity rating scale and students' journals was used as a source of data. The analysis of the journals indicated that students have naïve conceptions about the physical properties of air. It was surprising to find that students rated as the most fun, many activities that they watched rather than did themselves. The fun element seemed to be mostly related to how discrepant the activity was for them. The students said they would implement most of the activities in their own classrooms, but there did not seem to be a relationship between how the activities were done in the class, their ratings of fun, and whether they would implement as hands-on activities or as demonstrations. The students seemed to look primarily at safety issues (flames and glass lab equipment) and messiness in deciding that a demonstration was better.

Key Words: Science teaching, hands-on learning stations, discrepant science demonstrations, fun.

Öğretmen Eğitimi Programında Havanın Özellikleriyle İlgili Eğlenceli Deneyler

Özet -Bu araştırmanın amaçları: (1) öğrencilerin (lisans ve yüksek lisans) değerlendirmelerine göre havanın fiziksel özellikleriyle ilgili deneylerden çok eğlenceli ve az eğlenceli olanları belirlemek; (2) bu iki grup deneyleri belirleyip bunların öğretmen ve öğretmen adayaları tarafından kendi sınıflarında öğrenme istasyonu ya da gösteri deneyi olarak mı yaptırmayı planladıklarını incelemek ; (3) çok eğlenceli ve az eğlenceli deneylerin ortak özelliklerini ve farlılıklarını incelemektir. Öğrenciler fen öğretimi dersi kapsamında havanın özellikleriyle

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ilgili öğrenme istasyonları ve gösteri deneylerine katılmışlardır. Veri toplama aracı olarak yapılan deneylerle ilgili bir anket ve öğrencilerin deney raporları kullanılmıştır. Öğrenci raporlarının analizi, katılımcıların havanın fiziksel özelikleriyle ilgili kavram yanılgılarının olduğunu ortaya koymuştur. En eğlenceli deneylerin çoğunluğunun öğrenme istasyonu deneyleri değilde, gösteri deneyleri olması ilginç bir sonuçtur. Deneylerin eğlenceli bulunmasında, deneylerin katılımcılar için yeni, merak uyandıran ve farklı olmasıyla ilgili olduğu bulunmuştur. Deneylerin sınıfta gösteri veya öğrenme istasyonu olarak yaptırılması ile eğlenceliliği arasında bir ilişki bulunamamıştır. Öğrencilerin genellikle ateş ve cam malzeme gerektiren deneyleri laboratuvar güvenliği için gösteri deneyi olarak yaptırmayı planladıkları bulunmuştur.

Anahtar Sözcükler: Fen öğretimi, öğrenme istasyonları, gösteri deneyleri, eğlencelilik.

Introduction

Great discoveries often come about when scientists notice anomalies. Isaac Asimov said it well: "The most exciting phrase to hear in science, the one that heralds new discoveries, is not 'Eureka!' (I found it!) but 'That's funny...' " This suggests that lots of important science comes NOT from proposing hypotheses or even from performing experiments, but instead comes from learning to see what nobody else can see. Scientific discovery comes from something resembling "informed messing around," or unguided play. Yet "The Scientific Method" listed in textbooks says nothing about this. As a result, educators treat science as deadly serious business, and "messing around" is sometimes dealt with harshly. (Wieler, 1998)

According to Severeide and Pizzini (1984), people often think play and science are opposite concepts, with play seen as fun and enjoyable but science seen as serious and onerous, logical thinking. However, for many eminent scientists, including Nobel Prize winners Albert Einstein, Robert Burns Woodward, and Richard Feynman, the play was an important part of their childhood development and continued playfulness marked their scientific careers (Feynman, 1985; Frank, 1947; Woodward,1989). Play and science are partners in research and invention. According to Gregory (1997), "If necessity is the mother of invention, play is the father of discovery" (p. 192). Young children play with objects in the world around them and satisfy their curiosity through exploration. Their curiosity can be stifled if schools take fun and interest out of science (Trumbull, 1990). Letting children figure things out is the essence of "inquiry" advocated in the National Science Education Standards (National Research Council, 1996). Inquiry methods represent the investigative nature of science, as learners satisfy their curiosity and actively search for knowledge. Inquiry reflects the constructivist model of learning (Tobin, 1993) and involves hands-on instruction, allowing the learners to be active and independent, acquiring knowledge on their own.

Although inquiry is not in itself play, aspects of inquiry can be playful and open inquiry where students pose and investigate their own questions was rated as most fun by preservice teachers (Bulunuz, Jarrett, & Martin-Hansen, 2012).

