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Creativity and Thinking Skills Integrated into a Science Enrichment Unit on Flooding

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Floods that used to happen every hundred years are now occurring more frequently. Human influences on the damage inflicted by flooding need to be well-understood by future voters and property-owners. Therefore, the timely topic of flooding was used as the focus of a special multi-grade enrichment short course taught by two university education professors for 26 preK-8th grade high-achieving and creative students. During the course, students listened to guest speakers (city council member, meteorologist, and environmentalist), watched two flood-related videos, read books on floods, viewed electronic presentations related to dams and recent floods, discussed causes, effects, and mitigations of flooding, and devised creative games from recycled materials to teach peers about flood concepts. The de Bono CoRT Breadth thinking skill system was used to organize many of the course activities. The flood lesson activities were relevant to these students who had experienced a flood of the city's river the previous year and challenged students more than their typical classroom activities, an important finding considering that many gifted students drop out of school because of irrelevant and non-demanding class work. The course broadened students' knowledge of floods and assisted them in thinking beyond the immediate situation.

Keywords: Floods; Elementary Education; Enrichment

Introduction

Elementary and middle school students who are high-achieving in science and who exhibit creativity are often not challenged or given the opportunity to fully use their abilities in the regular classroom. Many gifted students drop out because school is boring, repetitious, and lacks relevance to real life (Hansen & Toso, 2007). Students who consider dropping out want more exciting, challenging tasks and coursework (Snyder, 2003). Unfortunately, many classroom teachers lack sufficient background knowledge to design stimulating, advanced science projects for these students; some avoid science altogether. A national survey (Fulp, 2002) revealed that multi-subject teachers (mostly elementary teachers) are ten times more likely as single-subject teachers to be unprepared to teach science. Another study (Dorph et al., 2007) found that eighty percent of K-5th grade multiple-subject teachers who were responsible for teaching science in their classrooms reported they spent an hour or less per week on science, with sixteen percent of teachers spending no time at all on science. Special programs for students that dig deeply into relevant science topics and highlight careers fill an important need, as motivated high-performers or exceptionally creative students are the ones most likely to become future scientists, engineers, and inventors. The attractiveness of science careers and self-confidence in science are strong factors in the choice of science or engineering coursework and careers (Robertson, 2000; Woolnough et al., 1997).

Zhao (2009) asks what knowledge is of most worth in the current global and digital economy that has changed the old economic rules by enlarging and connecting markets with workforces across the world, by meeting a larger variety of needs, and by reaching customers with unique wants. Preparing stu-

dents for the global and digital economy requires that future workers acquire 21st century skills of core subjects such as science; but also learning and innovation skills; information, media, and technology skills; and life and career skills (Partnership for 21st Century Skills, 2011). Besides a need for Science, Technology, Engineering, and Mathematics (STEM) skills for economic growth from innovative processes and products, the current global climate change phenomenon requires more scientific knowledge to mitigate and solve the effects of severe weather, flooding, tornadoes, hurricanes, blizzards, drought, and wild fires on energy supply, transportation and infrastructure, residential and commercial buildings, agriculture, forestry, waste management, and industry, among other issues (Barker et al., 2007).

To meet the need for a science enrichment short course focused on 21st century skills at a local elementary school, two education professors designed, in collaboration with school faculty, a short course for exceptional preschool through middle school students in which the students delved deeply into the science content of flooding. Students practiced learning and innovation skills as they devised creative games to teach their classmates about the information they had learned. They utilized information, media, and technology skills by accessing online information and developing game boards and components with drawing software. Three guest-speakers, who were working in the flood-related areas of meteorology, environmental science, and city planning, provided students with a glimpse of possible career paths related to this real-world topic. This article reports the results of this successful endeavor to provide ideas and guidance to others designing a similar program or teaching about the topic of flooding.

