Lessons on the Role of Fun/Playfulness from a Geology Undergraduate Summer Research Program

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ABSTRACT

This paper examines past and current experiences with fun and playfulness of participants in two summers of an NSF funded summer research experiences for undergraduates (REU) geosciences program. Thirty students responded to questionnaires on the role of play in their previous learning and their playful, inspirational, or "ah-ha" feelings while doing their summer research. They reported a sense of playfulness during science classes, promoted by engagement with interesting phenomena, ability to work independently, and a relaxed atmosphere. Their descriptions of playfulness in the program were similar to those of scientists describing playfulness while doing research. They described the fun of the work itself, the opportunities for playful social interactions with peers, and excitement at finding results. Implications for science education involve the inclusion of playfulness and fun in the modeling of scientific inquiry and the structuring of science classes and labs to allow more students' input into their own learning, the provision of field experiences, and the allowance of some socialization.

FUN/PLAYFULNESS FROM A THEORETICAL PERSPECTIVE

> "Imagination is more important than knowledge. Knowledge is limited. Imagination encircles the world."
>
> "If A equals success, then the formula is: A=X+Y+Z. X is work. Y is play. Z is keep your mouth shut." (Albert Einstein, n.d.)

According to the National Science Education Standards (National Research Council, 1996), science should be taught in schools in such a way that students learn about the nature of science and scientific inquiry through conducting investigations. In schools, science is often taught as a very serious subject, focused on the learning of content for tests and on getting correct results in lab exercises. In contrast, previous research strongly suggests that a sense of fun and playfulness is an important aspect both of the preparation of scientists (Jarrett & Burnley, 2007) and of the nature of scientific inquiry (Ganschow with Ganschow, 1998; Jarrett & Burnley, 2007; Kean, 1998; Cavicchi, 2006). This paper is a preliminary investigation into how student researchers in a summer NSF-sponsored geology program see fun and playfulness as part of their educational background and as part of their research experience. The findings from students interested in science and engaged in the conduct of real research have implications for how science inquiry should be experienced in the classroom.

What is play and what are the similarities and differences among play, playfulness, and fun? *Play* is difficult to define, since it can have many different elements subject to a variety of interpretations (Sutton-Smith, 1997). One of the clearest definitions (Klugman and Fasoli, 1995) says play includes some, if not all, of the following aspects: intrinsically motivated, freely chosen, enjoyable, active, and non-literal (i.e. pretend or a distortion of reality). A major body of research has linked play experience to social-emotional development and the development of fluid thinking and problem solving ability (Bekoff & Byers, 1998; Brown, 2009). Innovative companies applying science and technology have attempted to hire playful people and have included opportunities to play to encourage innovation (Schrage, 2000; Dodgson, Gann & Salter, 2005; Mainemelis, Harvey, & Peters, 2008). Play in the form of diversion ("goofing off") and play as engagement ("turning one's work itself into play") both stimulate creativity and produce a positive work environment according to Mainemelis, Harvey and Peters (2008, p. 40).

In a classical study, Lieberman (1977) described *playfulness* as "divided into sense of humor, manifest joy, and spontaneity" and "the factor common to play, imagination, and creativity" (p. 107). *Playful* has been described as a disposition in research on children (Barnett, 1998) and young adults (Barnett, 2007), but it can also describe situations where one feels playful. Though certain characteristics, such as uninhibited, comic, and dynamic can be used to describe playful individuals (Barnett, 2007), whether one sees a situation as playful or would describe oneself as playful is very subjective, involving the actions an individual classifies as play (Paglieri, n.d.).

Fun has both activity and emotion components and is enjoyable, though some enjoyable experiences are reward-driven and would not be described as fun (Podilchak, 1991). Research on fun has focused on the "fun value" of computer games (Koster, 2005; Shaffer, 2006), sports (Hanin, 1999), physical education classes (Griffin, Chandler & Sariscsany, 1993), and math manipulatives (Moyer, 2001) with an attempt to identify what activities, *designed* to be fun, are *actually* fun for the participants. As with playfulness, whether an experience is fun depends on what a person enjoys doing.

Several theories explain why fun and playfulness can promote learning as well as positive attitudes toward science and scientific investigation. According to choice theory (Glasser, 1986, 1988, 1998), fun, belonging, and the ability to make choices are basic human needs and can affect learning. According to Glasser (1986, p. 28), fun is "hard to define but we all know that fun is associated with

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laughter, play, and entertainment. It's the part of the job that you don't have to do, but doing it may be the best part of the job." If fun, belonging, and choices are not built into the school day, Glasser warns, students will create their own fun and socialization opportunities and make their own choices, disrupting official teaching plans. Choice is also important in the business world, according to Malone (2004), and is associated with innovation, creativity, and motivation. Self-determination theory (Deci, 1992; Ryan & Deci, 2000) does not specifically mention fun but proposes that people have a need for competence, relatedness, and autonomy and are intrinsically motivated to learn things that interest them and that they enjoy (Ryan & Deci, 2000, 2002; Krapp, 2002). Pekrun (1992) also discusses enjoyment as having a positive effect on the processes of learning and cites research that connects positive mood with creative and holistic thinking. Brain research supports the role of emotion in motivating the learner and helping the learner make meaning (Zull, 2002). Intrinsic motivators such as fun promote positive emotions, but fun alone is not sufficient for learning, according to Zull.

