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Comparing fossil instruction with and without analogy use for gifted middle-school students

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Twenty-eight identified gifted elementary to middle school students (n=28) (16 female, 12 male; 26 Caucasian, 1 Hispanic, and 1 Native American), participated in the study of Iowa fossils through form and function analogy compared to self-research of information on the Internet, and practiced new concepts through technology-rich or hands-on craft projects. This study compared using analogical thinking skills along with technology skills to determine the effects on science learning in the elementary gifted classroom. Analogical thinking or teaching is a method recognized as a valuable source of new ideas, a way to transfer previous knowledge to solve new problems. Content learning, creativity, and enjoyment of learning were key assessment points in this study that compared analogical and non-analogical instruction. This study found instruction highlighting analogy enhanced creativity in products. This study also found students preferred creating hands-on projects more than creating computer technology projects. They felt restricted in their creativity by the technology. The highest rate of recall of scientific knowledge in regards to an organism's body parts was produced through model-making of the organism studied.

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Abstract

Twenty-eight identified gifted elementary to middle school students (n=28) (16 female, 12 male; 26 Caucasian, 1 Hispanic, and 1 Native American), participated in the study of Iowa Fossils through form and function analogy compared to self research of information on the Internet and practiced new concepts through technology-rich or hands-on craft projects. This study compared using analogical thinking skills along with technology skills to determine the effects on science learning in the elementary gifted classroom. Analogical thinking or teaching is a method recognized as a valuable source of new ideas, a way to transfer previous knowledge to solve new problems. Content learning, creativity, and enjoyment of learning were key assessment points in this study that compared analogical and non-analogical instruction. This study found instruction highlighting analogy enhanced creativity in products. This study also found students preferred creating hands on projects more than creating computer technology projects. They felt restricted in their creativity by the technology. The highest rate of recall of scientific knowledge in regards to the organism's body parts was produced through model–making of the organism studied.

Chapter 1: Introduction

Importance of Analogical Thinking

Analogical thinking or teaching is a method recognized as a valuable source of new ideas, a way to transfer previous knowledge to solve new problems. First, analogy conveys parallel ideas between two situations or domains that share relational structure despite arbitrary differences in the objects that make up the domains (Gentner & Markman, 1997, Gentner, 1983). We store experiences and knowledge in large categories based upon similarity to a category representation or to stored exemplars (Genter & Markman, 1997, Smith & Medin, 1981). Analogies allow transfer of previous knowledge and experiences to new situations to solve new problems. (Gentner & Markman, 1997, Bassok, 1990; Holyoak & Koh, 1987; Keane, 1988, Kolodner, 1993, Novick, 1988, 1990; Ross, 1987, 1989; Winston, 1980) A key to analogy is the cross mapping of experiences. The properties of a star are connected to those of a light bulb, a wave of sound is found to be similar to ocean waves, all within the mind. Analogies must have similar parallel connections with a relational focus and systematicity (Gentner & Markman, 1997). This means that the anologies play similar roles, but need not involve common objects. One could compare a plastic pop bottle to a boat, because both float. Although they are not similar in size or design, they the same within the mind's mapping system because they both are able to float. So, as a result, they are filed in a higher order of thinking, because it's not an obvious comparison. Systematicity, tends to match connected systems of relations (Gentner, 1983, 1989). Picture the mind as a set of filing systems. If one is focused on how to make a car more gas-efficient through less friction via the tires, there will be a category of files within the mind of objects that are round that includes tires.

One accesses previous knowledge on what causes and reduces friction, then access the "round" file to determine what could be substituted for tires, perhaps marbles. One might jump to a completely different file focusing on flight, abandonning the idea of a car rolling along the road. Exploration proceeds through possibilities based on current knowledge categories , similarities, and connections, the while creating a massive "web' or mapping as one thinks analogically. Through the process of using old knowledge, one develops a new theory on how to reduce friction and creates a faster car by transforming old knowledge into a new mold. Claims about learning analogically typically assert that people can use a well-known subject or approach to make sense of a new topic or problem (Lowenstein, Thompson, & Gentner, 2003).

Some authors even go so far as to state that analogical reasoning is central to human cognition (Gentner, Holyoak, & Kokinov, 2001). In an instant, the mind accesses all of the different mental files and maps out a way to perceive the problem. This is the core of cognition. A person might think, "I think I have an itch." The person may consider raising the hand to scratch an itch or choose to ignore the itch. The person could also choose to get up and grab a backscratcher to scratch the itch. The mind maps out all of the choices and then chooses a path to pursue.

Importance of Technology Instruction

The push within our educational system is for students to construct individual creative products using technology in our classrooms to demonstrate their mastery of specific subject matter and skills. Technology is the buzz word of the 21st Century. Teachers are well aware of the 21st Century Skills initiative and therefore push to integrate technology into the classroom:

> "The benefits of technology integration are best realized when learning is not just the process of transferring facts from one person to another, but when the teacher's goal is to empower students as thinkers and problem solvers. Technology provides an excellent platform—a conceptual environment—where children can collect information in multiple formats and then organize, visualize, link and discover relationships among facts and events." (Sandholtz, Ringstaff, & Dwyer, 1997).

Students are immersed in a multi-media world outside of school. In order to reach our students we must, as teachers, use the technology to create motivation, prepare them for the future world they will live in and relate to the outside world.

> Our world economy has evolved from an industrial era to an information era and is now on the way to the creativity era, while at the same time our schools are stagnant in the industrial model. The 21st century skills are key elements in supporting our youth not only in surviving but excelling in the new global environment. (Iowa Department of Education, 2011, 21st Century Skills)

In this study, because technology use is so important to student learning, student projects that involve intense use of various electronic tools and computer applications will be examined when analogical thinking is and is not used. This will give an idea of the impact of analogical thinking on technology use.

Importance of Students Thinking Creatively

Hands-on, tactile-, visual-, multimodal forms of instruction are important to science learning and therefore to the science topic of fossil organisms. In science, students should make models of organisms or systems to enhance their learning. Therefore, hands-on "craft" projects will be employed with and without analogical thinking to determine possible effects of analogical thinking on hands-on products. Student learning and affective reactions will be compared between these craft products and technology-enhanced products to compare the effects of technology and hands-on use in education.

Personal Interest in the Topic

I've seen the benefits of technology with my own students in several areas. As a an educator of talented and gifted students, I'm always looking for ways to incorporate technology in the classroom, finding new strategies to challenge my students' creative minds, taking the opportunity to create an authentic learning experience and connect the curriculum to local history when possible. When students think of fossils, they think of dinosaurs. The subject of fossils in and of itself can be an authentic learning experience as students discover the rich natural history of their home and participate in project-work to inform others, thus my interest in the topic. My interest is to measure creativity and the motivation of my gifted students when they do not select their topic. Also to measures the role analogical transfer plays in our learning. Often students "cram" or memorize information for a fact-based test, but if they don't transfer and use the knowledge in other situations, which thinking analogically requires, then we forget the information we learned.