National Standards

Technology and invention are important components of the elementary and middle school science curricula. Science and Technology Content Standard E of the National Science Education Standards (National Research Council, 1996) states that, as a result of activities in grades K-4, all students should develop abilities of technological design. Similarly, Science and Technology Content Standard E for grades 5 - 8 states that all students should develop an understanding of abilities of technological design: "In the middle school years, students' work with scientific investigations can be complemented by activities in which the purpose is to meet human need, solve a human problem, or develop a product rather than to explore ideas about the natural world" (p. 161). Invention supports scientific inquiry, allowing students to make connections to the real world and to other subject areas. During this flood unit, all students worked either individually or in teams to invent a game using many recycled items that presented flood concepts to players.

The authors of the *Benchmarks for Science Literacy* (American Association for the Advancement of Science, 2008, 1993) in Chapter 3, The Nature of Technology, discuss how elementary and middle school students need to know about the connections between science and technology, the nature of engineering and design, and societal issues related to technology. Besides students considering the suitability of recycled items for game parts, students also considered the use of human technology in flood prevention and mitigation throughout the short course. Additionally, the *Benchmarks*, in Chapter 4, The Physical Setting, state that elementary students should know how water shapes the earth's surface through erosion and deposition. The topic of flooding explores these ideas.

Invention lessons address the often-neglected domains in science education of "Imaging and Creating" (Domain III) and "Using and Applying" (Domain V) as defined by Yager (2000). Invention allows students to combine objects in new ways, to produce alternate or unusual uses for objects, and to design and test devices and machines. Through invention, students apply learned science concepts and problem-solving skills to everyday technological problems and household devices. These operations occurred as students used cast-offs in their game-making. Students involved in invention also work in Domain VI, "Viewing Science and its History as Human Enterprises." In this science domain, students considered the motives of scientists, engineers, and technologists, along with investigating the history of technology and its effects on our society. These concepts were addressed as students learned of beaver dams, historic human dams, and modern hydroelectric dams during the project.

Objective of the Study and Rationale

The purpose of this project was fourfold: 1) to present high-achieving elementary and middle school students with a challenging special enrichment short course; 2) to involve students with the real world problem of flooding directly connected to their community; 3) to provide students with the opportunity to study a science topic in-depth with expert instruction that provided models of possible careers; and 4) to ask students to create an authentic product—a flood game—that would allow them to practice creative thinking and invention while applying recently-learned information about floods.

The invention of a flood game allows students to apply their new knowledge while practicing important creativity skills. Globalization since World War II has challenged America's role as economic and strategic world leader. Much of our workforce now competes for employment with lower-wage earners from other countries. Workers in other nations conduct innovative scientific and engineering work, and are easily employed through the Internet (National Research Council, 2005). Inventors and innovators will help Americans to compete with other nations and to craft solutions for our serious environmental problems.

Sustainable development is the practice of protecting the environment while improving living standards for all, and invention and innovation is the key to its success. Invention and innovation for sustainable development isn't just developing new technology, but includes new processes and new ways of solving old problems—creative thinking is the rubric... Despite the fact that people everywhere have an innate ability to be creative, rich countries are not doing enough to stimulate and harness invention and creative thinking... due to a combination of factors ... [including] education systems that don't inspire or value creativity... (Lemelson-MIT Program, 2003: p. 4).

Educational Theory

The Schoolwide Enrichment Model (Renzulli, 1976; Renzulli & Reis, 1997) has three main instructional components: Type I General Exploratory Activities, Type II Group Training Activities, and Type III Individual and Small Group Investigations of Real Problems. These three types of enrichment activities were implemented in the flood unit discussed here. The Type I General Exploratory Activities included the three speakers' presentations, the flood videos, a water table (with containers, sponges, blocks, and toys) for exploring how flooding works, many books on floods, and electronic slide presentations of various aspects of flooding. The Type II Group Training Activities were the de Bono CoRT thinking skill exercises. Finally, the Type III investigations centered on producing a game from found or recycled materials to teach peers flood concepts (games were later housed in the school library for check-out) and to provide models for teachers through conference presentations and publication.