THEORETICAL RELATIONSHIP BETWEEN NATURE OF SCIENCE AND PLAY

The nature of science (NOS) literature includes creativity and imagination as important NOS elements (Kurdziel & Libarkin, 2002; Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002; Schwartz, Lederman, & Crawford, 2004) and suggests that creativity and imagination are important not only in designing research studies but also in interpreting the results. The play literature proposes strong links between child's play and the development of creativity (Lieberman, 1977; Singer, Golinkoff, & Hirsh-Pasek, 2006).) and between playfulness and innovation in the adult world (Csikszentmihalyi, 1997; Dodgson, Gann, & Salter, 2005; Sawyer, 2006). According to these authors, the "as if" quality of play encourages imagination and the exploration of possibilities, qualities that are necessary in the conduct of scientific inquiry.

PLAYFULNESS IN THE CONDUCT OF SCIENCE

Many eminent scientists are known for their playfulness. Einstein's famous statement that "imagination is more important than knowledge…" and his formula for success, quoted at the beginning of this article indicate the value he placed on playing with ideas (Frank, 1947; White & Gribbin, 1994). For Nobel Prize winner in physics Richard Feynman, playing was a conscious decision: "I'm going to play with physics, whenever I want to, without worrying about any importance whatsoever" (1985, p. 157). Playing with the wobble of a plate thrown in the air in a Cornell University cafeteria led Feynman to play with rotating objects. "The diagrams and the whole business that I got the Nobel Prize for came from that piddling around with the wobbling plate" (p. 158). Other Nobel winners have been noted for their playfulness. The wife of Physics Prize winner Frank Wilcczek referred to her husband as "… very quick and playful. He loves to play with ideas" (Mishra, 2004). Kary Mullis, recipient of the Nobel Prize for Chemistry claimed: "I think really good science doesn't come from hard work. The striking advances come from people on the fringes, being playful" (Goettling, 1993). According to the daughter of Robert Burns Woodward, who won the 1965 Nobel Prize in organic chemistry, his lifetime work was playful, extending "into mature forms of search and research" (Woodward, 1989, p. 248). Arthur Schawlow, winner of the 1981 Nobel Prize in physics for his work with lasers, said, "I know a little bit about a lot of things and I have a lot of curiosity, and somehow, ideas come… I guess you'd say I like to play. That's true, I like to learn about a subject by getting in and getting my feet wet by trying something, doing some kind of experiment" (Schawlow, 2004, p. 329, 337).

What do others say about the general role of fun and playfulness in the scientific process? In his presidential address at the annual meeting of the Geological Society of America, John M. Sharp, Jr., discussed the interesting challenges in geology research and stated: "Have fun! Truly, there is adventure in geology" (Sharp, 2008, p. 4). Surveys of geologists clearly show that many of them found fun in parts of the scientific process. They also mentioned that their recreational pursuits, including hiking and swimming, sometimes gave them ideas for new research (Jarrett and Burnley, 2007). Ganschow with Ganschow (1998), reflecting on Watson and Crick's discovery of the structure of the DNA molecule, as well as their own professional experiences, speculate that playfulness involves the satisfaction of curiosity. They suggest that the scientific process can be categorized into playful and non-playful aspects, with playfulness appropriate and perhaps even necessary at the hypothesis development and inference drawing stages. Playfulness also occurs upon completion of research when attending conventions and sharing ideas and fun with colleagues. According to Kean (1998), chemists often play with chemistry throughout their careers. She cites a chemist who claims, "I still like to blow things up!" (p. 471). Chemists gain personal satisfaction from figuring out how the world works, attending conferences where there is often a playful sense of community, and seeking out opportunities to share chemistry with children and the general public (Kean, 1998). A report on the 1999 centennial meeting of the American Physical Society (McDonald, 1999) illustrated the fun side of a physics conference, as physicists attended a "cosmic cabaret," enjoyed actors dressed up as historical figures in science, and attended lectures on the physics of Star Trek and of beer. However, to make the point that conference-attendance was also serious business, the society's executive officer asserted, "Physicists always have fun. They just have fun talking about physics with one another" (McDonald, 1999).

Doing research, like writing and revising papers for publication, is not all fun. However, aside from the following, there is little written about the parts of the research process that are not fun or where feelings of playfulness are less likely to occur. According to

Ganschow with Ganschow (1998), between the playful aspects of hypothesizing and inference drawing stages are non-playful experimentation/ observation phases. In Jarrett and Burnley's (2007) research, a geology professor who had previously stated that she generally made things fun, said: "I am always serious when collecting data because collecting good data requires concentration. I often giggle and keep it light while working but I still stay focused" (p. 198).