Statement of the Problem

Synthesis, transfer of knowledge, creativity and enjoyment of learning will be key assessment points of focus in this study that compares analogical to non-analogical instruction. A second theme of this study is the comparison of products produced with intense use of computer technology to those produced in a hands-on craft manner. The counterbalanced research design will allow these variables to be separated and compared. In this age of almost instant Google searches and the mass of information available to students with a simple mouse click, what do our students actually learn and retain from the images they cut and clip and the factual information they find on websites and the multi-media projects they create with their "just in time learning" (Collins & Halverson, 2009)? How does this mode of knowledge acquisition compare to learning that is acquired in a more traditional hands-on craft manner? How does the use of analogical reasoning enhance these approaches to making meaningful products? In this study, to answer these and other related questions, the following research questions will be investigated:

1. What depth of science learning do students evidence for concepts related to fossil organisms studied and practiced through the making of an applied product when using an analogical reasoning approach compared to appropriate instruction that does not use analogy?
2. What level of creativity do students evidence for products related to fossil organisms when using an analogical reasoning approach compared to appropriate instruction that does not use analogy?
3. What reported affective characteristics (enjoyment of learning, motivation and interest in subject matter, perceived level of understanding) do students evidence for instruction and work related to fossil organisms when using an analogical reasoning approach compared to appropriate instruction that does not use analogy?
4. How do technology-created products compare to hands-on craft products in creativity, amount of factual information presented, and reported affective reactions of the learners (enjoyment of learning, motivation and interest in subject matter)?

Terms Related to the Study

Analogy. a similarity between like features of two things, on which a comparison may be based: *the analogy between the heart and a pump.* http://www.dictionary.com

Analog. In an analogy, the *analog* is the *familiar* object, process, or event that is being compared to the new object, process or event one is trying to understand. (Gentner, 2001)

Creativity. The ability to transcend traditional ideas, rules, patterns, relationships, or the like, and to create meaningful new ideas, forms, methods, interpretations, etc.; originality, progressiveness, or imagination. (http://dictionary.reference.com/browse/creativity, n.d.)

KidPix 3d. Video and editing software for Computers. (http://www.mackiev.com/kidpix/index.html, 2012)

Target. In an analogy, the *target* is the *new* concept that is being learned by comparison to something familiar. (Gentner, 1997)

Chapter 2: Literature Review

Preview

This literature review focuses on important concepts important to the study. The first is analogical thinking, as student learning via or without analogies is the crux of this project. Analogical thinking has been considered to be one of the core processes of cognition as one compares new ideas to more familiar ideas, identifying similarities to better understand their connections to other ideas. Electronic and computer technology is now applied just about everywhere; our students must develop the critical thinking skills to adapt to technological change as they prepare to enter their future world and workplace. Technology-rich project work is used in this study to allow students to learn to use various tools and identify ways they might be applied to other tasks. Finally, creativity is the key to innovation and competitiveness in the future global economy. The fossil-related student projects of this research study provide many opportunities for students to practice creative thinking skills. All three of these areas are important to our students' futures and should be an area of focused study.

How Analogical Thinking Works

Analogical thinking is the process of the mind accessing new information with connections to old information, finding similarities to the old schema and using this information in a new setting or situation to make sense of the new situation. As a result the mind creates new mapping within the brain, using old schema to create new schema. The person analyzes what is similar, what worked in the past, what didn't work based upon personal experiences. What is familiar and what isn't. How is something new similar to something old or in the past? The process continues throughout life over and over again allowing adaptation.

Studies Showing the Benefits of Analogical Thinking

Why is analogy important and why should we teach our students to think analogically? Many researchers believe that analogy is one of the core processes of cognition (Forbus, 2000). Only human's show the ability to perceive and represent perception in relational patterns (Gentner & Rattermann, 1991). This sets us apart from other animals. We live in a world where no two experiences are ever exactly the same (Gentner & Holyoak, 1997). So how do we adapt as humans to each new situation? We think analogically. We transfer information from similar situations and use this information in the newly encountered situation. This is how we (humans) create new tools, new medicines, buildings, food and technology a few important areas we use analogy in our everyday lives. We build off of the old information to create the new product. We adapt. If we run out of water, we develop the tools to bring the water to us. We don't simply migrate north or south. We find, design and create solutions. So why is this relevant to education and the classroom?

> Modern educational theory stemming from research in the cognitive sciences indicates that knowledge gained through activity that is motivating and authentic is learned more deeply and is more usable than is knowledge gained through memorization, prescriptive activities or word problems. (Kolodner, 1997, p.57)

Creating authentic classroom experiences for our students, this usually requires the students to work with the experience of others (Kolodner, 1997). The students then transfer the old knowledge obtained from those experiences, combine it with their own experiences, find simalarities and create their new knowledge of the situation. "The analogy literature tells us that reasoners naturally use their own experiences for such reasoning." (Kolodner, 1997) However, as Kolodner expressed, we as teachers are dealing with novices in analogy. Our students have little previous experience on which to base their reasoning on. They need help making analogies and connecting ideas. This is why students need to work with analogies, to develop their larger scale analogical mapping system. This opens their minds up to new possibilities and new ways of cognitivie thinking. Rule and Furletti (2004) incorporated analogy form and function in the creation of object boxes and tested their effectiveness with high school students, in the study of body systems. They compared the results to traditional research methods. They found the students remembered or learned more through the use of the analogy boxes. Rule and Rust (2001) reported similar positive results with third grade and upper elementary students in relation to bat adaptations.

Importance of Creativity in Education

What is creativity? How do you measure creativity? Who determines what is creative and not? Can you recognize creativity when you see it? Why? How? What stands out to you? "To be considered creative, a product or idea must be original or novel to the individual creator" (Starko, 2010).

Why is creativity important in the gifted classroom? As Mildrum (2000), pointed out, in the typical classroom environment the focus is often to get through the set curriculum. Creativity tends to be off the wall and not "normal" or "typical". Highly creative or gifted children often receive negative social cues from teachers and peers for their offbeat, unusual and usually misunderstood approaches, causing the student to withdraw or shut down. Students are also conditioned in the classroom to search for the "one" right answer and not to focus on other solutions or other possibilities. Baldwin, Rule & Shell (2009) combined the analogy object boxes with the SCAMPER method in relation to second grade inventions projects. They found that using the analogy boxes led to a positive effect on creativity of the inventions and increased learning of the material (RULE, 2004).

Sir Ken Robinson believes that only with creative experiences can we prepare our students for the world they will inhabit in the future (Robinson, 2005). We need creativity to solve our future problems, create new inventions and push our society forward in evolution.

> It would seem if we want our young people to be successful in the world they will inhabit, they will need more than the knowledge we can measure on traditional tests. They will need the skills, attitudes, and habits required for solving problems unimaginable today. They will need to see varied viewpoints and understand people across the globe. They will need to think flexibly and with imagination. They will need to be creative (Starko, 2010, p.5)

Importance of Technology in Education

Technology itself is a product of analogical thinking. People built upon older knowledge of electricity, metal, circuits, machines to analogically to develop new products leading to the technological revolution which is still ongoing today. The only limitation to technology in the future is the ability of the mind and the user's ability to adapt and keep up with the innovations. This is why education struggles to keep up with technology in the classroom. It takes years to obtain the appropriate funding and by the time the technology is implemented in the school, it is already outdated. "Enthusiasts argue that trying to prepare students for the 21st Century with 19-th century technology is like teaching people to fly a rocket ship by having them ride bicycles" (Collins & Halverson, 2009, p.10). So why do we bother to try and keep up with technology as educators, why is it so important?

