Fifth Graders' Creativity in Inventions with and without Creative Articulation Instruction

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Abstract

Industry and authors of 21st Century Skill Frameworks are calling for student proficiency in creativity, problem-solving, innovation, collaboration, and communication skills. This project involved 13 fifth grade gifted students in inventing products for a specified audience with a set of given materials, time limit, and topic constraints. The complex, challenging project supports Next Generation Science Engineering Process Standard 3-5-ETS1-2 and applies concepts of plant and animal adaptations. The study had a counterbalanced, repeated measures design in which student made an initial invention during the pretest, then participated in two trials with one in the control condition and the other in the experimental condition. The experimental condition involved creative articulation strategies of considering the audience for the invention, effective communication of the ways the product meets audience needs, and peer collaboration and feedback to improve the product ideas. Students found the invention process initially very challenging, especially generating unique ideas. No statistically significant differences were found in product creativity or student attitudes, which were very positive, between the two conditions of the experiment, likely because of the small sample size. Analysis of student advertisements revealed a statistically significant difference favoring the experimental condition with a medium effect size for including reasons the product meets audience needs in the advertisement. Examples of student-made products and teacher analysis of selected products provide ideas for coaching students into higher creative skill levels. Additionally, statistically significant gains in creativity skill occurred from the pretest to the invention of the product during the first trial and this was maintained into the second trial with large effect size. This study showed that multiple invention opportunities allowed students to develop their skills better than a single activity. The challenging, complex activities helped students achieve a state of flow as they worked during the experiment and helped students develop their creativity.

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Key Words

Creative articulation, students' inventions, Next Generation Science Standards, elementary students, research, creativity, peer feedback.

Introduction

Increased demands of teaching including analysis of student data from the Common Core State Standards (CCSS; Common Core State Standards Initiative, 2017) to determine areas that need remediation leave little time for attention (Garner, Thorne, & Horn, 2017) to the importance of teaching creativity in the classroom. However, redefinition of problems, generation of many possible resolutions and analysis of the most optimal solutions are creative skills required to fulfill the expectations set by the CCSS. Adding to the importance of creative thinking skills, business executives report that students will need to be able to respond to the demands of a complex world by thinking of creative solutions when they become employed (Karnes & Bean, 2015).

Students in today's schools do not need assessments of memorized information to prepare them for a global society. Students will need to apply the skills they have learned through tasks that require problem solving and

creative thinking (Stanley, 2012; Couros, 2015). Audience selection as a contributing factor in the acceptance of creative products has had limited consideration in research (Plucker, 2017). Therefore, school projects that allow students to practice creative thinking strategies and to determine important criteria and audiences for evaluating creative ideas are needed to fulfill requirements of the Common Core State Standards, to prepare students for the ever-changing jobs of the future, and to practice skills necessary for problem-solving in diverse situations. The current research study investigates students' use of creative articulation during problem solving and invention to shed light on this emerging area of creativity.

Literature Review

The following literature review begins by discussing recent ideas regarding creativity in today's schools. Then, attention is turned to the new field of creative articulation, speaking about creative ideas and incorporating the ideas of an audience's needs into the creative process. Finally, recent work involving the engineering standards of the Next Generation Science Standards (NGSS; NGSS Lead States, 2013) is discussed.

Creativity in Today's Schools

Much research and literature has been devoted to documenting the rationale for the inclusion of 21st Century Skills in our schools. The United States has increasingly emphasized the attention of standardized assessments to gauge students' progress and evaluate the performance of schools. The concern by many is that the U.S. has been devoting time and resources to elevate students' assessment scores, while other countries have been investing in the development of students' creativity (Lenz, Wells, and Kingston, 2015). Unfortunately, the majority of American schools continue to allow the rigid structure from the Industrial Age to pervade the classroom curriculum. Although there is not one distinctive definition for 21st Century Skills, the tenet of the term encompasses students learning concepts with transferable knowledge and applying their learning to creatively solve problems. In addition, students utilize collaborative skills to engage in authentic tasks and communicate their discoveries with others. Deeper learning occurs when students are creators, not consumers, of knowledge (Couros, 2015).

According to Drapeau (2014), creativity is at the heart of preparing students for their roles in the 21st Century, a time of rapid change. Despite the intention of the Common Core State Standards to prepare students for college and careers, the authors of these standards do not always consider the academic needs and characteristics of gifted learners (Heacox and Cash, 2014). The verbs written in the standards could easily be interpreted to low-level cognitive tasks. For example, *recount, explain,* and *cite* could be elaborated to include more creative verbs, such as *integrate, interpret,* and *compare*. Drapeau insists that all teachers should be incorporating creative thinking into their lessons, referencing Sir Ken Robinson's infamous YouTube video *Do Schools Kill Creativity?* (Drapeau, 2014; Robinson, 2006). Furthermore, as George Couros, a recognized educator in the field of innovative leadership, teaching, and learning states, "Although we say we want kids to think for themselves, what we teach them is compliance" (Couros, 2015, p. 4). This antiquated compliance and memorization approach toward education will not prepare American children to compete and contribute in the future global economy. In 2010, IBM's Institute for Business Value conducted a survey that included 1,500 CEO's from 60 countries and 33 various industries. Creativity was identified as "the most important leadership competency for business success" (Kern, 2010, para 2).