Whether teachers enjoy science activities in a playful way may influence whether they decide to teach in the same manner (Bulunuz & Jarrett, 2008; Bulunuz, 2012; Jarrett, 1998). Studies that find that teachers teach the way they are taught strongly suggest that teacher education programs should model the way that teachers are encouraged to teach (Andersen, 1993; Glass, Aiuto, & Stake et al., 1993). According to Stepans, Sheflett, Yager, & Saigo (2001), professional development experiences that simply talk about alternative ways to teach may miss the point that teachers, like students, need concrete, connected experiences to build knowledge, understanding, and ability. Teachers need direct experiences that put them again in the role of learners, taking risks to change their own misconceptions. It is the researchers' view that motivation to make science interesting and fun in the classroom comes when the fun of science is modeled in university methods courses for preservice teachers. A goal of these courses should be to develop a sense of wonder, curiosity, and playfulness in teachers.

Choice of Concept to Be Studied - Air

Although air is all around us and is an essential part of our everyday environment, its properties are taken for granted and not consciously considered by children. The nature of air is very difficult to teach because air is colorless, odorless and tasteless. Although children are familiar with the word "air," stationary air has little reality for them. Children's naïve beliefs about air appear to be first questioned by Piaget (1931) and described in his book The Child's Conceptions of the World. Piaget illustrates that children think that air is a spirit because it cannot be touched and that they also use "air" when they mean the kind of gas used in lighters and stoves. After Piaget's work, numerous research studies (Ambrosis, Massara, Grossi, & Zoppi 1988; Borghi et al., 1998; Driver, Leach, Scott & Wood-Robinson 1994; Sere, 1985; Tytler, 1998) have been conducted on children's conceptions about physical properties of air, such as whether or not air exists, occupies space, weighs something, or can exert pressure. Those research studies indicate that children seem to think that adding air to a container makes it go up (i.e. become lighter) and that air is weightless. They do not accept that air exists and occupies space unless it is moving as a wind. Moreover, they cannot imagine air exerts pressure without movement associated with it. Our previous research (Bulunuz, Jarrett & Bulunuz, 2009) found that middle school students have many misconceptions about air pressure. Also our research study (Bulunuz & Jarrett, 2009) on undergraduates' and master's students' understanding and the forms of reasoning used to explain air-related phenomena indicated that they have low level initial understanding and low level of epistemological reasoning (relation-based reasoning).

Although the concept of air is abstract for children, most teachers cling to the teacher's manual and teach it by using teacher-dominated expository methodology which focuses on the teacher and makes the students passive. According to Piaget's cognitive learning theory, learning is an active constructivist process (Piaget, 1974a) and does not occur by transmitting information from the teacher to the child's brain. Instead, each child constructs his or her own meaning by combining prior information with new information. Sere (1985) contends that to understand and interpret even simple experiments on air, children must use fundamental physical dimensions such as quantity, volume, mass, pressure and temperature, to describe the air. One practical solution to the problems of expository teaching might be the use of more hands-on experiments and discrepant event demonstrations in the classroom. Discrepant event demonstrations often contradict children's beliefs and previous experience. They are generally motivated by placing children in a state of disequilibrium and sparking their interest and curiosity (Green, 1989).

Why do so many teachers teach science, including concepts about air, in such an ineffective way? Many teachers don't like teaching science and are unsure of their own understandings of the content they are expected to teach. They may have their own misconceptions about air. Such teachers are likely to cling to the textbook and avoid suggested hands-on activities and demonstrations (Jarrett, 1999). According to Jarrett (1999) science methods courses should help teachers recapture the fun of figuring things out while modeling teaching methods that can be applied in the classroom. One way to do this is to provide experiences with scientific phenomena that challenge the thinking of the teachers, i.e. "discrepant events" which cause cognitive dissonance or disequilibrium in their thinking.