> If educators cannot successfully integrate new technologies into what it means to be a school, then the long identification of schooling with education, developed over the past 150 years, will dissolve into a world where the students with the means and ability will pursue their learning outside of the public school (Collins & Halverson, 2009, p.6)

As Collins and Halverson state, the world is changing and if we are going to prepare our students for the world they will be entering we have to adapt. Secondly, "Modern approaches to education suggest that student learning experiences should resonate with their learning experiences outside of the classroom so as to engage and motivate the children and give them way to get started." (Kolodner, 1997). If our students are immersed in technology outside of school, how can we expect them to be motivated in a pencil and paper environment for 7 hours a day? Is this realistic with the work environment today? How many employers don't use computers, IPad, cell phones, Skype etc.? Some people ask why are we teaching writing, when everything is typed? Why are we teaching spelling, when we have spell check?

> The benefits of technology integration are best realized when learning is not just the process of transferring facts from one person to another, but when the teacher's goal is to empower students as thinkers and problem solvers. Technology provides an excellent platform—a conceptual environment—where children can collect information in multiple formats and then organize, visualize, link and discover relationships among facts and event (Sandholtz, Ringstaff, & Dwyer, 1997, p.2).

Summary

Analogical thinking is vital to cognitive processing. Technology and creativity play an important role in our society and for our future prosperity as a society. The question is, is one method of thinking and tools used more beneficial to teaching, retaining information, and transferring information better than the other? Will technology limit our creativity or enhance our creative abilities?

Chapter 3: Methodology

Participants and Research Setting

Twenty-eight identified gifted elementary to middle school students (16 female, 12 male; 26 Caucasian, 0 African-American, 1 Hispanic, and 1 Native American), participated in the study of Iowa Fossils using analogy and technology project based teaching strategies. See Table 1 for a summary of grade levels of participants, who had a mean grade level of 3.9 (almost fourth grade).

Table 1. Grade Levels of Participants

Grade Level	Sex		Number of Students
	Male	Female	
2nd Grade	4	3	7
3rd Grade	1	2	3
4th Grade	1	1	2
5th Grade	2	5	7
6th Grade	1	0	1
7th Grade	2	3	5
8th Grade	1	2	3
Total Number of Participants	12	16	28

The students who participated in this study were accepted into the Extended Learning Program (identified as gifted and talented) based on performance on the Iowa Tests of Basic Skills and formal teacher recommendation with the exclusion of the second grade students. Second graders are selected by teacher recommendation only because of a lack of testing data. The talented and gifted students represent the top 10% of their respective classes.

The school is located in a rural Iowa setting and receives Title 1 funding. Second through sixth grade students meet on average once a day for 30 minutes with other the gifted students in their specific grade level and a teacher specializing in education of the gifted. Seventh and eighth grade students meet every other day for 80 minute blocks with a teacher specializing in education of the gifted. In this study, this teacher was the principle investigator.

Permission to conduct the study was obtained from the University of Northern Iowa's human subjects review committee and the principal of the elementary/ middle school. All students and their parents agreed in writing to participate.

Study Design

The study design is a pretest-posttest repeated measures study in which all study participants rotated through four different lesson-sets (instructional units), each focusing on a different fossil organism and having a different combination of instructional approach and project type. Each unit lasted two weeks. Students at all grade levels worked on the same fossil unit and form of instruction at the same time as the other students. See Table 2 for study set-up. All students had access to a set of high-quality fossil specimens of the fossil organism being studied.

Table 2. Study set-up.

Fossil Organism	Treatment	
	Method of Learning about the Fossil Organism	Final Product for Practicing Information Learned
Horn Coral	Students complete exercises with form and function analogy object boxes (analogy-focused)	Make bulletin board, scrapbook product or three-dimensional object (hands-on craft-focused)
Crinoids	Students conduct research on the fossil through texts and Internet (no analogy)	Create a KidPix movie. (technology-focused)
Trilobite	Students conduct research on the fossil through texts and Internet (no analogy)	Make a model of the fossil organism using recycled materials. (hands on craft-focused)
Brachiopod	Students complete exercises with form and function analogy object boxes (analogy-focused)	Create a Voicethread with at least one self created comic or cartoon slide (technology-focused)

Technology Instruction

All students were instructed on the technology used in this study for the first week of the two-week instruction for each unit that incorporated a product focusing on computer technology. This technology included Kid Pix and Voicethread. During the technology units the instructor only instructed the students on the use of the technology used. In the units that did not incorporate analogy, students used their own methods for researching the specific fossil and were not instructed by the instructor or given any background information beyond the general background Powerpoint that reviewed all four organisms at the beginning of the study.

Form and Function Analogy Instruction

Initially, students had the opportunity to examine photographs of excellent fossilized examples of the organism that included a diagram of the organism's anatomy and other facts. The form and function analogy materials consisted of a set of twelve manufactured items that had forms and functions similar to the fossil organism's body parts. These were accompanied by a set of twelve cards, each corresponding to one of the manufactured items. The front of the card described the form and function of the organisms' body part; the back of the card listed the corresponding manufactured item with the same form and function and explained the connections between the manufactured item and the organism's body part. See Figure 1 for four example cards from the horn coral box. These cards were created by Dr. Audrey Rule, the primary investigator's research advisor.

Figure 1. Example cards from the horn coral box.

"Rugose" means "wrinkled". Rugose corals have wrinkled exteriors where the cone diameter has expanded as the

http://www.go2add.com/paleo/FossilCorals

Pipe Connector

A pipe connector is a joint that connects a small pipe with a larger pipe. The joined area has "wrinkles" where the small pipe expands into the larger pipe. Similarly, the horn coral often expands its diameter, resulting in "wrinkles" where

Horn corals were filter feeders with polyps (soft tissue tentacles) that could be retracted or withdrawn into the top of the

http://www.go2add.com/paleo/FossilCor

Umbrella

An umbrella can be folded together and retracted into a compact shape *for protection when not in use*. Similarly, a horn coral could withdraw its polyp into the top of the horn

This is the top of the horn coral was where the living organism lived. It was cup-shaped

http://www.go2add.com/paleo/FossilCorals

Jewelry / Trinket Box

This trinket box is *cup-shaped* to *hold and protect* jewelry or small items. Similarly, the top of a horn coral had a cup-shaped depression to *hold the*

Horn corals lived on the sea floor *to receive* plankton and food particles that *fall down* through the

http://hudsonvalleygeologist.blogspot.com/2010/02/picture-of-

Bath Tub

A bath tub is located on the floor *to catch* water that *falls due to gravity* from a showerhead above. Similarly, horn corals live at the bottom of the sea to *catch* food particles *that fall*

Students first tried matching the cards with the object in the box thinking solely about similarities to form or function. Then they checked their work using the answers on the card backs (shown on the right side in Figure 1). Students were then given a chart on which to map the similarities and differences between the fossil organism's body part and the manufactured item. Then, the students had to generate a list of alternative objects that could fit into the box and that had the same form and function as the organism's body part. Finally, the students discussed how the body parts helped the organism survive.

Data Collection and Analysis

First, students answered a computer and technology survey. We wanted to know if our students had previous access to computers, if they had access to technology at home and any biases to technology itself.

Next, data were collected to answer the four research questions that were outlined in Chapter 1 and are reproduced here with comments about instrumentation and data analysis.