Students learning to develop their thinking skills and creativity need a structure that scaffolds their learning and allows them to practice skills. Therefore, the popular CoRT (Cognitive Research Trust) Breadth thinking skill system (de Bono, 2000) of Edward de Bono was chosen for this project. The CoRT system consists of 6 sets of thinking skills with the Breadth set being the most basic. These Breadth thinking skills have been used in numerous schools around the globe for several decades, are well-known in the field of gifted education, and have been employed by businesses and governments in solving problems (Barak & Doppelt, 1999; Gardyasz, 2007; Melchior, Kaufold, & Edwards, 1988; Rule & Barrera, 2006, 2008). The CoRT Breadth skills form the foundation of de Bono's *lateral thinking*, a creative thinking approach that helps thinkers generate new ideas in a way that may not be obtainable by traditional step-by-step logic (Carter, 2007). The set contains ten thinking skills generally referred to by initials or one-word titles. **Table 1** shows the skills and how each was applied during the unit on floods.

Table 1.
Edward de Bono's CoRT thinking skills applied to the flood unit.

Thinking Skill	Brief Explanation	Application to Flood Unit
CAF	Consider all factors	Make a list of all the factors involved in flooding to consider.
APC	Generate alternatives, possibilities, choices	Determine alternatives, possibilities and choices of games on which to model flood game final products.
C and S	Determine consequence and sequel of an action	Determine consequences and sequels of flooding at different time intervals: immediate, short term, and long-term.
Planning	Constructing a formal plan	Plan a flood game, including the object of the game, directions, flood facts, game board, and playing pieces.
PMI	Rate aspects of ideas as plus, minus, interesting	Consider the pluses, minuses and interesting aspects (neither positive nor negative ideas that arise as consequences or causes) of specific game ideas.
Decision	Make a decision based on criteria	Decide the basic components of the game that make it engaging and that teach flood concepts.
Rules	State rules	Write rules for the game.
FIP	Rate ideas for first important priority	List new learning and determine the most important ideas learned. Tell why they are most important.
AGO	Determine aims, goals, objectives	Check if any additional components could be added to bolster the aims, goals, or objectives of the game.
OPV	Consider other people's views	Obtain other people's views on the game and use this feedback to improve it.

Real World Connection

The topic of flooding is a timely one, as America is experiencing a steady increase in the number of record-breaking natural disasters connected to global warming with resources being overwhelmed by “hundred-year” events occurring much more frequently (Huber & Gulledge, 2011; Huq, Kovats, Reid, & Satterthwaite, 2007) Young citizens need to know how to vote to design communities and how to build homes in a sustainable way, harmonious with flood plain environments. A unit that helps students to understand the causes, effects, and mitigation of floods addresses important issues. In particular, the students in this investigation lived through a record-breaking flood of the river in their city that occurred less than a year before the students participated in this project. The students were highly motivated to learn how floods work, as many had experienced inundated homes or sandbagging efforts, firsthand. Therefore, this project had a very real-world, authentic focus for the students involved. The products—the games—generated by students were also effective because, through these games, students were able to review the information they learned and transfer it to peers who had not participated in the flood unit. The audience for the games extended beyond the school as the authors made two scholarly presentations of the project, highlighting the games students made to science educators and gifted educators.

Flood-Related Instruction Literature Review

In an editorial in the *Journal of Geoscience Education*, the editors (Libarkin, Elkins, McNeal, & St. John, 2010) stressed the importance of education for persons living in geologically hazardous areas so that they understand the causes, effects, and ways to mitigate disaster, making informed decisions about where to live (i.e., not on a floodplain), how to build, and how politics enter into the situation. In further exploration of the politics of disaster, Freudenburg, Gramling, Laska, and Erickson (2008) focused on the ways humans alter nature through levee- and canal-building, causing later human suffering during floods. They noted that, although many of these construction projects were promoted as economic development, they are

more accurately characterized as “removal of money from the many for the benefit of the few” (p. 1016). Therefore, students who are to become voting citizens need to understand the political and economic factors that create disasters.

Students need to better understand how global events affect local happenings, such as how the El Niño/Southern Oscillation phenomena is associated with flooding, droughts, and increased hurricane activity. Mjelde, Litzenberg, Hoyle, Holochwest, and Funkhouse (2007) presented a learning module combining science and mathematics that focused on students' understanding the probabilities of above or below normal precipitation, dependent upon Pacific Ocean anomaly patterns. Authors of another article (Mahaya, Tippins, Mueller, & Thomson, 2009) examined global water quality, highlighting the devastating effects of flooding on a pure drinking water supply. These authors presented classroom-tested activities including a case study of a Kenya water supply, along with water sanitation and bacteria testing methods.