PLAYFULNESS IN THE STUDY OF SCIENCE

Playfulness has long been an important aspect of informal science. Science programs for children like Beakman's World and Bill Nye the Science Guy, as well as websites featuring "Fun Science," (Appelbaum and Clark, 2001) impress children with the "wow" of science through demonstrations and hands-on activities that yield surprising results. NSTA Convention events such as the Flynn Incredible Evening of Chemistry have this same effect on teachers. Informal learning at science centers such as the Exploratorium (Gregory, 1997) and the Marian Koshland Science Museum of the National Academy of Science, Washington, D. C. (Smith, 2004) allow both adults and children the opportunity to play with science. Mitchel Resnick (n.d.) of the MIT Media Laboratory proposes that children learn best when self-motivated to learn through play opportunities with materials such as LEGO robotics. He calls such learning "playful learning" which he distinguishes from entertainment and education, both of which he considers to be passive. Whether a geology experience is considered fun appears to be an important aspect of the success of special geology programs (Repine, Hemler, and Behling, 2004; Revetta and Das, 2002). But do students get to play with science in normal classroom settings?

Few famous scientists have written positively about their school or university science course experience. However, Schawlow (2004) mentioned a memorable university lab where the professor challenged students to investigate the relationship between balloon air pressure and diameter and the depolarization of light. "It was a lot of fun, just turning us loose" (p. 315). Some teachers have deliberately tried to make learning science fun. In a study of a playful physics class, Court (1993) noted that the teacher made physics exciting and fun, used humor, and allowed students to work in low-stress cooperative groups. Raymond E. Beiersdorfer, who won an Ohaus-NSTA Award for Innovations in College Level Science Teaching called his teaching "Playful teaching: A simple teaching strategy that really works" (Beiersdorfer recognized…, 1995, p. 294). Using mood music, questionnaires on student feelings and interest, mutually established rules, student-written exam questions, mid-semester interviews, and real research, he gets his students involved and excited about learning. According to Beiersdorfer, "if my students are having fun and are excited about my class, they will get emotionally involved with the subject matter, learn more, and retain more" (p. 294). Berk (2002, 2003) recommends the use of humor to create enjoyment and promote learning in the university classroom. According to Zembylas (2004), emotional involvement is an important aspect of attitude toward science. In a retrospective study (Palmer, 1999), university students identified the attribute *made lessons fun/interesting* as one of the most important qualities of an excellent science teacher.

Another aspect of pleasure in learning science is social. Research on the consequences of fieldwork suggests that social aspects are important for enjoyment. Boyle, Maguire, and others (2007) found that students enjoyed "making good friends and getting to know fun and interesting people" (p. 312) as well as the physical aspects of exploring the outdoors during their fieldwork experiences.

A current controversy in science education is the appropriate role of fun in the teaching and learning of science (Appelbaum and Clark, 2001). According to Raizen and Michelsohn (cited in Appelbaum and Clark, 2001, p. 583), as "a hands-on activity becomes time to 'play' with science materials; the well-meant demonstration becomes only an entertaining show." Gregory (1997, p. 205) concludes that play is necessary in science learning and discovery but that "unguided play is not sufficient. Scientists must also have discipline and purpose to guide creativity." Sorge, Newsom, and Hagerty (2000) noted that fun experiences in a Space Science Education Program improved Hispanic students' attitudes toward science but unfortunately did not change their perceptions of their ability to become scientists.

In the present study, highly motivated students, who had developed an interest in the geosciences, shared their insights on the following: (a) the role of fun and playfulness in their previous school experiences, (b) the influence of playfulness and fun on learning, and (c) the role of fun and playfulness in their conduct of research during a summer geology research program. Their perceptions of the role of fun in their previous experiences, as well as the role of playfulness in the conduct of "real science," have implications for science education.

METHOD

Subjects

Subjects were 30 undergraduate students who participated in the final two summers (15 students each year) of a six-year NSF funded summer geosciences research experiences for undergraduates (REU) program. The participants included 17 men and 13 women, most of whom were majoring in science, though a few were in science education. Participants worked 40 hours a week for eight weeks. All received stipends. Some registered for course credit. Most of the students lived together in university housing, although the local students commuted from home.

Program

Three to five students with two to three faculty advisors worked in teams on each of four research projects that continued from one summer to the next over the course of the six summers. The faculty represented the host research university, a historically Black college, a community college, a small state university, and a small

private college. Students obtained either their first or second choice of project. They had input into the research, culminating in individual papers, group presentations, and abstracts submitted to conferences. The titles of their research presentations at the end of the last summer illustrate the nature of the research projects:

- Fluid inclusions in metamorphic rocks from the Uchee Belt.
- Geochemistry and structural significance of amphibolites and gneissic rocks from the Uchee Belt of Georgia and Alabama.
- Assessment of impacts of development in a Chatham County salt marsh using comparative downcore geochemical, micropaleontological, and sedimentological variations and GIS and remote sensing methods.
- Microfacies correlation of Upper Eocene Sandersville Limestone member of the Tobacco Road Sand to the Ocmulgee Formation on the coastal plain of Georgia.