Theory on Disequilibrium and Cognitive Dissonance

According to Piaget (1974b), a state of perplexity and doubt, a state that he called "disequilibrium," is a necessary first step in learning. According to his theory, learning takes place at all ages as people try to equilibrate (make sense of) dissonant experiences through the processes of assimilation and accommodation. He recommended puzzles as good sources for learning since they unsettle the learner, upset his intellectual equilibrium, and incite him to change or adapt his existing intellectual scheme. Similarly, the Theory of Cognitive Dissonance by Festinger (1957) proposes that dissonance, being psychologically uncomfortable, will motivate the person to try to reduce the dissonance. Events that don't fit one's existing understanding of events, "discrepant events," function by causing dissonance between what is physically observed to occur and what one thinks should occur. Since it is impossible to change what is physically observed to have occurred, the only alternative is to begin seeking information that logically explains the occurrence. "Discrepant events" prompted the discovery of radioactivity (Herry Becquerel) and penicillin (Sir Alexander Fleming). According to Baez (1980), "curiosity is the motor that drives the scientist's curiosity; it is the source of discoveries in science and technology. The spark of curiosity ought to be fanned into flame by teachers and parents. It can make learning a pleasurable experience, but it is sometimes stifled by uninspired teachers who find it easier to demand rote learning." When the learner faces a situation in conflict with what he expects, the doubt, perplexity, contradiction, and incongruity play an important role in stimulating the learner's curiosity. Voss and Keller (1983) stated that individuals actively seek new or unexpected experiences and tend to avoid stimuli that are monotonous or boring. Materials for discrepant experiences can be simple. According to Brandwein (1968) familiarity coupled with incongruity can be a powerful combination. In order to understand or recognize the problem, the individual first needs experience or be familiar with the object. That means using materials in the child's environment that are easily found, simple, and inexpensive can be more powerful in teaching science than complex and expensive materials.

Purpose of the Research

This exploratory research has three purposes: (a) to identify which air pressure activities students (teachers and preservice teachers) find most fun and least fun, (b) to determine for these two groups of activities the likelihood that teachers will do the activities in their classrooms and whether they will do them as hands-on activities or as demonstrations, and (c) to look for common characteristics and differences among the activities the students chose as the most fun and least fun.

Methodology

Subjects

The research was conducted in science methods courses in two different programs at a large U.S. southern urban university. One was an undergraduate course with 27 students; the other was a master's course with 21 students. In all, there were 3 males and 34 females. While taking the course, the undergraduates were in their junior year and were in field placements two days a week. The master's group had just completed an alternative certification program where they were in field placements in urban schools four days a week. When they participated in the research, they were full-time teachers. It is unlikely that either group had previously studied properties of air in their university coursework.

Air pressure experiments

Both groups participated in a series of centers and demonstrations on air pressure. In each class 15 hands-on activities on air pressure were set up as centers around the room. Students, working in small groups, rotated through the centers, doing each activity. The majority of the centers employed simple materials which can be found in most homes and schools or which can be cheaply purchased or scrounged; for example, plastic bags, cups, shoe boxes, syringes, balloons, plastic bottles, and ping pong balls. Following the hands-on activities, the students watched eight demonstrations some of which required more specialized laboratory equipment such as an alcohol burner, test tubes, a beaker, a flask, and a glass funnel. The description and an illustration of each activity and demonstration are found in appendix B. The first 15 listed are hands-on center activities, and the last eight are demonstrations. The experiments are related to properties of air such as "air occupies space," "air exerts pressure," "the Bernoulli Principle," and "Boyle's Law - relationship between volume and the pressure of a confined gas." The following list groups the activities by the properties of air they demonstrate:

Air occupies space: air catcher, the empty box and candle snuffer, tornado in bottle, paper ball on the neck of bottle, and mysterious bottle.

Air exerts pressure: linked syringes, the inverted glass of water, test tube in test tube, mysterious hot test tube, the balloon and the flask, and heated soda pop can.

The Bernoulli Principle: blowing through straw, leaping ping pong ball, blowing over a strip of paper, blowing under a paper bridge, ping pong ball over a hair dryer, and discrepancy in funnel.

Boyle's Law -relationship between volume and the pressure of a confined gas: Cartesian diver, air bubbles in syringe, two cups on a balloon, and discrepant syringe.

After completing the hands-on activities and watching the demonstrations, the students wrote about their explanations and responses in their dialogue journals. Before the next class the instructor read the journals and made comments on them, including clarifications and questions for further inquiry. During the next class period, areas of confusion were discussed and students filled out a questionnaire rating the activities. Sixteen master's students and 21 undergraduates completed the questionnaire.

Sources of evidence

The student journals were used to assess their understanding of the concepts being taught through the hands-on activities and demonstrations. They were also read for evidence that the students were having fun while engaged in the air pressure session.