1. What depth of science learning do students evidence for concepts related to fossil organisms studied and practiced through the making of an applied product when using an analogical reasoning approach compared to appropriate instruction that does not use analogy? A pretest-posttest instrument was developed to assess student knowledge of the four fossil organisms. This instrument accessed higher levels of thinking beyond simple recall. It is shown as Appendix 1. This test was administered a week before the lessons began and a week after their conclusion. Student performance on the two organisms studied through analogy was compared to student performance on the two organisms studied without analogical thinking.

2. What <u>level of creativity</u> do students evidence for products related to fossil organisms when using an analogical reasoning approach compared to appropriate instruction that does not use analogy? The creative products produced in the analogy condition and in the non-analogy condition were compared to determine if analogy use spurs creativity. A rubric was used to score each creative product on creative characteristics. The rubric used for project scoring is shown in Table 3.
3. What reported <u>affective characteristics (enjoyment of learning, motivation and interest in subject matter, perceived level of understanding)</u> do students evidence for instruction and work related to fossil organisms when using an analogical reasoning approach compared to appropriate instruction that does not use analogy? After the lesson on a particular fossil organism was concluded and *before students work on the creative products*, students completed a very brief attitude survey in which they rated their enjoyment of the lesson, interest in the organism, and perceived level of understanding of the organism's lifestyle and fossil occurrence. This survey is shown in Table 4. The numerical ratings were collected and analyzed to determine student preferences of analogical versus non analogical learning.
4. How do technology-created products compare to hands-on craft products in creativity, amount of factual information presented, and reported affective reactions of the learners (enjoyment of learning, motivation and interest in subject matter)? After each creative product had been completed (either the hands-on craft project or the technology-rich product), students rated their experience making the product with the attitude survey shown in Table 5. The numerical ratings were collected and analyzed to determine student preferences of hands-on craft versus technology-rich

product construction.

Table 3. Rubric for Scoring Products for Creativity

Criteria Question	Yes	Somewhat	No
Is the product visually/aesthetically appealing overall?	2	1	0
Does the product display unusual and unique ideas that are effective in the product?	2	1	0
Does the product display individual insight is expressed in relation to content?	2	1	0
Does the product display fine details or elaboration?	2	1	0
Is the product presentation done in a new way?	2	1	0
Total Possible Points		10	

Table 4. Science Lesson Attitude Survey

Please circle a number below to rate your enjoyment of learning about this fossil considering the way the lesson was presented and the lesson activities.									
1	2	3	4	5	6	7	8	9	10
Not enjoyable at all				Neutral					Very enjoyable
Please circle a number below to rate your interest in the fossil organism we just studied.									
1	2	3	4	5	6	7	8	9	10
Not interested at all				Neutral					Very interested
Please circle a number below to rate how well you think you understand the fossil organism's lifestyle and the way it occurs as a fossil.									
1	2	3	4	5	6	7	8	9	10
Don't understand it at all				Neutral					Understand it very well

Table 5. Creative Product Attitude Survey

Please circle a number below to rate your enjoyment of making the creative product associated with this fossil organism.

1	2	3	4	5	6	7	8	9	10
Not enjoyable at all				Neutral					Very enjoyable

Please circle a number below to rate your interest in the fossil organism we just studied, now that you have made a creative product related to it.

1	2	3	4	5	6	7	8	9	10
Not interested at all				Neutral					Very interested

Please circle a number below to rate how much you would like to do another creative product in this way using the techniques used to make this product

1	2	3	4	5	6	7	8	9	10
Don't want to at all				Neutral					Want to very much

Table 6. Rubric for Assigning an Academic Score to Technology and Craft Projects on Fossil Organisms

Criteria	Yes Completely	Mostly	Somewhat	A Little	No
1. Did the student illustrate in some manner **8 different body parts** or anatomical features of the organism?	4	3	2	1	0
2. Did the student **explain** in the project **how** these 8 different body parts or anatomical features **help the animal survive?**	4	3	2	1	0
3. Was the **environment** of the animal well shown in the project?	1	0.75	0.5	0.25	0
4. Did the project **follow the directions** given - was it made with the correct software or craft materials or techniques?	1	0.75	0.5	0.25	0
5. Were the ideas particularly **insightful or intelligent** (skill, smartness, deep thinking, extra considerations) (beyond what is nominally expected)?	2	1.5	1	0.5	0
6. Was the **overall appearance and quality** of the final product excellent?	3	2	1	0.5	0
Total Academic Score for the Project out of 15					

Table 7. Rubric for Scoring the Technology or Hands-on Craft Fossil Organism Projects on Creativity

Criteria	Yes Completely	Mostly	Somewhat	A Little	No
1. Did the project present ideas in an **unusual way** that may involve wild ideas or break unspoken rules such as drawing outside the box?	1	0.75	0.5	0.25	0
2. Did the project include puns, **word plays**, alliteration or assonance, or parody?	1	0.75	0.5	0.25	0
3. Did the project involve **humor, funny aspects, or jokes**?	1	0.75	0.5	0.25	0
4. Was the product particularly creative in showing a lot of **detail and elaboration**?	1	0.75	0.5	0.25	0
5. Did the product show **unusual views, inner workings or cutaway views**, etc?	1	0.75	0.5	0.25	0
6. Did the product show **shading and perspective, foreshortening**, or 3-dimensionality (beyond what was expected because of the medium)?	1	0.75	0.5	0.25	0
7. Was the product particularly **aesthetically pleasing** or artistic?	1	0.75	0.5	0.25	0
8. Did the project show **movement or action** of the organism in some way?	1	0.75	0.5	0.25	0
9. Was the project **emotional expressive** through words or expressions on organisms or human characters, etc.?	1	0.75	0.5	0.25	0
10. Did the project tell a story so that one could determine what happened before and what would happen afterward (**story-telling articulateness**)?	1	0.75	0.5	0.25	0
Total Creativity Score for the Project out of 10					

Chapter 4: Results

Student Data-Computer Surveys

Students were given a computer survey prior to starting the Iowa Fossil Unit. We wanted to know if the students have a computer available to them at home and how they spent their time at home on the computers. As the age level increased, the amount of time on the computers increased, as well as gaming and social networking usage. See Figures 2, 3, and 4. Students listed IPads, Smartboards, Powerpoints, Microsoft Word, Windows Movie Maker, Imovie and blogging for computer technology used previously with the exception of second graders. The second graders listed none. They do have a Smartboard in their classroom, but the teachers operate the equipment rather than the students. Students listed Google the most as their source of information for homework. Also mentioned were .gov websites, school links and the Encyclopedia Britannica website. Again, the exception was the second grade students who listed none.

In response to the question of determining credibility of a website, all of the students, except for the seventh and eighth grade students, answered they did not know how to determine if a website were credible or responded “ask someone.” The seventh and eighth graders all participated in a National History Day exercise with the Talented and Gifted instructor in which they examined the website validation process together. They answered that they would look at the web address, contact information, references, credentials, date created and last date updated.