In addition to the lab work related to the research, most of the groups went on field trips to collect samples, and all of the participants attended weekly group meetings, colloquia, and philosophy of the geosciences seminar sessions. There were also social occasions each summer, including parties at the beginning and end of the summer, and an outdoor recreation trip (e.g., kayaking). The development of evaluation instruments and the evaluation of the first years of the program were published in Burnley, Evans, and Jarrett (2002) and Jarrett and Burnley (2003).

Procedures

Toward the end of last two summers, the evaluator (first author) asked participants to respond in writing to the following:

1. Discuss briefly if and when you felt playful in a science class, science lab, or doing a previous science research project.
2. Discuss experiences this summer during the program when you felt playful.
3. Evaluate the role of playfulness, inspiration, or "ah -ha" feelings while you were doing this summer's research.

These questions were deliberately framed to elicit a variety of very personal reactions. Question 1 was designed to identify the types of previous course and lab experiences the participants considered playful and the importance they ascribed to those experiences. The purpose of question 2 was to identify aspects of the summer experiences that could best be described as playful while the purpose of question 3 was to interpret the role and importance of playfulness in the research process itself. During the final summer, a week after responding to the above questions, the 15 students participated in a session on play in the weekly philosophy of the geosciences seminar. In preparation they read *Playfulness in the biological sciences* (Ganschow with Ganschow, 1998) and *Chemists and play* (Kean, 1998). At the beginning of this session, students wrote briefly on what they saw as the role of play in learning, and at the end, students were invited to write down anything they wished to add about their playful experiences of the summer. The session included a discussion on the definition of play, a video clip on science play at the Exploratorium, and a paper helicopter design activity. Various definitions of play (Klugman & Fasoli, 1995) were discussed, most involving a list of qualities, some or all of which are present in play. The helicopter activity was included to illustrate, in a playful way, the hypothesis generation and data collection phases of the scientific research process.

Data Sources and Analyses

Written responses were analyzed qualitatively using constant comparative analysis (Glaser & Strauss, 1967). In constant comparative analysis, the researcher reads the first participant's answer, highlighting themes with examples and then each other participant's answer in turn, adding additional themes with examples. Also, tallies were made of the frequency of types of responses. Other data sources were observations by the evaluator and the principal investigator. The evaluator attended the opening meeting, the socials, most of the group meetings and philosophy of geosciences seminar sessions, some of the colloquia and field trips, and the final meetings at which participants presented their geological research. The principal investigator (second author) participated daily and was advisor for one group. Approximately halfway through the program, the evaluator interviewed each team in its laboratory with the following questions: What are you doing? What are you learning? Are you learning what you wanted to learn? What suggestions do you have? Their answers were not analyzed for this study, but mention of fun was noted in many of the interviews.

Reliability and Validity

Quantitative researchers explain the trustworthiness of their research in terms of reliability, objectivity, internal validity, and external validity (Golafshani, 2003; Lincoln & Guba, 1985; Morse, Barrett. Mayan, Olson, & Spiers, 2002). In qualitative research (Lincoln & Guba, 1985), internal validity is "truth value" or credibility, and external validity is demonstrated by transferability and applicability. The equivalent of reliability is consistency and dependability. Objectivity is neutrality or lack of bias. In this study, credibility was supported through prolonged engagement by the researchers across the grant period and across the summer, persistent observation of the participants and triangulation of observations and mid -summer interviews with themes that emerged from the questionnaires. Tallies of the mention of ideas related to the emerging themes, though not usually included in qualitative research, allowed for notation that themes were mentioned by many, several, or just one participant and gave some measure of the trustworthiness of the themes that emerged. Evaluator notes from the interviews and observations by both authors (the evaluator and principal investigator) added insights on aspects of playfulness that were not covered in the surveys and helped to triangulate the data. Although direct transferability is limited to students in similar research

programs, the authors relate the findings to similarities found in previous research and in classroom observations. Consistency was supported by the commonality of the subjects (students interested in the geosciences) and the inclusion of all the participants during the final two years of the program. Objectivity was supported by the collaboration between the two authors, one with a particular interest in play; the other perhaps more objective. The trustworthiness of the data, adapted from Lincoln and Guba (1985, p. 290), is summarized in Table 1.

RESULTS

Although the questions were phrased in terms of play and playfulness, many students mentioned fun as part of their answers. The next sections include the themes that emerged from the responses.