The questionnaire was a rating scale on the air pressure activities the students experienced in the class. On a five-point Likert Scale 1 (low) to 5 (high), they were to rate each activity according to: (a) how much fun it was, (b) how likely they were to plan to use the activity in their classrooms and (c) whether they would do the experiment as a hands-on activity or as a demonstration. A copy of the questionnaire, organized according to the findings on "fun" is found in Appendix A.

Results

Student answers on the questionnaire are found in Appendix B. The overall mean ratings on "fun" for air experiments ranges from 3.5 to 4.75. The common characteristics of the top 12 experiments (overall mean greater than 4.00) appear to be that they are counter intuitive or new for the participants. Almost 100 percent of the participants planned to implement the top 12 experiments in their classroom. Also the participants planned to use more than 70% of the least "fun" experiments in the classroom. The experiments they planned to use as demonstrations rather than learning stations generally involved safety precautions.

The Most Fun Activities

To identify which activities were considered most and least fun, the mean rating of each activity was calculated using data from all the preservice teachers who completed that activity. The activities were then ordered according to mean from most to least fun. See Appendix B for the means of student ratings of all the activities. The activities with an overall mean of 4.5 to 5.0 on "fun" were considered the most fun activities. Table 1 provides the means and standard deviations for four activities rated as most "fun." It also includes the percentage of those students who plan to use these activities with their own class, over 90% in each case (mean = 97%). The last columns show the percentage of students who would do the activity in a hands-on manner versus as a demonstration. Two of the most "fun" activities, the mystery bottles, and the collapsing soda cans, were done as demonstrations. In three of the activities, students showed preference for implementing the activities as demonstrations.

Table 1. Top Four Activities: The Most "Fun"

Activities	Fun Mean & SD	Plan to do in class (%)	Hands-on (%)	Demonstration (%)
Mystery bottles	4.58 .75	.100	41.2	58.8
The ping pong-ball over the hair dryer	4.71 .46	97.0	48.6	51.4
The inverted glass of water	4.50 .70	96.8	62.5	37.5
Heated soda pop can	4.75 .65	94.1	18.2	81.8

The Least Fun Activities

Table 2 shows the four activities which had the lowest means on "fun," although the responses were not really negative. These four items had means which ranged from 3.5 and 3.59.

Table 2. Bottom Four Activities: The Least "Fun"

Activities	Fun Mean & SD	Plan to do in class (%)	Hands-on (%)	Demonstration (%)
Linked syringes	3.54 1.04	94.1	97.0	3.0
The air catcher	3.50 1.33	88.2	86.7	13.3
Blowing through straw	3.54 1.36	71.9	66.7	33.3
Two soda pop cans on straws	3.59 1.31	71.9	79.2	20.8

The standard deviations of the least fun activities were greater than those of the higher rated activities, indicating disagreement on the lower-rated activities. Preservice teachers indicated less intention of using the least fun activities in their classroom. The percentage of students who said they would implement these activities ranged from 71.9% to 94.1% with a mean of 81%. The activities they rated as least fun were all done as hands-on activities.

The common characteristics of the most fun activities are related to external stimulus parameters such as surprise, novelty, and change in congruence and complexity. The results of these fun activities are unexpected experiences or observations. For instance, in the "mysterious bottle" activity, they were very surprised when the balloon inflated in one of the bottles but not in the other one not since the bottles look identical. It took a while for them to find the pin hole at the bottom of the bottle in which the balloon was inflated. The common characteristics of the least fun activities are that they not very surprising or new to the participants. For instance, in the "air catcher activity" blowing up a bag with air was not very new or surprising.

Journal analysis

The journals were read for evidence that the students were surprised at the results of the activities or that they had fun doing the activities. Their journals explained things that we saw them do, including experimenting with materials, changing the angle of the hair drier, and varying the number of ping pong balls in an experiment. All of the students wrote positive comments about activities that they did relate to properties of air. The following excerpts illustrate the students' spirit of experimentation and playfulness:

MS "Discrepant funnel: "I thought the ping-pong would have come up when blown from the bottom, but it didn't move at all. Yet, when he held it in his hand and blew into the funnel, the ping-pong went up into the funnel. It was extremely fascinating! I was thinking that the space is too small for air to get through. When he did the reverse experiment, I thought that he would blow the ping-pong off of his hand. I think that when he blew the air out, it surrounded the ping-pong and since it is flowing air, there is less air pressure causing the ball to go up. I thought that the paper would fly off of the two binders completely, but it didn't. The paper, instead, sunk down in between the two binders very slightly. I guess this happened because the air blown underneath the paper only slightly reached the paper and only slightly pushed the paper down. The air molecules are moving faster around the paper. Flowing air has less pressure than stationary."