Neuroscientists have published recent research findings that implicate the need for gifted students to have learning opportunities that encourage deeper, more complex thinking. Gifted students "have more neural connectors in their prefrontal cortex than do typical learners" (Heacox and Cash, 2014, p. 14). Educators need to meet the needs of gifted learners by providing learning experiences that demand more complex thinking and recognize these students' rapid processing skills. Such complex thinking experiences generally involve projects centered on problems involving many possibilities and aspects to consider. The project on which this study focuses involves fifth graders who have been identified for gifted education services in invention activities.

Creative Articulation

How can teachers prepare students to think creatively? According to Plucker (2017), "programs that attempt to increase personal creativity should include some instruction and practice in the articulation of creative products." Plucker defines *creative articulation* as not only the verbalization of creative ideas, but also the incorporation of processes that interact to result in acceptance or rejection of the creative product. Creativity has evolved to a broader understanding of the roles of society and audiences in the 21st Century (Plucker, 2017). Therefore, students need to be prepared to consider the needs of different audiences and to communicate their ideas effectively and convincingly.

Marketing is a skill that may not be typically taught in elementary schools, yet supports the idea of creative articulation and will prove to be advantageous for students in the 21st Century. In their book *Launch,* Spencer and Juliani outline several benefits to teaching students about the concept of marketing, which include: developing marketing ethics, building confidence and empathy, learning the art of persuasion, understanding rejection and success, and becoming critical consumers (Spencer & Juliani, 2016).

An exploration of the role of creativity in advertising (Smith & Yang, 2004) generated a definition of creativity as ideas, solutions, inventions, or products made by people that are divergent (or uniquely different, original) and relevant to a specific social group such as teenagers or new mothers. This means that audience is an important aspect of creativity; ads that are relevant to one group may have little relevance to another. Ads are creative products, just as other inventions; creative issues found in ads are relevant to other creative products. Relevance of an ad occurs when the advertisement produces significant meaningful links to the consumer (Smith & Yang, 2004). Another characteristic of advertisements is the effectiveness of the ad: the ad's ability to reach and prompt the consumer to purchase the advertised product or service (Smith & Yang, 2004). Effectiveness depends, in part, upon creativity of the ad. Other important aspects of advertisements include persuasive message, brand logo, images or text of product usage, and other elements such as the layout, design, photographs, graphics, and color. In the current study, students must consider the characteristics and needs of their audience to create a successful product and to create an effective advertisement.

Inventions

Science fairs (Bellipanni & Lilly, 1999), invention conventions (Hadi-Tabassum, 1997), and development of new products and tools have long been a part of science instruction, though not always explicitly mentioned in standards. The recently-developed Next Generation Science Standards (NGSS Lead States, 2013) are unique science standards in that they contain engineering design standards, which often call for students to develop a new or improved product or tool, to test and compare two objects designed for the same purpose, and to collect data to support the idea that the object works as planned. Additionally, more occasions for creating are now available: maker spaces in schools, libraries, and after-school clubs provide opportunities for students to create their own new inventions or to re-create inventions of the past to discover how they worked (Bull, Standish, & Tyler, 2016).

An analysis of major websites providing frameworks for 21st Century Skills (Kereluik, Mishra, Fahnoe, &Terry, 2013) concluded that there were three main broad categories: foundational knowledge, meta knowledge, and humanistic knowledge. The second category of meta knowledge includes creativity, innovation, problem-solving, communication, and collaboration. Designing an invention of some sort for an audience encompasses these skills.

Several recent studies in this journal have involved K-8 students making inventions as part of the engineering standards of Next Generation Science Standards. A study with kindergarten students learning about the water cycle (Smith & Samarakoon, 2017) involved students in inventing and testing waterproof boots in response to NGSS ETS1-1, which states that students will analyze the data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs. Kindergarten students reacted positively and learned many concepts about materials and design through the comparison of boots made by peers. Another study conducted with sixth graders (Olsen & Rule, 2017), involved students in making toys that illustrate science concepts in response to NGSS MS-

ETS 1-1. In a third study (Borsay & Foss, 2016), third grade students designed musical string or percussion instruments with recycled and craft materials they could "purchase" with given points in response to NGSS 3-5-ETS1-1: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost. Student products met more criteria during the experimental condition with students experiencing more motivation and enjoyment under that condition (Borsay & Foss, 2016). Another invention project with fourth graders (Hussain & Carignan, 2016) addressed the same NGSS Engineering standard but with application of animal form and function ideas, similar to the application of animal adaptations in the current study. Fourth graders made inventions under the two conditions of using the SCAMPER technique of idea generation with or without animal form and function ideas (Hussain & Carignan, 2016). The researchers (Hussain & Carignan, 2016) found that use of animal form and function ideas improved scores on inventions, especially originality and complexity.