Times in a previous science class, science lab, or doing a previous science research project when students felt playful

All participants but one could identify playful times during a previous science class or lab. Several themes emerged: (a) *Interesting phenomena*. Many students felt playful when working with particularly interesting phenomena such as thin sections of rock, fossils, "glowing stuff," dry ice, or "cool experiments." Several also mentioned field trips and fieldwork as being interesting and fun. (b) *Independence*. Some students felt playful when they were working on their own research, for example science fair projects. Just being able to work independently was considered fun. One student said, "I usually feel playful whenever I can play with the equipment without supervision." (c) *Relaxed atmosphere.* Another theme had to do with the way the teacher organized the class. Participants enjoyed friendly support of teachers and relaxed labs where it was, "OK to mess up." One participant said, "In college during my principles of chemistry lab, we were able to work on a very informal basis. We worked when we were ready and could ask questions when we needed help, but the instructor wasn't peeking over our shoulders every few minutes. I was very relaxed in that environment so I had fun most of the time. We usually took forever to finish labs, but we knew what we were doing and did it well." (d) *Fooling around.* A fourth theme had to do with social behavior, what might seem to a teacher as "inappropriate play." A few students said they became playful to keep from being bored, "fooling around," teasing, or "goofing off" with peers they felt comfortable with, often while waiting for the completion of lab procedures. As stated by one participant: "If you watch a canister of soil for long enough, you are bound to start joking around with your friends."

Experiences during the summer program when students felt playful

The examples given in response to this question corresponded to aspects of play mentioned when writing about their previous experiences. Participants mentioned: (a) the fun of the work they were doing, (b) playing while working, (c) socializing at work, and (d) socializing at other times. Many participants gave examples of playfulness in lab and on field trips. Figure 1 shows the humor one group showed in the "decoration" of the door to their lab. The material on the door contains a number of things, some are humorous pictures and inside jokes that appear to have no relationship to what the students were doing but may have served to bond the group together.

Others are jokes that are directly related to the work (for example, the photomicrographs of fluid inclusions). The photos of the synchrotron were originally on the door

FIGURE 1. Lab door "decorations" of a particularly playful group of students.

TABLE 1. WAYS IN WHICH TRUSTWORTHINESS IS ESTABLISHED

Aspects of Trustworthiness	Study Elements
"Truth value" (internal validity)	• Prolonged engagement by both authors • Triangulation of questionnaire, interviews, and observations by both authors.
Applicability (external validity)	• Application to how real science is conducted. • Students engaged in scientific inquiry.
Consistency (reliability)	• Similarity of students, all with interest in the geosciences. • Data collection across two years with students having somewhat different experiences each year. • Inclusion of all participants in the data collection and analysis.
Neutrality (objectivity)	• Collaboration of the two authors. • Written answers to questions on play and playfulness.

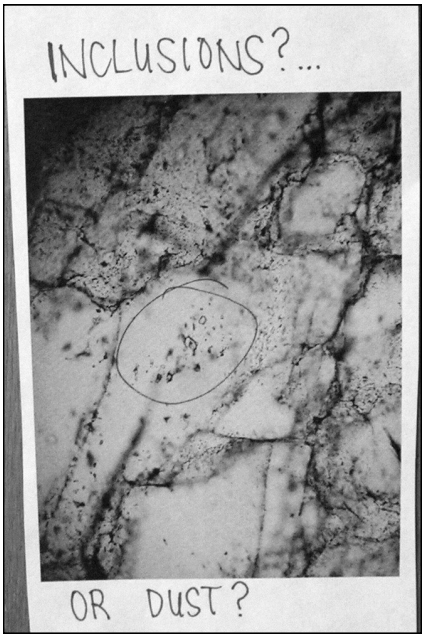

FIGURE 2. Photo of a thin section with fluid inclusions: A door decoration joke.

and the "Hughes Landing" sign at the top was a private joke of the faculty member who managed the lab. The students made jokes about fluid inclusions and hung them on the door. One of the jokes says "Inclusions or dust?" See Figure 2. Looking at fluid inclusions can be frustrating. Sometimes they are very tiny, and it is hard to figure out what it is they are doing or even what they are.

The other picture of fluid inclusions, captioned "connect the dots with fluid inclusions," is more "silly" but still is a commentary on the "serious" way scientists tend to perceive their work. See Figure 3.

The PowerPoint presentations at the end of the semester were also an opportunity for students to include playfulness and humor in their work. Figure 4 shows self-caricatures of all group members at the end of one PowerPoint research presentation.