JW "Balloon over beaker: I did not expect that to happen. The balloon was sucked inside after put over the lid with the boiling water. When placed over flame water it popped out again and began to expand."

KC "Discrepant syringe: 40 degrees water in tube begins to boil when pulling the plunger out. Why? Very cool but I am not sure why? Is it because you quickly increased the air pressure?

When you are higher in altitude, it takes less time to boil. I didn't know why. Makes me want to find out though."

As seen from the journal entries of the participants, the common theme in all of the examples was that what they observed was against their intuition or their prediction. None of the participants complained or wrote negative comments about experiencing something that was against their intuition. Actually they were surprised and enjoyed having unexpected results in the experiment, making comments such as "fascinating", "very cool", "I liked it" and "makes me want to find out through."

From their journal, it can be seen that they also had difficulty explaining the discrepancy in the experiments. They expressed this as " I am not sure why." Also they occasionally had wrong explanations in their journals. For instance KC explained boiling warm water in the syringe by an increase in pressure. In contrast, when the piston is pulled up, the air pressure in the syringe decreases.

These activities seem to increase participants' positive attitudes toward science. For instance, the following week KC wrote in his journal: "Thanks! I really love experimenting and science! I loved doing these and would love to try at home or in a classroom! I didn't think about water vapor filling the bag. I didn't know the % of gases in the air either. Thanks for info."

Conclusion and Discussion

The results of the survey questions indicated that motivation to do specific activities in the classroom was highly related to the fun value of the activity for the student. This finding was consistent with Voss and Keller (1983) that individuals have dispositions toward new and unexpected experiences. The students said they would do a much higher percentage of activities they rated as fun than the activities they rated as less fun. It was surprising to find that students rated as most fun many activities that they watched rather than did themselves. The fun element seemed to be mostly related to how discrepant the activity was for them. Though they were only watching, they gasped at the collapsing soda can and laughed over the mystery bottles, which were presented like a magic trick. The hands-on activities that were rated as the most fun, the ping pong-ball over the hair dryer and the inverted glass of water were activities that invited experimentation. Students varied the angle of the hair dryer to see how much they could tip it before the ping pong ball fell. They also replaced the water in the inverted glass experiment with fresh and stale Coke to see the effect. The standard deviations of the top four activities were low, indicating considerable agreement on their fun qualities.

There was less agreement on the least fun activity, as evidenced by the large standard deviations. All of these activities were hands-on, but the students either found them very easy (catching air in a plastic bag) or they had difficulty with them. Students generally needed help with the clanging soda pop cans and lifting water through a straw. The Students were less likely to say they would do most of these activities in their classroom.

There did not seem to be a relationship between how the activities were done in the class and the ratings of fun. The fun quality of the activities mainly depended on how much the experiment was surprising and new for them. However, there was the relationship between how the activities were done in the method class and whether the students would do the activity as a hands-on activity or as a demonstration. High percentages of the students said they would do the experiments as demonstrations in their classroom as they were done in the method class. The students seemed to look primarily at safety issues (flames and glass lab equipment) and messiness in deciding that a demonstration was better. For instance, a balloon and flask, heated soda pop can and empty box and candle snuffer are the activities that involve working with flame. Where the activities were relatively safe and not too messy, participants were in favor of letting children do the activities as hands-on.

From observations of the students doing the activities and from reading the students' journals, we realized that preservice teachers and new in-service teachers experienced activities physical properties of air that were counter-intuitive. While they were doing hands-on experimentation or watching demonstrations, they got a chance to test their prior knowledge, which according to their journal entries, contained misconceptions (e.g., that moving air has higher pressure than stationary air). These hands on activities and demonstrations were surprising and fun for the participants. For example, the movement of the balloon, ping-pong ball, and water or soda can were unexpected and against their intuition. The counterintuitive results motivated the students to try to figure out why the events happened. The activities surprised them and made them rethink their prior conceptions and seek to modify their beliefs.

The findings of this study were similar to the findings of Jarrett (1998), Bulunuz & Jarrett (2008), and Bulunuz (2012), suggesting that fun is a major motivator for preservice teachers to potentially promote engagement with science in the elementary classroom. In this research, student ratings of many demonstrations as fun suggest that teachers can enjoy and learn from watching as well as from hands-on activity. Demonstrations have a place in the science classroom, especially when special lab equipment, flames, and test tubes and flasks are needed. A topic of discussion in the science methods class should be when demonstrations are appropriate and when to allow children to engage in hands-on learning.