Several authors have presented ideas for helping students who have experienced floods understand their experiences. Shreve, Danbom and Hanhan (2002) examined the artwork and writings of children who were victims of a Red River flood. They recommended that teachers ask children about their thoughts and experiences, explain how other people (rescue workers, firefighters, volunteers) help during the disaster, and initiate lessons that show how floods actually work so as to aid understanding and alleviate anxieties. Similarly, Zevenbergen, Sigler, Duerre, and Howse (2000) examined teachers' spontaneous changes to the next school year's curriculum after a flooding disaster occurred at the end of the previous academic year, finding that most teachers chose flood-related examples to illustrate information they taught, along with more discussion, drawing, and writing activities related to floods. Because many of the students in the enrichment class had been flood victims themselves, we added in opportunities for emotional expression and community-building.

The Flood Unit

A description of the setting and participants, the course con-

tent, the special speakers, the materials, and the pretest/posttest follows.

Setting and Participants

Twenty-six high-achieving and creative students participated in the special science enrichment class on flooding. The class was divided into two multi-age sections of equal numbers of students from grades prekindergarten through third grade (9 females, 4 males; 4 third graders, 4 second graders, 3 first graders, 1 kindergartener, and 1 preschooler) and fourth through eighth grade (6 females, 7 males; 1 eighth grader, 4 sixth graders, 5 fifth graders, and 3 fourth graders), each group meeting separately for an hour and a half each day for eight days near the end of the school year. Students were chosen through teacher recommendations, standardized test scores, and scores on a short creativity test. The authors obtained approval from their university's human subjects committee to collect data on the efficacy of the project. All students and parents gave permission for participation, data collection, and for photographs to be used in any subsequent publications.

Course Content

The course consisted of hour-and-a-half classes, eight in all, for each of the two age-groups, which occurred over a two week period. Course content was delivered via guest speakers, videos, reading of books, and electronic slide presentations. Exercises and discussions using the CoRT thinking skills helped students mentally process and better understand the information they received, as shown in **Table 1**. Each day, students were asked to contribute their ideas on several large posters as a way of recording ideas that could be discussed or used in the games being developed. Topics of these fact sheets were the causes, effects, vocabulary, exciting facts, and mitigations of flooding. Following each guest speaker or presentation, the instructors prompted students to add additional ideas to the posters.

The three guest speakers were a meteorologist, an environmentalist, and a city council member. A former local television meteorologist was the first speaker who explained how rainfall is measured, how river levels are monitored, and how these levels, gathered throughout an area, inform flood predictions. He brought a rain gauge and other instruments for the students to explore, demonstrating how they work. He also talked about flood safety, telling how one of the most common causes of death during flooding is drowning in a car that has been swept away by flood waters. Many people are unaware of the danger of driving into or across flooded streets; only two feet of water can float a car and allow it to be swept away. Rolling down windows and escaping immediately may save the occupants' lives. The second speaker was the director of the Center for Energy and Environmental Education at the local university. He provided an effective demonstration of soil permeability and water storage by use of a clever analogy. As a demonstration, he poured a bucket of water onto an empty tabletop allowing students to verbally react as the impermeable surface caused the water to cascade onto the floor as runoff. Then, covering the table with a folded beach towel simulating prairie grasses, he again poured a bucket of water onto the table. This time, however, the "grasses" absorbed the water, showing how deeprooted vegetation can store water and prevent flooding. He also ex-

plained how rivers naturally overflow their banks inundating their floodplains regularly; structures such as artificial channels and levees confine the river to a narrow path but produce overflow elsewhere because the volume of the river stays the same. Therefore, allowing the river to expand onto its floodplain and halting construction in this area would prevent much damage to human structures.