Regarding the types of games they play on the computers, the students questioned our categories and they were confused by the genre labeling. Several students chose several genres. Students pointed out that if they play games it is not on a computer normally but a game system, such as Xbox, Wii etc. Ten responded, "yes," to playing arcade games, 5 none, 5 all, 4 action role play, 3 educational, and 1 wrote in "strategy." When asked if students preferred a computer to create class projects or if they would rather create project by "hands on" craft work, 5 reported preferring computers, 10 reported hands on, 3 stated both and 10 stated no preference. Some responses to why they preferred computers were: does the work for you, faster, easier to use, easier to take home, less paper used, easier to look for information, less stressful to type than draw, more reliable, can explore more, has a business feel to things, and uses different parts of your brain. Some responses to preferring "hands on" creating were, like to build things, I enjoy using my hand to run my imagination, sometimes I want to create things I can't create on a computer, more fun, more satisfied with the outcome, like to get my hands dirty, can't type and more creative.

Figure 2. Computers and Internet Availability at Home

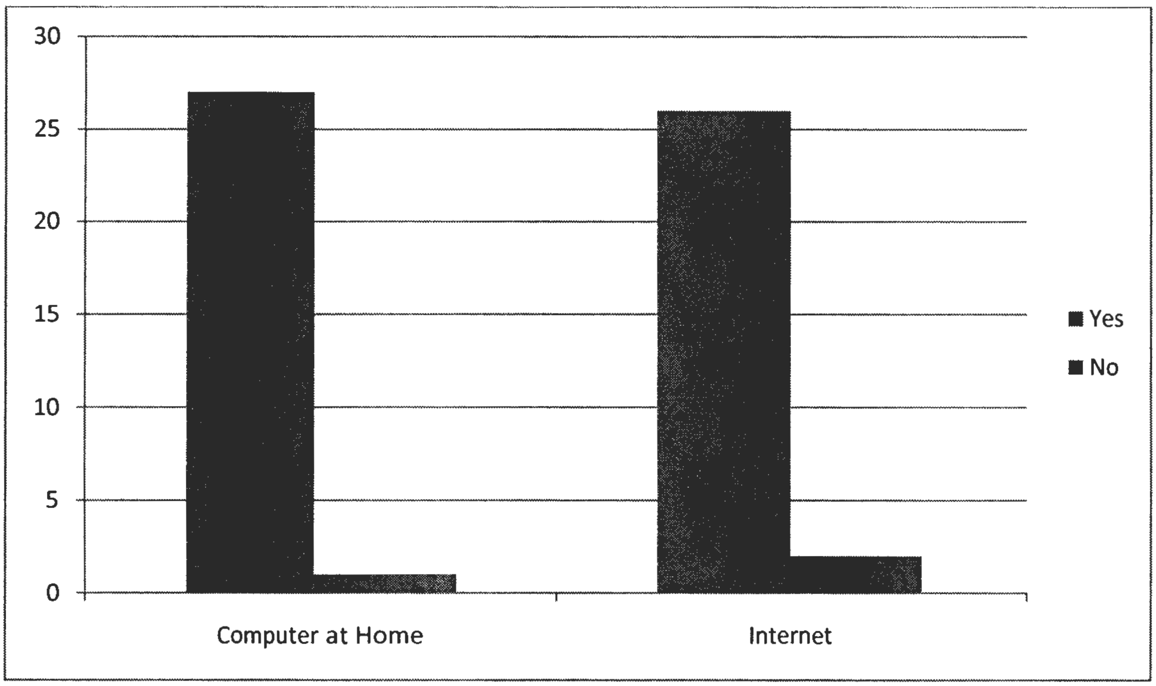


Figure 3. Use of Computer Time

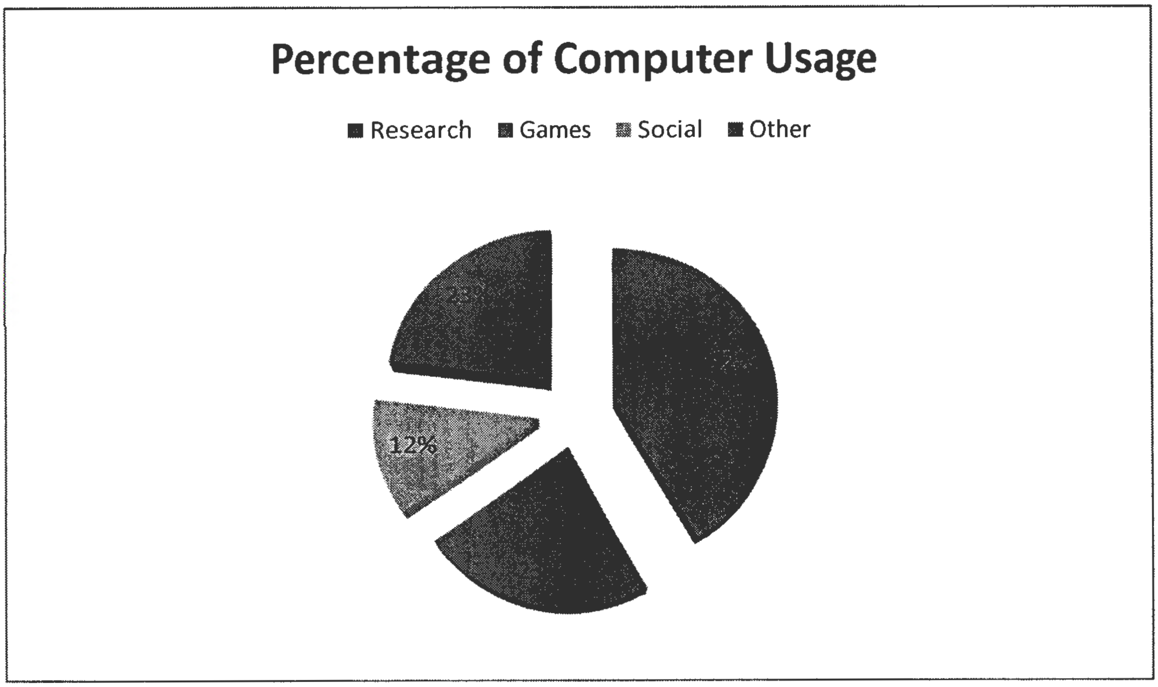
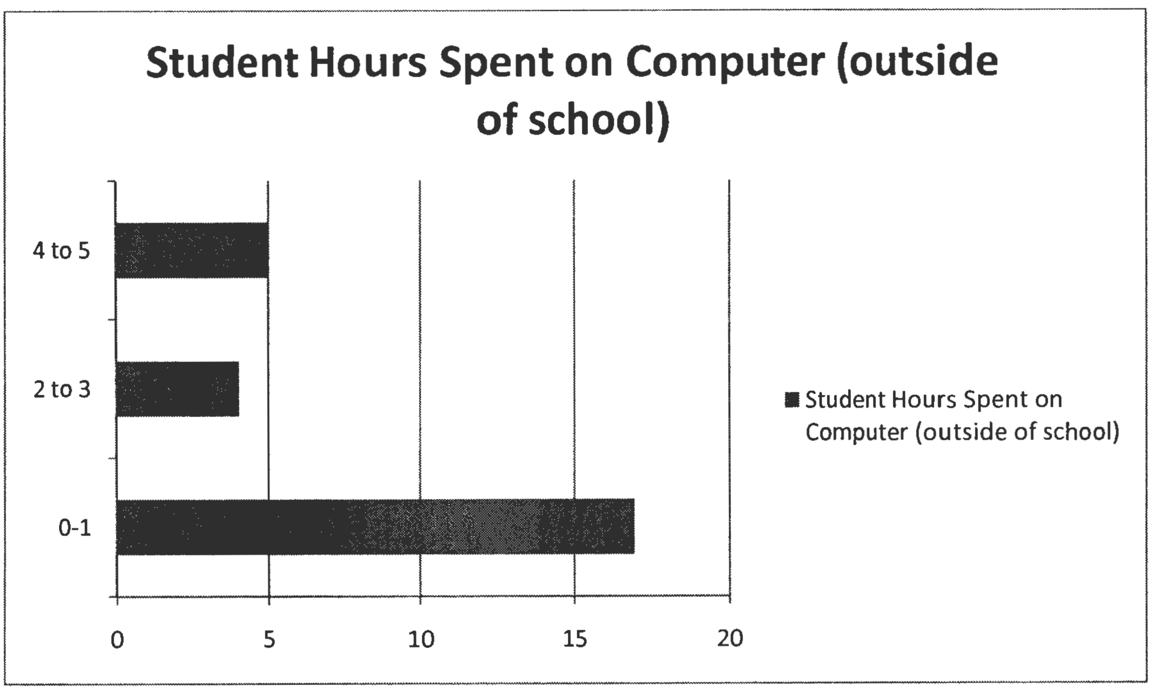