The current study addresses the engineering standard 3-5-ETS1-2: Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design problem. Fifth grade students made inventions to fit a specific need of an audience and then evaluated the inventions of fifth graders from another school. The invention project occurred near the time students were studying plant and animal adaptations in their science class; therefore, the theme of the student inventions was chosen to reinforce that learning. The following section explains the invention experiment that was conducted with fifth grade students.

Method

The creative articulation concepts being investigated through this study included the considerations of audience needs, creative trait identification, and communication of creative product characteristics.

Research Questions

The study was designed to address the following research questions:

1. Will students who are taught the principles for choosing an audience, strategies for communicating their ideas to that audience, and receiving peer feedback on their ideas be more successful than students in a control condition spending the same amount of time on the project but without creative articulation instruction and peer feedback? The answer to this question was determined by scores on creative products by the audience, teacher observations of student reactions to the project, and student reflections through responses to a questionnaire.

2. What types of ideas and products do students create in response to the animal adaptation prompts and what do these indicate about student learning of creativity principles and Next Generation Science Standards? This question was answered by observation and analysis of student products.

3. What types of creative articulation are students using and how might these strategies and techniques be improved? These ideas were measured by examining the product advertisement created by students and by audience scoring or reactions to the students' persuasive arguments and products.

Participants

Thirteen White fifth-grade students (6 male, 7 female) identified for gifted education services participated in the study. Six students (1 male, 5 female) attended School 1 and seven students (5 male, 2 female) attended School 2. The same gifted education teacher taught the lessons to both groups of students as she traveled between the schools on different weekdays. Both schools served middle class populations and were about three miles apart. The free and reduced-cost lunch percentage at School 1 was 19% and at School 2 was 8%. All students and their parents provided fully-informed signed consent for participation in the study.

Research Design

The experiment was structured using counterbalanced repeated measures as shown in Table 1. Two lessons and the pretest preceded the experiment. The

first lesson focused on creative characteristics of products using published photographs of products made from identical sets of given craft and recycled materials (Rule et al., 2011). Students viewed the creations and discussed the aspects they viewed as being creative. Then, during the next class meeting, students took the pretest. During this assessment, students were each provided with a bag of craft materials and items from which to construct a scene or object related to a plant adaptation for survival in the environment. This topic connected to what students had learned in science class the previous month. During the third class meeting related to this study, photographs of student pretest products were shown to students at both School 1 and School 2 and the creativity of these products was analyzed to further student understanding of these concepts.

After these preliminary lessons to build a foundation in recognizing and producing creative products, the counterbalanced experiment began. The School 1 students experienced the experimental condition first with attention to creative articulation, while the students at School 2 were involved in the control condition. This group received instruction on creative design and audience considerations, and received peer feedback to consider during the construction phase. The group from School 2 devoted their entire work time to developing their independent projects, without creative articulation instruction or peer feedback. Both groups made new products from identical given sets of materials for the prompt: create an object or scene showing an adaptation allowing an animal to defend, protect, or prevent it from being eaten by other animals in its habitat. Students then switched conditions so that students at School 2 experienced the experimental condition, learning about application of creative articulation principles. All students in both groups again received a bag of craft materials and items to use in their product construction. Their challenge was to create an object or scene showing an adaptation allowing an animal to find, obtain, or eat food in its habitat.

Table 1. *Study Design*

Activity	Group 1 at School 1	Group 2 at School 2
Preliminary lesson	Both classes view images of creative products made from given materials from Rule and others (2011). Discussion of what makes the products creative. Teacher provides a common object and students generate alternate uses or ways it could be part of a product.	
Pretest	Students were provided a set of given materials and asked to create an object or scene related to a plant adaptation for survival in the environment. Grading of the product with a rubric provided students' pretest scores.	
3 Lesson Periods	Experimental Condition	Control Condition
Product-Making	Students were provided a set of given materials and asked to create an object or scene showing an adaptation allowing an animal to defend, protect, or prevent it from being eaten by other animals in its habitat.. Products graded with rubric by teacher.	
3 More Lesson Periods	Control Condition	Experimental Condition
Product Making	Students were provided a set of given materials and asked to create an object or scene showing an adaptation allowing an animal to find, obtain, or eat food in its habitat. Products graded with rubric by teacher.	