The third guest speaker was a city council member who showed a documentary video of the city's flood and discussed the current city issues of buying property that had been underwater during the recent flood. Students noted the familiar landmarks and remembered the awesome impact of the flood. The other video shown to students was a NOVA presentation called *The Mystery of the Megaflood* (NOVA, 2005a). An odd landscape located about 200 miles east of Seattle includes vast, deep gorges, huge boulders dropped in a seemingly random pattern, rippled hills, and gigantic, waterless waterfalls (NOVA, 2005b). An insightful geologist, J. Harlan Bretz hypothesized that a huge flood had created the unique landscape, caused by a glacial dam giving way to a huge glacial lake. Later, other geologists agreed with Bretz, after a similar, smaller glacial dam burst in 1996 in Iceland.

The flood-related books were written at several reading levels and contained exciting stories with interesting visuals (Kusky, 2008; Sipiera & Sipiera, 1998; Thompson, 2000; Woods & Woods, 2007). Students read them in their free time, especially to find additional flood facts for their games. Several electronic slide presentations illustrated and explained current floods across the nation (images and information were drawn from Internet news sites); how flood control and hydroelectric dams work, including the differences between historic and modern dams; beaver dams and their role in natural flood control; and another flood of a nearby community that involved an upstream town on the same river.

Pretest-Posttest

At the start of the unit, students were asked to respond in writing (younger students could dictate their ideas) to several open-ended criterion-referenced questions with these same questions being asked at the end of the unit as a way of comparing pretest and posttest knowledge of floods. These included the following questions:

- 1) What is a flood?
- 2) Tell as many different effects of flooding as you know.
- 3) How can people prevent or lessen (mitigate) the negative effects of floods?

A survey of "Attitudes about School and Learning" (Rogers, 2002) was administered to students at the start and end of the unit to gauge the attitudinal impact of the unit and to determine whether students perceived work during this short course differently than their regular schoolwork (This survey was read to younger students). Twenty statements related to perceptions about school in general were provided. Students responded on a four point scale: 1—always agree; 2—usually agree; 3—sometimes agree; and 4—disagree. A few example statements are listed: "3. School is exciting, every day is great," "7. My work at school makes me feel proud," and "20. The harder the work, the more interesting it is" (Rogers, 2002: pp. 454-455). The wording of some of the attitude statements was changed slightly on the posttest to reflect work during the flood unit rather

than toward school in general. Cronbach's alpha (Cronbach, 1951; Cronbach & Shavelson, 2004), a commonly-used measure of internal consistency of test scores, was .83, indicating reasonably strong reliability.

Results

Results of the effectiveness of the unit were measured through the students' products of creative flood games to teach others what they had learned and a comparison of the pretests and posttests. Examples of the games are described in the next section. Results of the study are illustrated in **Table 2** through 5.

Creative Flood Games

Students used creativity skills to put recycled and found materials to new uses or to use parodies of existing games in their flood games. Flood game products were of several types: fine motor skill activities, a word find, board games, a flood simulation game, a memory game, and matching puzzle games.

The fine motor skill games were made by younger students and involved using tongs to move animals or people from flooded areas to safety or to place miniature sandbags along a river to build a flood levee. A fine motor skills game was made by a kindergarten student who was very concerned about the animals that would become engulfed in flood waters. She found clipart images of her favorite animals, mirrored them on the computer, and cut them out. She glued a pompom in between the two sides to make them three-dimensional, so they could stand and be easily manipulated using tongs. She also designed sorting boards for the animals, as every individual animal was a different clip-art image. **Figure 1** shows her in action with the game.

The second fine motor skills game was created by a first grade student and is shown in **Figure 2**. It had a village fashioned from cut pieces of craft foam, trees represented by green flat glass marbles, and hills made of trimmed foam packing material, and the river represented by shredded blue paper. Her game involved mostly sandbagging because her family had sandbagged their home before the flood; she wanted to honor their efforts by making a game of it.

The student wrote the directions for her game called "The Big Flood:"

There can be 2 to 3 players. Use tongs to pick the sand bags up. You have to be careful. Use the board carefully so you do not break the board. Block the water from the houses with sandbags. DO NOT USE WATER! When all your sand bags are placed, you win.