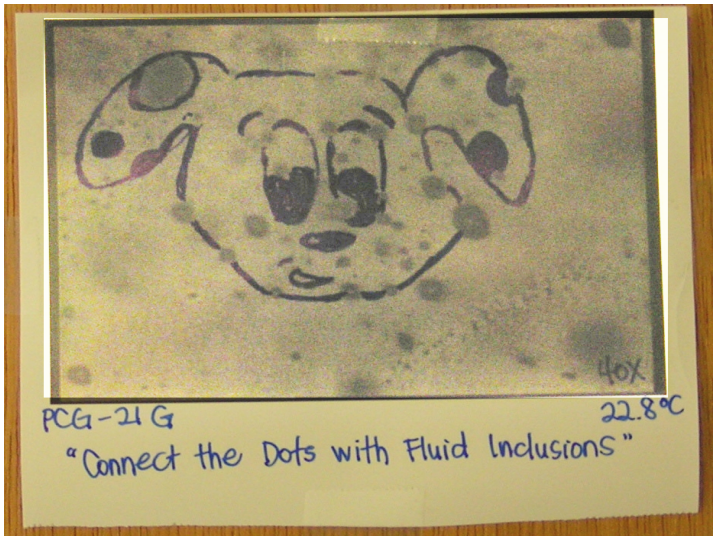

FIGURE 3. Connect the dots picture also from fluid inclusions.

One group apparently became a little too playful at the beginning of the program: "Our group (coastal) is a generally playful clan. We got into trouble at first, but now we are trying not to cause a ruckus!" The following quotations represent the *fun of the work* itself:

- In the labs --- ICP-MS ---that's all play to me. I love hands-on lab work or field work.
- Working with the microscope
- Working in the rock prep lab, particularly cutting rocks was good old fashion fun. I could take beat-up, weathered rocks, and producing a clean face where the foliations were visible was enjoyable.
- I felt playful when we cut our rock samples up by using the saw blade. It was a fun machine and amazing at how cutting a rock would produce a thin section.
- Working in the marsh was hard work but also a lot of fun. As a group we experienced delight in finding unusual creatures and although we had trouble with our coring apparatus, we turned that difficulty into a fun experience trying to come up with ways to solve our problems.
- I don't know if playful is the word because we had to be careful. But melting the rocks to make fusion beads is great fun.
- When pouring HCl on carbonate rocks was "fun," to see it fizz was exciting.
- Most of the research involving fluid inclusions is playful. From the inclusions themselves, dancing when heated, or filling the containers with liquid Nitrogen, you're always wanting to freeze a banana or shatter a penny, etc.

Playing with liquid nitrogen is a transition to the next theme, *playing while working*. The people working with fluid inclusions had fun freezing things. As one students said, "Last week we kinda had fun in the lab because we felt pretty comfortable with the equipment and while we were emptying the liquid Nitrogen tank so we could order more, my group members had a little fun freezing things." "I feel very playful because of the ability to freeze everything." In another example of play while working,

FIGURE 4. Self-caricatures of student researchers at the end of their final research presentation.

the Coastal group played on their field trip. One mentioned, "I got to play in sinkholes and streambeds." The big play experience however, was a mud fight. "We got to play in the mud and marsh, wrestling, getting soaked together was a blast." "When Coastal took its trip to Skidaway, Jim and I kept throwing mud at each other in the marsh, which helped to make it fun." Another type of play while working was *play with ideas* and included discussion, problem solving, and challenging one another to "I bet you didn't know" type things in geology.

Besides play at work, participants mentioned two types of *playful socializing*: that which took place at the workplace and that which took place during off hours. The participants enjoyed talking and eating together at the university and during their off-hours, goofing off, playing games, and attending sporting events. Most found one another congenial and fun. Those staying in campus housing felt it was nice to come home and "be goofy."

Evaluation of the role of playfulness, inspiration, or "ah-ha" feelings while doing the summer's research

When asked to discuss playfulness while doing research, approximately half of the students identified "ah -ha" feelings when they *figured out something new, discovered something important about a phenomenon, got results* (such as the melting/freezing moment of fluid inclusions), *developed a model*, or *discussed findings with their colleagues*. Preparing PowerPoint presentations on their projects were "ah-ha" experiences for some students as their ideas finally "came together." The following quotations show the range of responses:

- When I am having fun, I think I learn more and most importantly I actually enjoy working. It is less stressful and tiring that way.
- There has been a lot of inspirational learning in the research process.
- Playfulness in the field was a significant contributor to maintaining the spirit of our work. So it acted as motivator to keep us going.
- Looking at the thin section and being able to build a story, milling [sic] over of the information, trying to sort out what do all the slides mean. This happens in the lab, on the bus, right before I fall asleep. I think and "play" all the time if the excitement/ motivation is there.
- I think playfulness is absolutely necessary when doing research, [name of program] or otherwise. Without playfulness, your mind seems to lose a lot of its creativity. As a child, imaginations run wild and many may lose that.
- Very important to make new discoveries. Like a light is turned on that leads to a new…

Role of play in learning

At the beginning of the session on play during the philosophy of the geosciences seminar, the 15 students in the last year of the program responded to the question: What is the role of play in learning? From the analysis of their answers, four themes emerged: (a) *Play makes learning easier*. This was the dominant theme. Several students said that things are more memorable when they are fun. The students also claimed that they learn faster and that learning becomes more natural when it is fun. (b) *Play increases interest*. There seem to be two aspects of this theme. The first links play through interest to better learning: "[Play] is very important. In order to interface new information the learner must attach it to something they already know. This link is often times made from a certain interest level." The second links play to interest as a motivator for future learning: The role of play is "to get students interested in learning the details of a particular subject, and to get them thinking about future education in that field." (c) *Play improves attitude*. Play is "needed to make sure to sustain a positive fun attitude." (d) *Playfulness relieves boredom*. This was discussed from two angles: play during work, "to liven up the work you are doing, to break the monotony," and play as a break from work, e.g. "to take a break from the grindstone to watch a movie."