Lesson Procedures

The same teacher taught all lessons to both groups of fifth graders. Lessons lasted approximately 30 minutes each. Students in both the experimental and control conditions spent the same amount of time in the combination of lessons and work on products. Because students in the experimental condition spent time learning about creative articulation, they had somewhat less time to construct their products. Table 2 provides more details of the lesson procedures.

During the experimental condition, students were allowed to choose one of two audiences for their products. During the control condition, audiences were randomly assigned. The audience choices for the first set of lessons were: 1) People at a charity auction who are looking to purchase an ornament ("Which will be sold for most money as an ornament at a charity auction") and 2) School Librarians who are looking for the best product for a library science display ("Which will be chosen for a science display in the library?"). The second lesson set had these choices of audience: 1) Third grade teachers who want examples to show to third graders for teaching animal adaptations ("Which would third grade teachers choose to use as an example for teaching their students about animal adaptations?") and 2) Art Teachers who are looking for the examples of creative products ("Which will be chosen by the art teacher as an example of a product that is very creative?").

Table 2. *Details of Lesson Procedures*

Experimental Condition	Control Condition
Students are taught how to give and receive feedback and implement changes or improvements; shown how to present a sales pitch to an audience. They choose the audience for their product from a choice of two audiences.	Students under the control condition do not give or receive feedback, but spend all of their time creating their products. Students are randomly assigned an audience for each of their products.
Class Period 1: Provide materials and challenge. Students have 5 minutes to think and plan alone. They write down three ideas they have. Five minutes of teacher instruction on important points to consider in planning the creation and modeling of some ways to say these ideas to others. Students have 10 minutes to talk to partner to receive feedback on ideas. Students are allowed to use half of the materials to begin constructing the idea.	Class Periods 1 and 2. Students are provided the challenge and told they have two class periods to work on their products. Students work along without talking.
Class Period 2: Teacher presents points to consider in examining the work of others. Teacher presents ideas about what makes an object or scene creative (10 minutes). Kids give feedback to partner. Kids complete their creations. Creations need to have a title and the maker's name hidden on the bottom.	
Class Period 3: Teacher gives information on how to present a sales pitch tailored to the audience or how to convince an audience of the originality and usefulness of the product (10 minutes). Students receive feedback from peers on how their products are great (10 minutes) and suggestions for tailoring it to the audience. Students create ads for their products.	Class Period 3: Students work on creating advertisements for their products.

Instrumentation

The rubric used to score student invention products is shown in Table 3. Another instrument used to gather data was a simple attitude survey that was administered after each experimental trial. This instrument is shown in Table 4.

The posttest contained several open-ended questions to which students responded: 1) How was your product unique or original? 2) How was your product useful? 3) How was your product meaningful to the audience for which it was made? 4) What part of this project was the most fun? 5) What project aspects taught you the most about creative articulation? Students were asked to provide their insights or tips for others on three subjects: 1) Insights or tips on creating a product from a given set of materials; 2) Insights about creative articulation; and 3) Insights about how considering the audience and receiving peer feedback was or was not helpful. Finally, the rubric shown in Table 5 was used to score student advertisements for their products. Both rubrics were made available to students so that they could use them in planning their work.

Table 3. *Rubric used to Score Student Invention Products*

	Criteria	Yes, Great 3	Good 2	Somewhat 1	No 0
1.	Originality (unusual): Was the theme or topic of the overall product unique?	No one else made a product like this	One other person made a similar product	Two to four others made a similar product	Five or more made a similar product
2.	Fluency (many): Were all of the craft and recycled items given actually used in the product?	All used in meaningful way	All used, but some just hidden inside others or 1 item not used	Two or three items not used	Four or more items not used
3.	General Flexibility (different): Did the student use the materials in ways others did not	Three or more items used in ways different than others	Two items used in ways different than others	One item used in a way different than others	No items used in unusual ways
4.	Resistance to Premature Closure: Were the plastic animal and plastic flag used as something different than what they appear to be?	Both were used in ways that were vastly different than what the object was.	Both used in ways that were somewhat different than what the object was.	One was used differently than what the object was.	None used differently or weak differences
5.	Elaboration (details): Extra details were added to the project with the marker or through cutting details or through cutting items into pieces and using them to make details.	Highly detailed product	Some detail in product in more than one area	Detail in one area	No detail
6.	Humor or Wordplay: Was there humor or word play through an exaggerated situation, funny expressions, pun, surprise, etc.	Three instances of humor or wordplay (include title)	Two instances of humor or wordplay (include title)	One instance of humor or wordplay (include title)	No humor or wordplay (include title)
7.	Emotional Expression: Did the product or its title express emotions?	Three or more places in the product or title showing emotion	Two places in the product or title showing emotion	One place in the product or title showing emotion	No emotion expressed