In the fine motor skills game shown in **Figure 3**, a player draws a card from a stack of 20 scenarios and reads the information, such as, "Floodwater fills home—people need rescue," "Live power lines down—rescue people," or "Man drives car through flooded streets; car floats away—rescue people," and then acts out the drama by picking up plastic people with tongs and placing them on the rooftop for helicopter or boat rescue. Blue shredded paper was used to represent the flood waters, while brown rocks represented boulders and debris carried by the flood waters. Students made the homes out of used paper cartons with clip art house fronts glued to them. For all these fine motor skill games, the tongs were made with two complete Popsicle sticks with several partial sticks glued between them at one end, allowing lever action when pinched.

Table 2.
Pretest and posttest responses of 26 students to, "What is a flood?"

Component of Flood Definition	Frequency	
	Pretest	Posttest
Consists of water	24	25
Excess or over-abundant amount of water	12	10
Overflowing usual confines	10	11
Rising or surging	10	7
Causing damage to human structures	6	4
Caused by rain	6	4
Puts land usually dry under water	5	4
Caused by dam break	2	2
Dangerous/can kill	1	5
Contains polluted water	0	1
Carries debris or ice	0	1
Causes erosion	0	1
Total	76	75



Figure 1.
Fine motor skills game of rescuing and sorting animals made by first grade student.

A word find, made by a kindergarten student, focused on new flood-related vocabulary, such as *mudflow*, *jumble ice*, and *debris*. Words were printed backwards and on diagonals with other non-related words (e.g., happy, joy, sweet) used to fill space and make it more entertaining. Clues for the words were complex and attempted to direct the player to a certain place of the board.

A variety of board games was created. One activity made by



Figure 2.
The big flood fine motor skills sandbagging game.



Figure 4.
Game combining fractions in rebuilding flood-damaged homes.



Figure 3.
Fine motor skills game flood rescue game made by second grade students.



Figure 5.
Topographic contour map game of rising and falling river levels.

second and third graders combined fractions with house-rebuilding in a cooperative format of moving around a board, landing on spaces, and giving fractional house pieces to flood victims attempting to rebuild their homes (See **Figure 4**).

Others focused on answering questions about flood fact information to move around a board or to rescue people from flooded homes. For example, one pair of sixth grade boys made a parody of a Monopoly® game that focused on flood issues. There were interesting properties and spaces such as “levee”, “river”, “river gauge”, “drainage pump”, and “foot-deep water”. “Rescue” and “Flood” cards told flooding scenarios and consequences for the player.


Another unique game involved players matching questions to answers, resulting in raising or lowering the river level. This game consisted of a three-dimensional topographic contour river scene. The landscape of this game, shown in **Figure 5**, was made with layers of thick cardboard cut to show the contours of hills surrounding a river valley. The parts that had been cut away from each cardboard layer fit exactly into the river valley and were colored blue to represent different stages of the river that could be placed onto the landscape. These pieces were

added or subtracted in response to players’ work of matching cards showing terms and definitions or explanations, thereby raising or lowering the water level of the river. The game was made by three fifth graders collaborating with a sixth grader who assumed a leadership position. Students disassembled some pompoms and colored the fibers with a marker to make vegetation. They made houses from bits of sponge foam with paper roofs.

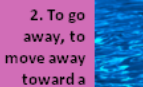
Two other games required players to place puzzle pieces (identical sectors of a circle) into a tray (actually, a decorated label-covered compact disk (CD) cut into 8 pieces labeled A-H placed into a CD case with areas marked 1 - 8 with a permanent marker) as players matched vocabulary to definitions or identified the order of events in flooding. The reverse sides of these pieces, when the tray was flipped over, revealed a pattern that matched the pictorial key if the player had answered all of the questions correctly. Two sixth grade students working on this game are shown in **Figure 6**; a page of questions and pictorial key that fit neatly into the CD case is shown in **Figure 7**; the glued-on labels for the sectors of the cut-apart CD are shown in **Figure 8**.



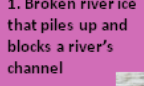
Figure 6. Two middle school students working on a fact puzzle game made from a compact disk and its case.