A strength of the air pressure lab was that it taught important concepts while modeling the use of hands-on centers using readily available materials. One teacher implemented many of the activities in her classroom using materials she gathered up in the week following class. Further research could include clinical interviews with students to find out why they would do certain activities as a demonstration or hands-on activity. Also further research could be conducted with more classes to have enough subjects for an inferential study. Ideally, students could be observed in their classrooms to see whether they implement air pressure activities (or activities on other concepts) in a manner that passes the fun and curiosity onto their students.

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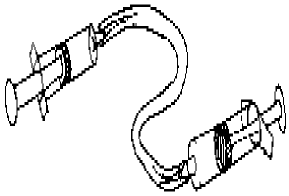
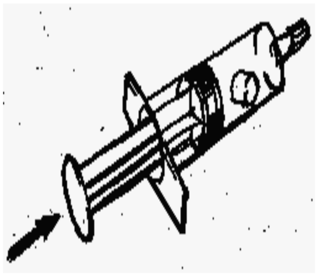
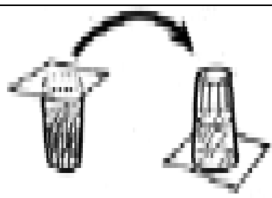
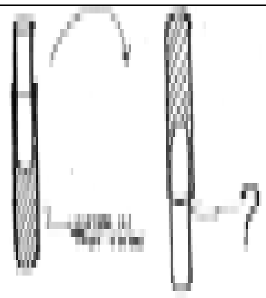
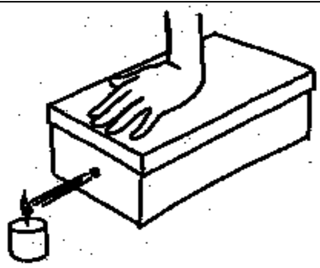
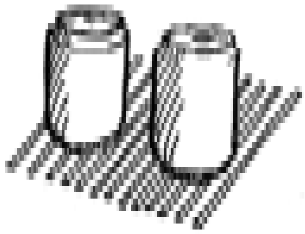
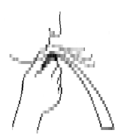
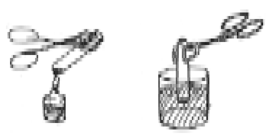
Appendix A.

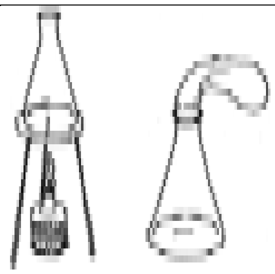
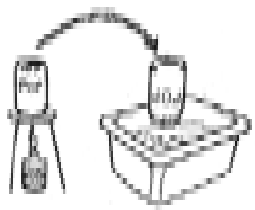
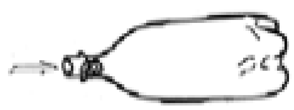
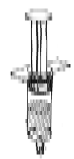
Air Pressure Experiments

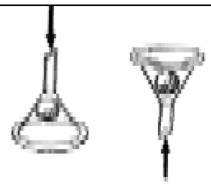
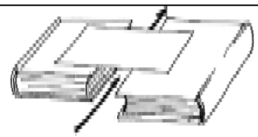
Hands-on Science Stations	Illustrations
1. Linked Syringes Two syringes are linked by a flexible tube. Push the plunger of one syringe and watch what happens to the other plunger. Try pulling a plunger and see what happens. Explain what happens when the plunger of one syringe is pushed and pulled. Try to explain what is happening. Materials: Two syringes, a flexible tube.	
2. Air Bubbles in a Syringe Put a small balloon or a marshmallow into the syringe. Either start with the plunger pulled out or with the plunger pushed into the syringe. Block the nozzle with your finger and either pull the nozzle out or push it in. What happens to the balloon or marshmallow? Explain what happens when the plunger is pulled out or pushed into the syringe while the nozzle is blocked with your finger Materials: syringe, small balloon, and marshmallows	
3. The inverted glass of water Fill a cup full with water. Place the paper card on the cup. Then while putting one hand on the top of card, invert the cup over a container/tub. Now, slowly take away the hand that was holding the card. Watch what happens to the water. Explain what happens to the paper card when a glass of water is inverted. What will happen if the cup is filled with half way with water? What will happen if you use a carbonated drink (soda) instead of water? Materials: A transparent glass, an index card, soda, tub, water.	