Figure 4. Hours Spent on the Computer Each Night



Student Data-Creative Product and Science Lesson Attitude Surveys

At the conclusion of each fossil unit students were given surveys to reflect on the unit and their attitudes toward the ways information was presented or practiced. See Table 8 and Table 9.

Table 8. Creative Product Attitude Survey Results

Questions about Creative Product	Mean Student Rating (Standard Deviation)			
	Horn Coral	Crinoid	Trilobite	Brachiopod
Rate your enjoyment of making creative product results (1= least enjoyable; 10 = most enjoyable).	7.50 (2.8)	7.61 (2.3)	8.61 (2.1)	7.21 (2.7)
Rate your interest in this fossil organism after making the product. (1 = least amount of interest; 10 = most interest).	6.21 (2.6)	6.50 (2.8)	7.25 (2.5)	6.57 (3.0)
Would you like to create another project this way? (1 = not at all; 10 = very much).	8.61 (2.3)	7.50 (3.0)	8.39 (1.9)	7.25 (3.2)
Analogy or non-analogy lesson presentation	Analogy	No analogy	No analogy	Analogy
Final project type of technology-emphasized or hands-on crafts-based.	Crafts-based Scrapbook, Bulletin Board or 3d Object.	Technology-rich Kidpix 3d Movie	Crafts-based Model out of recyclable materials	Technology-rich Voice Thread

Table 9. Science Lesson Attitude Survey Results

Questions about Attitudes	Mean Student Rating (Standard Deviation)			
	Horn Coral	Crinoid	Trilobite	Brachiopod
Rate your enjoyment of learning about this fossil (1 = least enjoyable; 10 = most enjoyable).	7.32 (2.5)	6.89 (2.7)	7.63 (2.5)	6.29 (2.9)
Rate your interest in this fossil organism (1 = least amount of interest; 10 = most amount of interest).	6.61 (2.5)	6.11 (2.8)	7.18 (2.7)	5.79 (2.9)
Rate your understanding of the fossil organism's lifestyle and the way it occurs as a fossil (1 = no understanding; 10 = most understanding).	7.21 (2.5)	7.25 (2.4)	7.55 (2.0)	6.07 (2.6)
Analogy or non-analogy lesson presentation	Analogy	No analogy	No analogy	Analogy
Final project type of technology-emphasized or hands-on crafts-based.	Crafts-based Scrapbook, Bulletin Board or 3d object.	Technology-rich Kidpix 3D Movie	Crafts-based Model made from recyclable materials.	Technology-rich Voice Thread

Some students asked on the scrapbook if it could be in 3d. I said yes, but they turned out more like "objects" rather than scrapbook pages.

Student Data-Rubrics

After completion of each project the Talented and Gifted instructor rated the student's project academically using Table 3, Table 6 and the rubric for scoring technology. Below are the mean results for each fossil in regards to creativity and academic score.(See Table 11). In the Horn Coral unit some students worked together in groups instead of individually. The Crinoid projects students completed individually, as well as the Trilobite and Brachiopod projects.

Table 10. Rubric Mean Scores

Mean Scores For Each Fossil Project Group	Mean Student Score (Standard Deviation)			
	Horn Coral	Crinoid	Trilobite	Brachiopod
Score from applying academic rubric (15possible points) Table 6.	7.18 (2.4)	7.25 (3.6)	9.29 (3.4)	6.25 (3.2)
Score from applying creativity rubric (10 possible points) Table 3.	5.21 (3.1)	5.93 (3.2)	6 (2.8)	7.14 (2.7)
Scoring Technology or Hands-on projects creativity (10 possible points) Table 7.	3.50 (3.0)	4.71 (3.2)	2.80 (1.8)	5.78 (2.0)
Analogy or non-analogy lesson presentation	Analogy	No analogy	No analogy	Analogy
Final project type of technology-emphasized or hands-on crafts-based.	Crafts-based Scrapbook, Bulletin Board or 3d object.	Technology-rich Kidpix 3d Movie	Crafts-based Model made from recyclable materials.	Technology-rich Voice Thread

Pre and Post Test Data

Prior to the students starting the fossil unit they were given a pretest, in which the scores were 0 for 100% of the students. None of the students had schema on the fossils we selected to study. After the eight weeks of fossil units, the students were again given the same test as a post-test. 5th and 6th grade were combined since we had one sixth grader who met at the same time with our 5th graders. (See Table 11.) As the grade levels increased so did the test scores. All grade levels were instructed in the same manner with the same materials.

Table 11. Post-Test Data Mean Scores and Standard Deviation by Grade Levels

Grade Level	Post-test Data Mean (Standard Deviation) Total possible 74 points
2nd Grade	15.29 (2.9)
3rd Grade	26.67 (8.3)
4th Grade	23.00 (5.7)
5th & 6th Grade	38.25 (5.5)
7th Grade	41.20 (19.9)
8th Grade	46.33 (2.1)
All Grade Levels Combined	31.87 (7.4)

Chapter 5: Conclusions and Recommendation

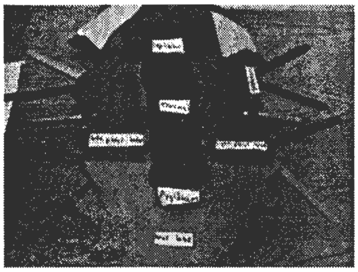
Summary of Results

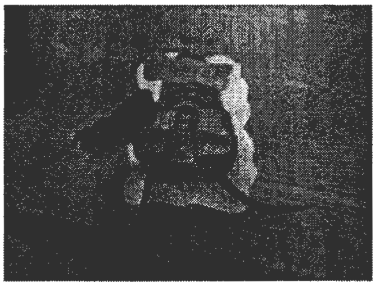
What depth of science learning did the students learn through their projects and use of technology and analogical thinking?

On the posttest, the students stated a similar number of facts about all four organisms. There was no difference in perceived understanding of the organisms, regardless of the technique to learning or the product used to reinforce learning.