1. Broken river ice that piles up and blocks a river's channel



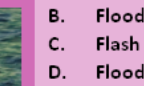
2. To go away, to move away toward a distant area



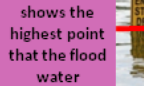
3. Line that shows the highest point that the flood water reached



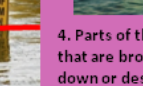
4. Parts of things that are broken down or destroyed



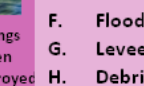
5. A sudden and destructive rush of water down a narrow gulley or over land



6. A wall built along the side of a river to prevent it from overflowing



7. The river's widened channel – the deep river and current



8. The maximum space a river needs

Flood Vocabulary

A. Recede
B. Flood Line
C. Flash Flood
D. Floodway
E. Ice Jam
F. Flood Plain
G. Levee
H. Debris

Figure 7. Matching questions for modified compact disk game.

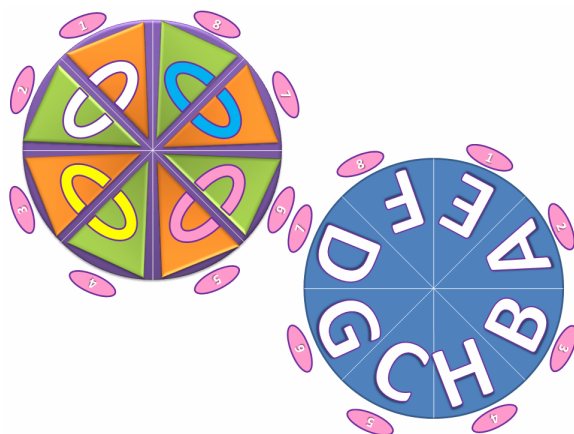


Figure 8. Fronts and backs of the eight game pieces made from a cut-apart compact disk with glued-on labels.

Posttest Outcomes

Table 2 shows that most students, even the younger group of kindergarten and first graders, had a good concept of what a flood was at the beginning of the program, with ideas shifting slightly with the experience of the flood instruction unit. This is understandable, as many students had witnessed the flooding of the city's river the previous summer. New ideas, addressed during instruction, that were mentioned were the ideas of polluted water, debris piles, erosion, and the many dangers of flood waters.

Table 3 shows that on the pretest, students focused on the immediate effects of flood damage, inundation, danger, and loss of property, while on the posttest, students recognized the after-flooding problems of debris piles and jumble ice, and looked ahead to clean-up and rebuilding. This demonstrates a broadening of student time perception related to flooding effects from the present to the near and more distant future. Some secondary effects of flooding such as more flooding, emotional toll, and building of dams are additional indications of broadening the ability to recognize longer-term effects.

Sandbagging was the most common response of flood mitigation methods on both the pretest and posttest. Students knew about sandbagging because they had seen it on television news reports and many had participated or had relatives who did. On the pretest, several students, as shown in **Table 4**, suggested currently impractical ideas such as trying to stop rainstorms or keep flood waters from coming into the area. On the posttest,

Table 3. Pretest and posttest responses of 26 students to, "Tell as many different effects of flooding as you know".

Flood Effect	Frequency	
	Pretest	Posttest
Building damage and destruction	11	11
Water invades homes/things underwater	10	2
Drowning/injury/death of people	9	7
Dirt/ mud/mold everywhere	8	8
Lost possessions/cars	8	5
Danger and evacuation	5	3
Trees/telephone/electric poles fall over	5	1
Homeless people	3	4
Water carries dirt/soil/sewage/disease	3	4
Power outage/surges damage items	3	2
Erosion of topsoil/mudslides	2	4
Economic cost/business loss/crop loss	2	4
Rebuild roads	2	0
Animals die	2	3
Debris washed into piles	1	10
No safe drinking water	1	1
Items moved by flood waters	1	0
Drains overflow	1	0
Jumble ice left behind	0	6
Knock houses off foundations	0	3
Rebuilding/other people help	0	3
Clean-up	0	3
Snakes in water	0	2
Scabland landscape	0	1
More flooding	0	1
Emotional toll-sadness	0	1
Dams regulate water	0	1
Total	77	90

Table 4.

Responses of 26 students to, "How can people prevent or lessen the negative effects of (mitigate) floods?"