4. Test-tube in a test tube Fill the larger test tube half way with water. Then, let the smaller test tube float on the water in the larger test tube. Push it in a little further so the water will overflow. Now, invert both test tubes over a container to catch any dripping water. What happened? Explain why the small test-tube moves upwards against gravity. What will happen if you use soda instead of water? Materials: Two test tubes (one just fitting into another), a little colored water, container/tub.	
5. The air catcher Take the garbage bag, open its mouth, and move the bag with two hands back and forth. Then quickly close the mouth of the bag with a twisting motion. What was filling the bag? Would the material in the bag be the same if you blew into it? Materials: Plastic garbage bags.	
6. The empty box candle snuffer There is a small hole in the side a box. Light a candle and place it in front of the hole with the hole at the height of the wick. Hit the box with a sudden tap. Watch what happens to the flame? What did the tap do to the volume of box? Experiment putting the candle different distances from the hole in the box, and measure the distances. What happens if you push gently on the top of the box? Materials: An empty shoebox, candle.	
7. Two cups on a balloon Blow the balloon about one-third full holding it in the mouth. Place two cup's open ends on opposite sides of the balloon (while the balloon is in the mouth). Then blow further until it is twice as large. Let go of the two cups. Watch what happens to the cups. Explain what happens if the open ends of two cup placed on opposite sides of the balloon while it is inflating Materials: A round balloon, two small plastic cups.	

8. Two soda pop cans on straws Spread the straws parallel to each other on the table and leave about 1/2 cm gap between them. Place the two cans upright about 2 cm from each other on the straws. Now, blow hard in between the cans. What happened? What will happen if you blow more gently? What will happen if you place the cans different distances apart, such as 5, 10, 15, and 20 cm away from each other, and then blow? Materials: Two empty soda cans, two dozen drinking straws	
9. Blowing through straw Fill a cup with water and add a few drops of food coloring. Cut one of the straws in half and dip a short straw vertically in the colored water. Place the long straw at a right angle horizontally and touching the opening of vertical straw. Ask your partner to hold a white sheet of paper on the other side of the equipment set up. Blow through the horizontal straw until colored water is sprayed against the paper. What do you create by blowing the air with straw? What lifts the water in the vertical straw? Materials: Two drinking straws, a glass, food coloring, and a white sheet of paper	
10. Leaping ping-pong ball Place two identical cups about 2-3cm apart on the table and secure them down with tape or just hold them. Put the ping-pong ball in one of the cups. How can you move the ball from one cup into the other without touching the ball and leaving the cups as they are? Hint: blow a short and hard puff obliquely into the far side of the cup that holds the ball. (it may take a few practice blows to make the ball leap successfully). What makes the ball jump out of the first cup? How far away can you place the second cup in order for it to catch the leaping ball? Materials: Two identical cups with slanted sides, a ping-pong ball, and tape.	

11. Cartesian diver Squeeze the bottle and watch what happens to the dropper. Can you explain why this happens? Squeeze the bottle and watch what happens to the dropper. Release your hand. What happens? Can you explain why this happens? Materials: A glass dropper, potholder or clamp, plastic soda bottle.	
12. Tornado in bottle Turn the bottles over to get the water in the top bottle. Holding the bottom of the bottom bottle in one hand, rapidly rotate the top with the other hand. You should see a tornado-like vortex of air bubbles in the water. Tornado air moves in a clockwise direction. Be sure to spin your jar in that direction if you want to replicate “real” tornado. Materials: Two plastic soda bottle, connector, and water.	
13. Fountain in a bottle Turn these bottles over and you will make a fountain in the top bottle. Examine the bottles carefully and see whether you can figure out how it works. Materials: Two plastic soda bottle, connector, and water.	
14. The ping pong ball over hair dryer Using a hair dryer, blow air vertically upward. Then place a ping-pong ball over the mouth of hair dryer. Watch what happens. What will happen if you move or tilt hair dryer slowly? Try to explain your observations. Materials: Hair dryer, ping-pong ball or balloon.	
15. Blowing over a strip of paper Make a fold at one end of the paper strip. Hold the strip near the chin and blow over it. What do you observe? What will happen if you blow against the underside of the paper? Materials: Strip of paper about 15x3cm.	
Demonstrations	
16. The mysterios hot test tube Fill a jar with colored water. Put a little water in a test tube and boil it vigorously. Then invert this test tube immediately in the colored water. What happened? What is in the test tube	