The most noticeable differences in academic scores on the post-test regarded labeling and describing the organisms body parts and the body parts function for survival. Trilobite had a combined total point scored of 245, versus 133 for the Crinoid, 123 for the Brachiopod, and 119 for the Horn Coral. The Trilobite also had the highest academic rubric score of 9.29 (see Table 10). Students were instructed to create a Trilobite model including body parts labeled with the body parts function using recycled material. Students were able to draw, label, and explain more about the trilobite's body parts (about twice as much) than they were able to draw, label and explain about the other organisms. This is because the Trilobite had more familiar body parts similar to insects (antennae, compound eyes, legs, mouth) and therefore were easier to understand. The other organisms (Crinoid, Brachiopod, Horn Coral) had less familiar body structures (see Figure 2). According to the post-test academic scores, the model method was the most effective way for students to recall knowledge based information on the organism's body parts and functions.

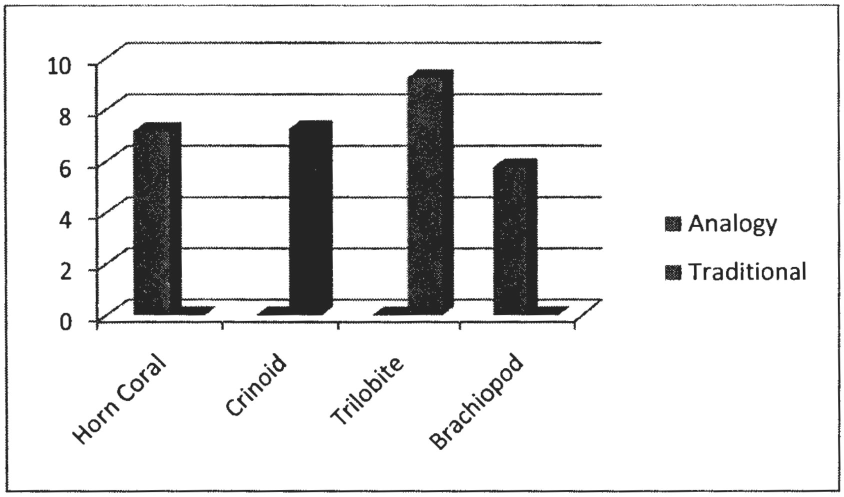
Figure 2. Examples of Students Trilobite Products





Analogy was not directly used during this session. However, when the researcher asked the students why the Trilobite was easier for the students to remember on the post-test, they responded it was the one organism with "real" body parts, meaning it had body parts similar to ours: eyes, legs, and so forth. They were thinking analogically, even though they were not instructed specifically using analogy. The students compared and mind mapped the Trilobite body parts to their own body parts, creating more connections and enhancing their memory of the organism. Regarding the Brachiopod, students recognized the organism as a shell, but they could not relate to the parts inside. Students also could recall the horn coral being shaped like a horn and the stinging tentacles. Even though students may not have remembered the specific analogies made with the object cards, they did remember body parts based on their own analogies. For example, one student responded on the post test that she liked the Crinoid because it looked like a flower. The students made analogy comparisons to things they knew in order to make sense of the Crinoid's body parts (see Table 12).

Table 12. Academic Mean Scores



So why did our results differ from past studies in regards to academic enhanced learning? Do gifted children use analogy automatically more than non gifted students? Why didn't the organisms employing direct analogy methods result in higher scientific learning of the body parts? As previously mentioned when the students were questioned on how they remembered parts, they were still thinking analogically unknowingly. This brings up a key point of this study and for future study. Since analogy is such a key cognitive process, is it possible for humans to not use analogy in our thinking processes in any situation? Is it possible to separate the processes from the creative process? Even though analogy was not used with certain groups, the researcher believes the students automatically used analogical thinking to help process the unknown. The fossils the students struggled with most were the Horn Coral and Brachiopod because they struggled to make analogical connections to their young lives and young schema. The older students possessed a wider schema to make analogy connections with, and the higher post-test scores reflect this argument. Another possible reason for low scores on the Horn Coral is the amount of time from the introduction of the lesson to the time they took the test. Approximately eight weeks had passed since the introduction of the organism.

In an examination of the quantitative data results, three more conclusions can be made regarding content knowledge gained: (a) the students portrayed more content knowledge when making crafts; (b) the students portrayed a preference in making crafts to show how well they understood the organism; and (c) students portrayed more content knowledge when researching information on their own.

In making the crafts, many of the video products focused more on playing with and exploring drama, and incorporating humor and emotion, rather than merely learning scientific facts. This play aspect suggests a reason for student portrayal of more content knowledge. Additionally, students were more serious when making the crafts and when they formed the body parts out of paper or craft materials, suggesting that they may have paid more attention to these details.

Finally, the students portrayed more content knowledge when researching information on their own. This latter finding is different than a study by Rule, Baldwin, & Schell (2008) in which a general education classroom of second graders learned more through form and function analogy object boxes than in finding information in texts and Internet searches. Gifted students may be better able to research and absorb information on their own; in this study, the teacher observed that the gifted students spontaneously used analogies in all of their fossil work, not just in the form and function analogy object box condition.

What level of motivation did the students have in learning about the fossil considering the way the lesson was presented and the lesson activities? What reported affective (enjoyment of learning, motivation and interest in subject matter, perceived level of understanding) do students evidence for instruction and work related to fossil *organisms when using analogical reasoning approach compared to appropriate instruction that does not use analogy?*

The posttest qualitative data indicated that 20 students preferred hands-on craft projects, seven preferred making products with computers, and one indicated no preference. Generally, they perceived that the crafts allowed them the opportunity to be more creative. It may be that they thought that they did not have the computer skills to use technology in a creative manner, but that they did feel that they possessed the skills of cutting, coloring, and pasting to be creative with the crafts.

Non-analogy lessons where the student researches the organism on their own scored a mean score of 7.25. Analogical thinking lessons which involved the object boxes scored a mean scored 6.96. This was a topic and subject given to the students by the instructor and not chosen by the student. These particular gifted students are used to picking the topics they study within our classroom. They are not accustomed to a specific topic being given to them without their input and given a specific way to study and apply what they have learned. For these reasons, the teacher noticed motivation as a key factor in quality of the projects created. There were individual students who rebelled and made it known they were not interested in Iowa Fossils, also.