Flood Mitigation Action	Frequency	
	Pretest	Posttest
Use sandbags to make levees or walls to protect property	22	21
Build higher than flood plain or away from shore	5	13
Stop rain storms and water from coming	5	0
Have stronger walls	3	0
Have a drainage system for water	3	0
Go to high ground	3	0
Go upstairs/Move items upstairs	3	0
Lock doors and seal cracks	2	0
Purify water	1	0
Sing rain song to lift spirits	1	0
Stop urbanization	1	0
Use amphibious vehicles	1	0
Use dams to regulate water	0	11
Plant prairie grasses creating spongy soil to absorb runoff	0	6
Be prepared	0	4
Evacuate when told to	0	3
Educate people about flood s	0	2
Don't waste water	0	2
Don't litter or dump debris in water	0	2
Don't change a river's shape	0	2
Don't drive cars into flood waters	0	2
Work as a team	0	1
Plant more trees and forests	0	1
Have plumber fix drains	0	1
Total	50	71

students exhibited more knowledge of the effects dams have in regulating flood water and the importance of not building on the floodplain. New knowledge of the role of deep-rooted vegetation and safety rules such as evacuating when required and never driving into flooded streets, appeared on the posttest.

Table 5 shows the mean scores of the responses to the attitude questions that exhibited significant change from the beginning to the end of the program. These questions show that students felt more challenged during this special program than during their regular classroom activities where many were used to taking the spotlight as the most knowledgeable students in the class (see questions numbered 6 and 8 in **Table 4**). The fact that students were less satisfied with grades and checked their work more carefully before turning it in indicates the more rigorous nature of the flood unit. The overall means of attitude statements on the pretest and posttest were almost identical, corresponding to answering "usually agree" to most statements. This indicates an overall satisfaction and feeling of motivation toward both regular schoolwork and the special flood unit.

Conclusion

This project satisfied its four planned objectives. First, the project presented high-achieving elementary and middle school students with a challenging special enrichment short course. High-achieving elementary and middle school students were challenged by the content and skills of the unit as evidenced by their responses to the attitude survey. They felt less confident and checked their work more thoroughly during the enrichment project.

Second, the project involved students with the real world problem of flooding directly connected to their community. The enrichment topic was particularly relevant to the students who

Table 5.

Student responses to attitude statements that showed significant pretest to posttest changes and overall mean scores on all questions.

Statements	Mean Rating ¹		T-Test Result <i>p</i> value
	Pretest	Posttest	
6. Teachers think I am one of the best students (pretest). The professors think I am one of the best students (posttest).	1.92	2.35	.02
8. Teachers count on me for correct answers (pretest). The professors count on me for correct answers (posttest).	1.96	2.42	.04
10. I am satisfied with the grades I get (pretest). I am satisfied with the assessment of the work I did on this project (posttest).	1.44	1.88	.02
17. I check my work carefully before handing it in (retest). I checked my work carefully before handing it in on this project (posttest).	2.04	1.63	.01
Overall mean of all 20 questions	1.83	1.85	.84 ²

Note: ¹indicates always agree, 4 indicates disagree. ²this *p* value does not indicate a statistically significant difference.

had endured the flooding the previous year.

Third, students had the opportunity to study a science topic in-depth with expert instruction that provided models of possible careers. Students enjoyed listening to and asking questions of the guest speakers about their jobs as a meteorologist, an environmentalist (also a college professor), and a city council member. Additional information was provided via videos, electronic presentations, and books.

Finally, the project asked students to create an authentic product—a flood game—that would allow them to practice creative thinking and invention while applying recently-learned information about floods. Students were thoroughly engrossed in developing their flood games and finding interesting facts for game questions. They worked individually or in small groups to create an authentic product—a flood game—using recycled or found materials such as pebbles, sponges, cardboard, plastic lids, fabric scraps, string, clothespins, and egg or milk cartons. This allowed them to assign new uses to common materials, thereby practicing creativity and their newly-acquired knowledge of floods.

A focus on the current, local science issue of floods with an authentic product motivated the students. Incorporation of thinking skills boosted effective processing of information, while attention to the science domain of creativity resulted in exciting game products. This enrichment unit on flooding exemplifies a successful, challenging, integrated, authentic science project.

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