Table 3 Continued. *Rubric used to Score Student Invention Products*

	Criteria	Yes, Great 3	Good 2	Somewhat 1	No 0
8.	Action or Movement or Sound: Do parts move or are characters shown in motion, are there motion or shine lines or action words or sounds or speech?	Three or more instances of action or sound.	Two instances of action or sound	One instance of action or sound	No action or sound
9.	Internal Visualization: A cut-away view or a way to look through a window or door and see the inside.	Three or more instances or two very clever or highly detailed ones.	Two instances of internal visualization or a very clever or highly detailed one	One instance of internal visualization	No internal visualization
10.	Story-Telling Articulateness: Does the product convey through the title or product what has happened or is about to happen?	The product and its title tell a strong story	The product **or** its title tell either what happened or is about to happen	There are hints at a story in the product or title	Not really
11.	Additional Creative Strengths: Abstract idea, parody, fantasy, beauty or artistic appeal (richness), sensory appeal (colorfulness), unusual visualization, three-dimensionality, breaking boundaries.	Three other instances of a creative strength not already noted	Two other instances of a creative strength not already noted	1 other instance of a creative strength not already noted	Not really
12.	Usefulness: Appropriateness to given prompt. Did the product comply with the prompt about adaptations?	Product fits the prompt very well	Product fits pretty well	The product idea can be stretched to fit the prompt	Not really
13.	Social Environment: Appropriate to audience: Did the product contain features that would make it appealing to the audience?	Product fits the desires of the audience well in several ways	Product matches audience desire in two ways	Product ideas fits audience desire a little	Not really
	Total Points for Product	Total Points this column	Total Points this column	Total Points this column	Total Points this column

Table 4. *Simple Attitude Survey Instrument.*

Circle a number on the scale below to indicate how much you enjoyed recently making your invented product.											
Did not enjoy making it at all	1	2	3	4	5	6	7	8	9	10	Enjoyed making it very much
Please give reasons why you gave this rating.											
Circle a number on the scale below to indicate how much you learned about creative articulation by participating in the recent activities related to your invented product.											
Did not learn much at all about creative articulation	1	2	3	4	5	6	7	8	9	10	Learned very much about creative articulation
Please give reasons why you gave this rating.											

Table 5. *Rubric for Scoring Students' Advertisements*

Title of Product:				
Criteria	Yes, Strongly	Moderately	Slightly	No, Rare or absent
Points	4	3	2	1
1. Is the message clear to the audience through **effective communication?**				
2. Is the product described well, communicating **best features?**				
3. Are **reasons** for a **specific audience** choosing the product present?				
4. Are **Humor or wordplay** present?				
5. Is an **Emotional appeal** present?				
6. Does the ad contain thoughtful use of color and space causing **aesthetic appeal?**				
7. Does the ad contain elements of creativity and individual expression, **different from other ads?**				
8. Are there any additional **endorsements, testimonials, slogans, and jingles**, present?				
9. Did the student apply grade-appropriate **spelling** and conventions?				
10. Was the **organization**, logic, and neatness of the ad excellent?				

Results

After a slow and somewhat frustrating start, students gained skills along with confidence and began to enjoy the activities. The level of new learning of creativity skills was overwhelming at first, but students made large gains on the rubric on second invention and tended to maintain these during the third invention round. Students reported similar high enjoyment and moderate learning levels under both conditions. More details are provided in the data analysis that follows.

Product Scores

Comparison of pretest to later product scores. Students completed a product with a set of given materials three times during the study: first in the pretest, next as the first trial of the experiment, and then again in the second trial of the experiment. Student mean product scores (combining the scores from both conditions for the first and second trials of the experiment), determined with the rubric previously noted in Table 3, are shown in Table 6. Three paired *t*-tests were conducted comparing the pretest scores to each of the trials of the experiment and between the two trials. The results of these *t*-tests are shown in Table 6. Students showed marked improvement from the pretest to each of the two trials, indicating their learning with a large effect size. There was no significant difference between the mean scores of students from trial 1 to trial 2, indicating that the main growth occurred the second time students made a product during the initial trial of the experiment and that growth was maintained at the third time they each made a product. The new skills were fairly overwhelming for students at the time of the pretest, but they caught on quickly and showed great growth at the time of the first trial.