Additional thoughts after the workshop

Of the 15 final year students who participated in the session on playfulness during the philosophy of the geosciences seminar, seven added ideas to the back of their surveys after the session ended. Several mentioned thoughts they had not written before. A few were negative, such as "working with people who don't like to play is a drag" and "it's hard to find people who will play with you – some people mistake being playful for being unprofessional and that sucks." Most were positive and talked about ah-ha moments that were worth the long tedious periods or said that the work in general was fun. A hallmark of the program had been that the participants felt that they could contribute ideas and creativity to the research, and one student mentioned that having input into the research made it fun. However, another student mentioned lack of input and how his group played when work was routine rather than creative: "We played in the lab (although we weren't supposed to) because the work we were doing at the time did not require much precision or focus. It was really boring and time consuming, so we had to find ways to amuse ourselves. It would have been more fun to help in deciding our research focus/ hypothesis. Instead, we were given the hypothesis and just made to gather the data. So we didn't get to play with the ideas very much. Now that we are interpreting the results it is a bit more playful."

Trustworthiness of data

Although the groups were not asked specifically about playfulness or fun in the interviews conducted in the middle of the summer, comments made during the interviews corroborated the importance of fun in the functioning of the groups. The participants often volunteered that they enjoyed working together and identified aspects of playfulness in their lab work. During the field trips, the authors noticed playfulness that was also mentioned by the participants. Author observations of the labs and during the final presentations identified aspects of fun/playfulness not mentioned by the participants, including the use of humor on the doors and

during the final presentation. Several of the themes that emerged from the surveys were found in most of the participants' survey answers, thus supporting the trustworthiness of those themes. Student responses after the workshop indicated that the workshop did not change their working definition of play, but spending more time on the topic of play seems to have reminded almost half the group of new thoughts they had about the summer experience.

DISCUSSION/CONCLUSIONS

The geology summer program gave students the experience of working with geology professors to do real geology research. Since the projects had been ongoing for several years, the students did not have input into posing the original research questions, though students generally had their first choice of the project with which to work. However, students participated in hypothesis refinement and testing, data collection, and interpretation of the findings. The play/fun research reported here explored how geology student researchers perceived the role of playfulness in the conduct of their research and the role of playfulness in their previous learning experiences.

The findings of this small study must be considered preliminary. The students were already interested in science, and we did not ask them specifically how their interest developed and the effect of fun or playfulness in the development of that interest. However, their insights on the role of fun and playfulness in classroom learning and in the conduct of real science have implications for schools and colleges in developing learning environments that model how scientists work and that support interest in science.

Playfulness during the summer: The role of playfulness in the research process

Ganschow and Ganschow (1998) proposed that playfulness is appropriate and perhaps even necessary at the hypothesis development and inference drawing stages, with less playfulness at the data collection stage due to the care that must be taken to collect accurate data. Although the students did not initiate the research, they had input into refinement of the research questions and the methods used; and they had considerable flexibility in data interpretation. Most students participated in at least one field trip in which specimens were collected for their team or for another team, though most of the data collection/analysis was done in the university laboratories. The field trips were seen as playful and important for the research, as well as for the bonding of group members. The examples of fun and playfulness given by the students included all aspects of the summer project: (a) humor as teams bonded; (b) the fun of the work itself, whether taking core samples in the marsh, cutting thin sections, freezing and heating fluid inclusions, or interpreting the results for presentation; (c) playing while working whether playing with liquid nitrogen or engaging in a mud battle; and (d) playful socializing during breaks at the lab, social events, and time off. Both aspects of play, as engagement and as diversion (Mainemelis, Harvey & Peters, 2008) were mentioned. These students had fun and engaged in playful behavior at all stages of the research process, including the data collection stage. We conclude that collaborations with peers, input into the research, new experiences, and making meaningful connections are all important aspects of playfulness that can make science research fun and worthwhile. Although data analysis was tedious at times, the students were learning new things and working together at their own pace, making both work and social interactions fun.