besides the water before heating? What happens to water when it is boiled? Materials: A test tube and test tube holder, a jar, an alcohol burner or other source of heater, food coloring.	
17. The balloon and the flask Put a little water in a flask and heat it to boil vigorously for a while. Take the flask off the fire and immediately place the balloon with the mouth over the flask's mouth. Let it cool slowly at room temperature. Watch what happens to the balloon. What is in the flask besides the water? What is the steam doing to the air in the flask? Why did the balloon do what it did? Materials: A flask, a balloon with large mouth, hot plate or burner and stand.	
18. Heated soda pop can Put a little water in an empty coke can and heat it to boil vigorously for two minutes. Take the can with boiling water off the heat and invert immediately in a cold-water container. Watch what happens. Try to explain the changes in the can. Materials: Soda pop can, hot plate or burner, stands, and pot holder or glove to protect hands.	
19. A paper ball on the neck of a bottle Roll the piece of paper into a ball and wrap it in tape to hold its shape. Then, place the paper just inside the mouth of the bottle, which is held horizontally. Now, blow the piece of paper into the bottle. What happened? Explain what happens when you blow hard into the neck of bottle. Try to explain your observations. Materials: Soda bottle, one small piece of paper (5x5cm), and tape.	
20. Water in a syringe Fill a syringe one-third full of colored warm water, then put the cap on it. Now, pull the piston. What happened? Try to explain your observation**.** Materials: A syringe, warm water, and food coloring	

21. A discrepant funnel "How can I pick up the ball with the funnel without sucking through it? I may not touch the ball" Pick up the funnel by the stem; place it over the ball and blow through the stem, lift the funnel while blowing. What happens when we stop blowing? Is it possible to blow the ball out of the funnel? Where is the air moving fastest when we blow the ball out of the funnel? What is the flowing air creating that stationary air doesn't? Materials: One long stem funnel, one ping-pong ball.	
22. Blowing under a paper bridge Place a sheet of paper between two books. What will happen if you blow hard under it? What is different about flowing air compared to stationary air have? Materials: A sheet ofpaper, and books or folders	
23. Mystery bottles Insert the air pump tube into the balloons and try to blow them up one at a time. You will need to push the tube in fairly far and pinch your hand around it to prevent air from escaping. Do the two balloons react differently? Can you explain why? Can you figure out a way to keep the one balloon blown up when the air tube is removed? Materials: Air pump, balloons, two-soda bottle (one with a tiny, hidden pin hole).	

Illustrations by Christopher Jarrett and Karen Kimble.

Appendix B.
Organized Questionnaire According to the Mean Ratings on “Fun”

Activities		How much fun?	Would you like to do it in your own class?	If yes, How would you like to do it in your own class?	
		Mean	(%)	Hands-on %	Demonstration %
18	Heated soda can	4.75	94.1	18.2	81.8
14	The ping pong-ball over the hair dryer	4.71	97.0	48.6	51.4
23	Mystery bottles	4.58	100	41.2	58.8
3	The inverted glass of water	4.50	96.8	62.5	37.5
16	Mysterious hot test tube	4.47	93.9	40.6	59.4
12	Tornado in bottle	4.42	100	82.9	17.1
10	Leaping Ping-pong ball	4.33	94.4	91.2	8.8
13	Fountain in the bottle	4.28	91.7	90.9	9.1
17	The balloon and the flask	4.25	88.6	37.5	62.5
4	Test-tube in test tube	4.17	94.1	78.8	21.2
2	Air bubbles in syringe	4.09	91.4	84.4	15.6
11	Cartesian diver	4.06	96.8	62.2	37.8
7	The cups and the balloon	3.94	81.8	75.0	25
20	Water in a syringe	3.94	93.3	60.0	40
21	A discrepant funnel	3.94	84.4	53.3	46.7
6	The empty box candle snuffer	3.90	91.2	25.0	75
19	A paper ball on the neck of a bottle	3.86	97.2	85.7	14.3
15	Blowing over a strip of paper	3.81	96.7	78.1	21.9
22	Blowing under a paper bridge	3.67	96.6	74.2	25.8
8	Two soda pop cans on straws	3.59	71.9	79.2	20.8
1	Linked syringes	3.54	94.1	97.0	3
9	Blowing through straw	3.54	71.9	66.7	33.3
5	The air catcher	3.50	88.2	86.7	13.3