Table 6. *Pretest, First Trial, and Second Trial Mean Scores and t-test Results.*

Scores of Both Classes and Conditions Combined	Mean*	*p*-value	Cohen's *d*	Effect Size Interpretation
Pretest product score	0.85 (0.3)			
First trial of experiment product score	1.24 (0.4)			
Paired *t*-test comparing product scores of pretest to first trial of experiment		0.0006; statistically significant	1.11	Large, favoring first trial of experiment.
Second Trial of Experiment	1.22 (0.5)			
Paired *t*-test comparing product scores of pretest to second trial of experiment		0.004; statistically significant	0.86	Large, favoring second trial of experiment.
Paired *t*-test comparing product scores of first trial to second trial of experiment		0.43; not significant	Not calculated	Not calculated

* Standard deviations in parentheses

Comparison of control and experimental conditions. The data in Table 7 show the mean scores of student products and the mean gain scores of student products from the pretest to trial 1 and from trial 1 to trail 2. Differences in product scores and gain scores between the two conditions were not statistically significant. However, there was a trend of students performing better in the control condition which may be caused by control condition students having more time to think of ways to make their products rather than spending time learning about creative articulation. The creative articulation advice students received from their inexperienced classmates may not have been very helpful in improving their product scores. Additionally, the students who experienced the experimental condition first carried that knowledge to their work in the control condition, thereby possibly bolstering the control condition scores. More definitive results may be obtained in the future if: 1) students receive a greater number of lessons about creative articulation to reach better proficiency; 2) more students participate in the study; 3) the study design is modified so that there is still a comparison group, but that learning garnered in the experimental condition is not carried into the control condition.

Table 7. *Comparison of Control and Experimental Conditions*

Group	Mean Pretest Score*	Condition for Trial 1	Mean Product Score for Trial 1*	Mean Gain Score from Pretest to Trial 1*	Condition for Trial 2	Mean Product Score for Trial 2*	Mean Gain Score from Trial 1 to Trial 2*
Group 1 at School 1	1.00 (0.2)	Exper.	1.31 (0.3)	0.38 (0.3)	Control	1.49 (0.4)	0.17 (0.6)
Group 2 at School 2	0.74 (0.3)	Control	1.18 (0.4)	0.44 (0.3)	Exper.	0.99 (0.5)	-0.19 (0.3)

Group	Mean Control Condition Score	Mean Exper. Condition Score	Paired *t*-test p-value	Mean Control Condition Gain Score	Mean Exper. Condition Gain Score	Paired *t*-test *p*-value
Both	1.32 (0.4)	1.14 (0.5)	0.08; not significant	0.31 (0.5)	0.05 (0.5)	0.18; not significant

* Standard deviations in parentheses

Student Attitudes

The mean rating scores for student attitudes are shown in Table 8. Student ratings for enjoyment of the product-making did not differ significantly between the experimental and control conditions. Student ratings for learning did not differ significantly between the experimental and control conditions. The ratings regarding perceived learning for the experimental condition had a higher mean value, but there was too much variation in ratings for this difference to be significant.

Table 8. *Student Attitudes of Enjoyment and Learning during the Experimental and Control Conditions*

Attitude	Experimental Condition*	Control Condition*	*p*-value from Paired *t*-test	Statistically Significant Difference?
Enjoyment of invention process on a scale of 1-10 with 10 being maximum enjoyment	9.18 (1.1)	9.46 (1.1)	0.34	No
Perceived learning about creative articulation on a scale of 1-10 with 10 being maximum learning	7.36 (1.9)	6.85 (2.4)	0.12	No

* Standard deviations in parentheses

Student Products

Figure 1 shows several of the student-made products for the first activity before the experiment began at School 1. Students were directed to use all of the given materials to "invent an object or scene related to a plant adaptation for survival in the environment." Figure 1a was titled "The House Plant" by a student who imagined a plant that looks like a house, which possessed the ability to capture and eat any animals that would go inside as a way of protecting itself. Figure 1a has clever word play with the *house*plant having a base in the shape of a house Figure 1b is titled "The Circle of Life" because it demonstrates the life cycle of a lion hunting the giraffe, which is eating the plant and also a dead carnivore, and helping the tiny plant grow as it drops seeds underneath the carcass. The student who made Figure 1b creatively used all the materials and cut out an area of the cardboard tray Figure 1c depicts a science fiction scene of an underwater plant that spreads seeds around the ocean floor, which attach to sea creatures to aid in plant dissemination. The maker of Figure 1c colored the base and several pieces black, a unique treatment of the materials. Figure 1d shows a "Roseshroom," which is a scene that is comprised of both a rose and a mushroom. The flower in 1d has a very distinctive and aesthetic shape. Figure 1d is an example of a student demonstrating premature closure to a creative idea. The student was initially highly focused on creating an aesthetically pleasing representation of a rose. However, realizing that several materials remained after completing the rose, she decided to randomly create a mushroom. Interestingly, her attitude toward the rose was very passionate in her creativity; when creating the mushroom, she was indifferent and hasty. Rather than revisiting the rose to further her creativity, she used the remaining objects to create a second object, with completion being her primary motivation.