It was interesting how the session on playfulness, conducted in the philosophy of the geosciences seminar, affected students' thoughts on their own research experiences. Those who added additional thoughts generally described in more detail the fun of the work experience itself. However, a few were reminded of times that were not playful, either because their team members were too serious or because they did not have enough input into the project. The perception of lack of input, rare since the students were encouraged to behave as researchers rather than as lab assistants, affected the experience of fun for at least one student. Input, related to Glasser's (1986, 1988, 1998) *control* construct and Ryan and Deci's (2000) *autonomy* construct appears to be very important in making work more playful and less boring.

Playful times in a previous science class, lab, or doing previous research

The final year students, in reflecting on the role of play in learning, had insights useful for teachers at all levels, from elementary school through college. The theme mentioned by the most students, that *play makes learning easier*, suggests that playful engagement with course material makes that material more memorable. Other themes, including the role of *playfulness in relieving boredom*, *improving attitude toward school*, and *increasing interest* help explain the role of play in learning and innovative thinking described by Singer, Golinkoff, & Hirsh-Pasek (2006). The assertion that play increases interest is important in self-determination theory (Deci, 1992; Ryan & Deci, 2000) since interest is seen as crucial for the development of intrinsic motivation for learning. The last two themes, that play improves attitude and relieves boredom, are probably related and have implications for classroom management.

According to the students from both years, opportunities to engage in interesting experiments were inherently fun. Also much of the fun came through open-ended explorations and investigations over which they had some input and control. When they had input into the research question and/or the design of a study, all other aspects of the research process had fun elements. Those included collecting and analyzing data but more importantly discerning the meaning of the data and drawing conclusions. They liked to be able to act independently in a relaxed atmosphere where they were allowed to work at their own pace and where, within limits of safety, they were allowed to learn from their mistakes. Creating a playful atmosphere in the classroom may require a spirit of playfulness on the part of the teacher. Although students described teachers as relaxed

and friendly, no one mentioned the need for the teacher to be deliberately humorous. Future research could specifically examine the effect of teacher use of humor as described by Berk (1998, 2002).

Participants' enjoyment of the work itself and the ability to socialize in the lab correspond to Mainemelis, Harvey and Peters's (2008) differentiation of workplace play as both (a) engagement, through the work itself, and (b) diversion ("goofing off"). In the classroom, as in an innovative company, both elements may be beneficial. The essential elements students mentioned (the fun of the phenomena, the control they felt when able to work independently, and the sense of belonging that occurred when students were able to socialize together in labs or during field trips) support Glasser's (1986, 1988, 1998) assertion that fun, control, and belonging are crucial in healthy schools.

IMPLICATIONS FOR SCIENCE EDUCATION

Many science classes bear little resemblance to the engaging classes described by the students in this summer research program. Science is often taught as a body of knowledge summarized in a textbook rather than a method for learning about the world, and hands-on labs are rigidly designed to confirm what is already explained in the textbook. During visits to elementary school classrooms, the first author has noticed classroom rules and instructions that promoted the image of science being extremely serious. Students were told not to play with the materials and that "the scientific method" had invariant steps that must be followed. Students did cookbook labs and filled in the blanks with no control over the research questions or the means of answering those questions. In such classrooms, there is little fun and students are not learning about the playful aspects of real science.

How does a fun, playful classroom or lab look? Fun, belonging, and control (Glasser, 1986, 1988, 1998) should be considered in the way science is taught at all levels. Science activities don't need to be designed as fun for fun's sake, as noted by Appelbaum and Clark, (2001), and just being fun is not sufficient for learning (Sorge, Newsom, and Hagerty, 2000; Zull, 2002). However, inquiry learning, in which students have opportunities to answer their own research questions, collect their own data, collaborate with peers, and draw meaning from the data can provide enough fun to interest them in science. Input at all those stages of the research provides students with a healthy amount of control over the process. Working together in a relaxed atmosphere where interactions are allowed enhances belonging. Collecting trips, even in the neighborhood, provide new experiences and perspectives and connect the real world to the lab. Mud battles, as mentioned by a few participants, are extreme and are not necessary in order for collecting trips to be fun! High school students sometimes have the experience of presenting their work at science fairs, an experience somewhat akin to scientists going off to conferences. Even elementary school students can present their research at what Pearce (1999) calls a Kid's Inquiry Conference and enjoy the collegiality of sharing with their peers.

The participants' descriptions of playfulness in the summer program were similar to those of scientists describing playfulness while doing research (Jarrett & Burnley, 2007; Ganschow with Ganschow, 1998; Kean, 1998). In order to create an atmosphere in which students enjoy science and learn to behave like scientists, teachers need to understand the role of playfulness in the conduct of science. Nature of science courses should include readings and discussions on the role of fun and playfulness in doing scientific research. Also, summer programs engaging teachers in work with scientists can give them personal experience with both the work and the social aspects of fun. And, as part of the social aspects, teachers may discover that, "If you watch a canister of soil for long enough, you are bound to start joking around with your friends." Maybe that is not so bad for students, teachers, or scientists.

Acknowledgement

Special thanks to the National Science Foundation whose funding of the REU summer program made this research possible.

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