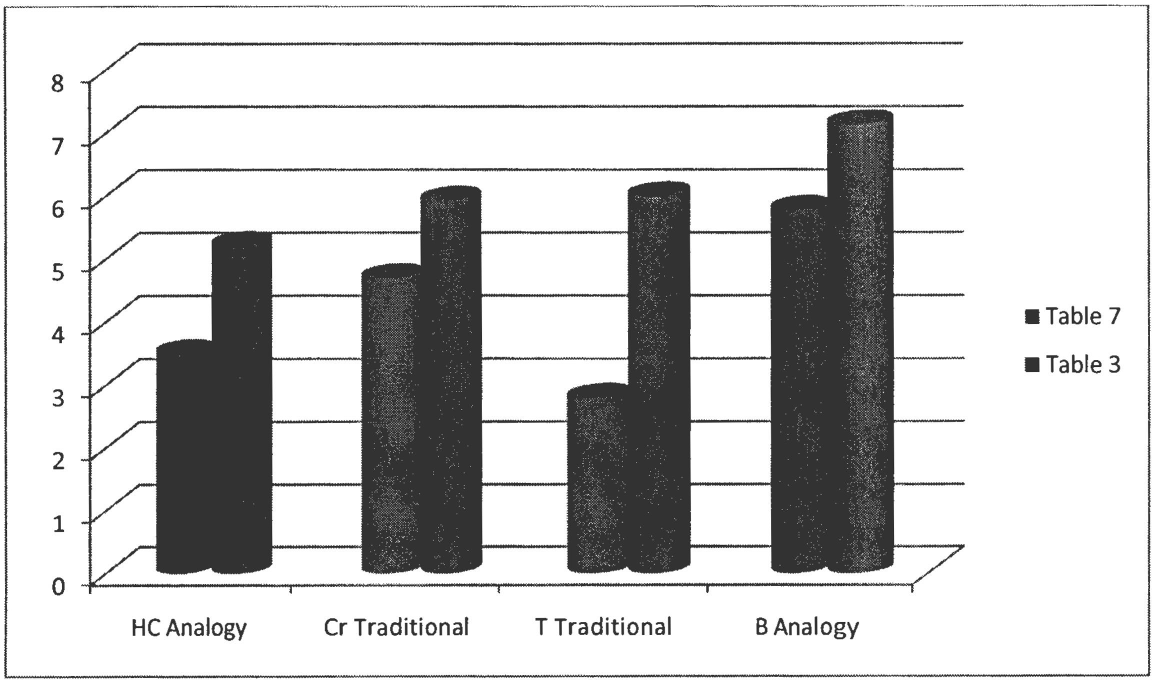
Trilobite had the highest interest by the students. On the post-test 54% stated Trilobites was their favorite fossil organism. On the attitude survey Trilobite scored the highest interest level with a mean score of 7.25. Many commented on the post-test that they liked the Trilobite more because it looked scary and had more “real” body parts. The students analogically thought of this organism to movies they’ve seen and current day bugs. The Trilobite was more mysterious and exciting for the students than the other fossils. Trilobite as a result had the highest scores on the post test. In regards to enjoyment of making the creative product analogy mean scores were 7.35 and non analogy mean scores were 8.10 out of 10. These particular gifted students liked the freedom of learning on their own and completing their own research, instead of guided instruction. In regard to interest level in the fossil organism studied, analogy mean scores were 6.71 and non analogy mean scores were 6.85 out of ten.

Overall, the students were not extremely interested nor were they extremely opposed to studying Iowa Fossils, as a whole group. In regard to the student's desire to create another product using the same techniques to make this product, the mean score for all four lesson products was 7.94. The creative product with the highest enjoyment mean score of 8.61 out of 10 was the bulletin board, scrapbook, or 3d object creations. Second was the recycle material model creative product with a mean score of 8.39. This data suggests that students enjoyed the hands on crafts more than the technology units. In the post-test, 68% responded they preferred the craft projects over the technology projects. Why? The students reported on the post-test that they felt the technology limited what they could create and were frustrated with getting the programs to do what they wanted them to do. The students commented they enjoyed all projects, but they felt they could be more creative with the hands on projects. Students reported on the post-test they understood the Trilobite the best and the post-test scores confirm they indeed understood the Trilobite the most compared to the other fossil organisms.

What level of creativity did the student products reflect?

Using Table 7 rubric for creativity, the highest product creativity mean score was the Brachiopod projects with a mean score of 5.5. This lesson incorporated both technology with analogy (see Table 13). The lowest creativity score was Trilobite. When students create a model, it is extremely difficult for students to vary from the original organism and this affected creativity scores. Analogy enhanced creativity when combined with technology above the other combined lessons.

Table 13. Creativity Rubric Mean Scores for Table 7 and Table 3



The researcher noticed that the students working in the same classroom and their close proximity allowed for them to integrate the creative ideas of their classmates. If they saw a student using a cool idea, they quickly incorporated it into their own project. For example, one fifth grade student thought of wrapping paper in a cone shape for his horn coral, and within seconds, three other students included the same idea. Individuality seemed much more difficult for the younger students. Another example was when a second grader announced her Voicethread would be about a Brachiopod being eaten by a shark. Numerous subsequent voice threads incorporated sharks in their Voicethreads. The exception was the eighth and seventh grade students who held fast to their individuality. What was once creativity and new, quickly became an old idea and used by everyone. This fact did change creativity scoring. Once a researcher saw a shark story, the next one didn't seem so innovative. A problem the researcher encountered was with grading the creativity. The researcher did not always catch who came up with the creative idea first.

Interestingly, the quantitative data regarding the creativity shown in the products indicated two areas of results: (a) the technical products showed more creativity than the crafts, and (b) the use of analogies supported a greater display of creativity. First, although the students thought the crafts allowed more creativity because they felt more in control of the craft-making and more able to do what they felt like doing, they actually displayed more creativity using technology, even though they felt the choices were more prescribed and limiting. With the technology, the students were more likely to show movement, expression, and humor in the videos and voice thread presentations. Second, the higher levels of making analogical connections was more conducive to transforming ideas creatively than in researching facts about the organism.

Conclusion

Students were able to state a similar number of facts about all four organisms and displayed no difference in their perceived understanding of the organisms, regardless of the technique of learning or the product used to reinforce learning. Students portrayed more knowledge of the organisms through the craft projects, as indicated on the posttest, and by researching information on their own. Due to the more familiar body structures of the Trilobite, students were able to identify and explain more about the Trilobite's body parts than they were for the other three organisms.

Students liked learning about all of the organisms, regardless of the way they learned about each or which type of product was required. By the end of the lessons, the majority of students preferred hands on craft products to products made using technology. The students perceived that they could be more creative with the crafts, and may have liked the Trilobite and Horn Coral organisms more than the other two because the products were hands on craft products. That is, creating a hands on craft model of the organism enhanced learning the most in regard to understanding the organism's body parts. Students indicated that they strongly desired to make craft products in the future, rather than make products through technology.

Although students indicated a strong preference for the craft products, the technical products displayed more creativity. The technology-based products showed movement, expression, and humor. However, whether analogy was used or not with these gifted students in this particular case is still to be determined. They were not instructed specifically with analogy boxes, yet their responses indicated that they definitely were thinking analogically. Additionally, higher levels of making analogical connections was more conducive to their creativity than by researching for facts about the organism. The question is, do they automatically think analogically as gifted students, or was the analogical thinking caused by the prior analogy lesson?

Recommendations for further study

Recommendations for further study might include a study of the effects of analogical thinking and whether it is truly possible to think, create, and learn without using analogical thinking. Is it possible in our creative thinking to not think analogically? Would results be different with non gifted students? Do gifted students use analogical thinking more often and naturally without instruction when compared to students who are not labeled gifted or struggling? Would testing within a shorter time period affect the outcome of the posttest? Since the model recreation produced the highest recall memory of body parts, would the same be true of recreating a model using technology instead of the hands on craft material? Is there a stronger connection to the brain if we use hands on activities instead of virtual recreations? Some authors even go so far as to state that analogical reasoning is central to human cognition (Gentner, Holyoak, & Kokinov, 2001) After completing this study and analyzing the responses the students gave on their thought processes, the researcher would agree with this statement. Now the question is, in the world of Google and other search engines, will we lose our ability to make connections analogically with a smaller schema, thus limiting our own creative possibilities, or will technology increase our schema to allow for more creative possibilities?

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