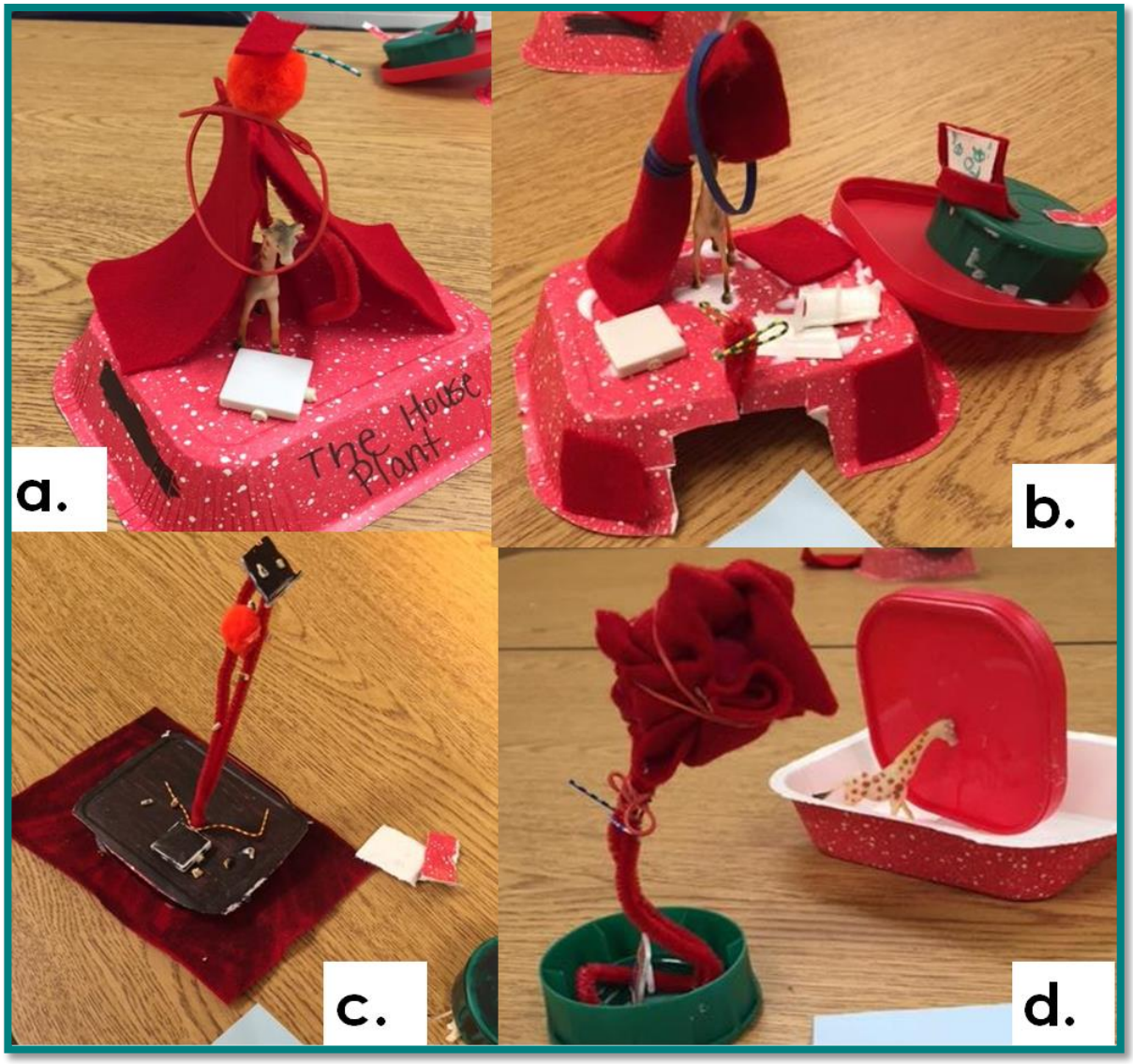

Figure 1. Initial invented products made by students at School 1 before the experiment began. Figure 1a represents "The House Plant"; Figure 1b is titled "The Circle of Life"; Figure 1c depicts an underwater plant; Figure 1d shows a combination of a flower and a mushroom, which the student labeled a "Roseshroom."

Figure 2 presents student initial products from the other school with the same plant adaptation prompt. The neatness and aesthetic appeal of a carefully- constructed scene are evident in Figure 2a, in which the student cut strips into the foil cardstock to create tall grass for the cheetah's natural environment. Figure 2b shows a pipe cleaner being used as a plant step, where the stem can suck special nutrients from the ground. Figure 2c and 2d are scenes of a Venus Flytrap ingesting a "bug" (represented by the cheetah). The scenes are separated by time and motion, very creative ideas

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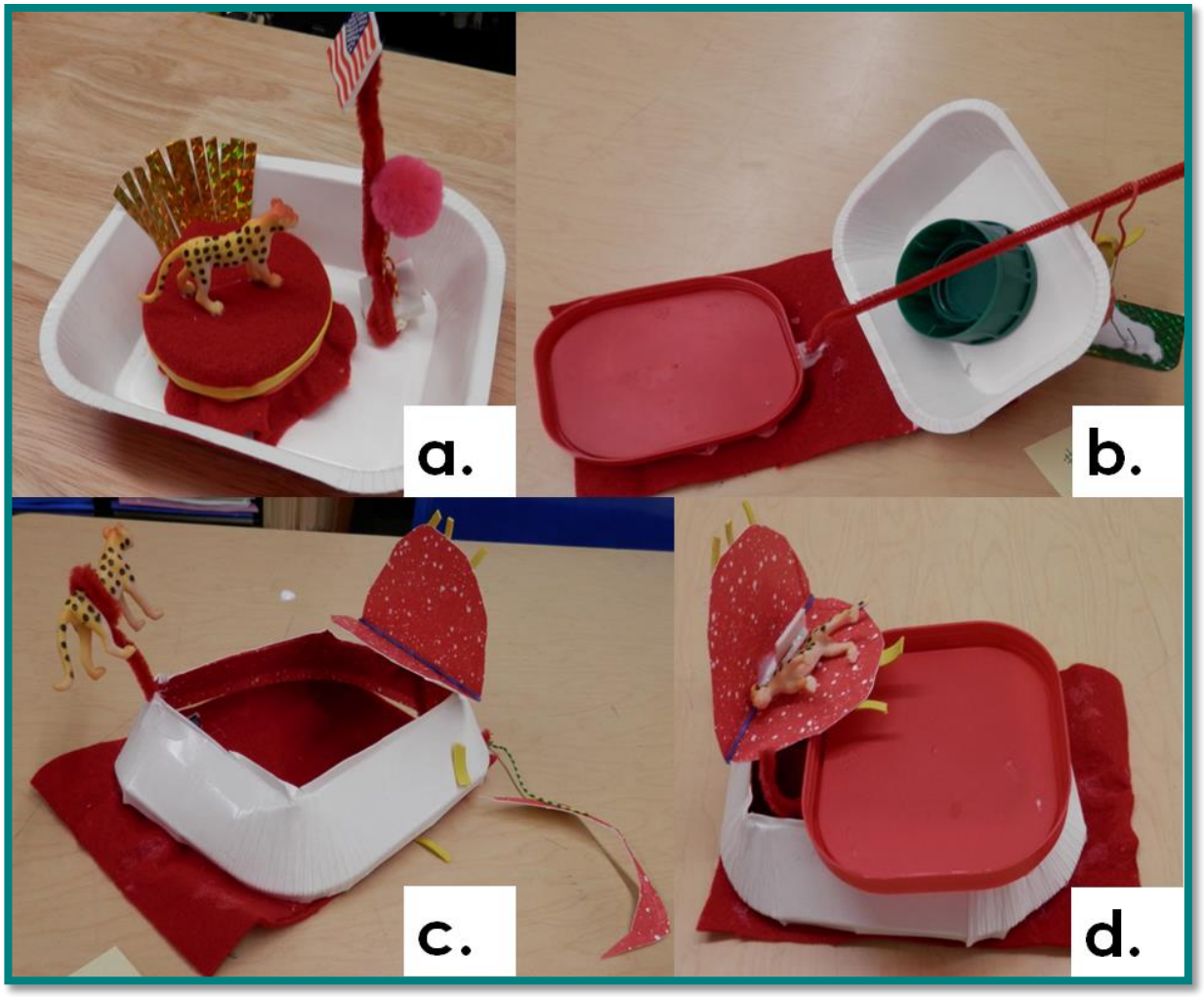

Figure 2. Initial invented products made by students at School 2 before the experiment began. Figure 2a shows an animal defending its territory; Figure 2b is a "Nutrient Stealer"; Figure 2c and 2d are two views of the same plant that is an action model of a Venus Flytrap.

Figure 3 presents example projects made during the second set of inventions under the experimental condition at School 1. Figure 3a displays a tortoise with a shell of spikes, heading toward his prey. This student utilized the materials creatively, including creating eyes out of a plastic flag. Figure 3b shows how a student colored the felt and cut apart the materials to create a model of a spider. Figure 3c is a model of a snake in a cave, using echolocation as an adaptation for survival. The student drew lines on the felt background to demonstrate the action of echolocation, as well as cutting and coloring pieces of a plastic animal to represent rocks in the cave. Figure 3d depicts a rhino with armor being attacked by snakes, which includes creative use of a plastic flag and rubber bands as armor for the rhino

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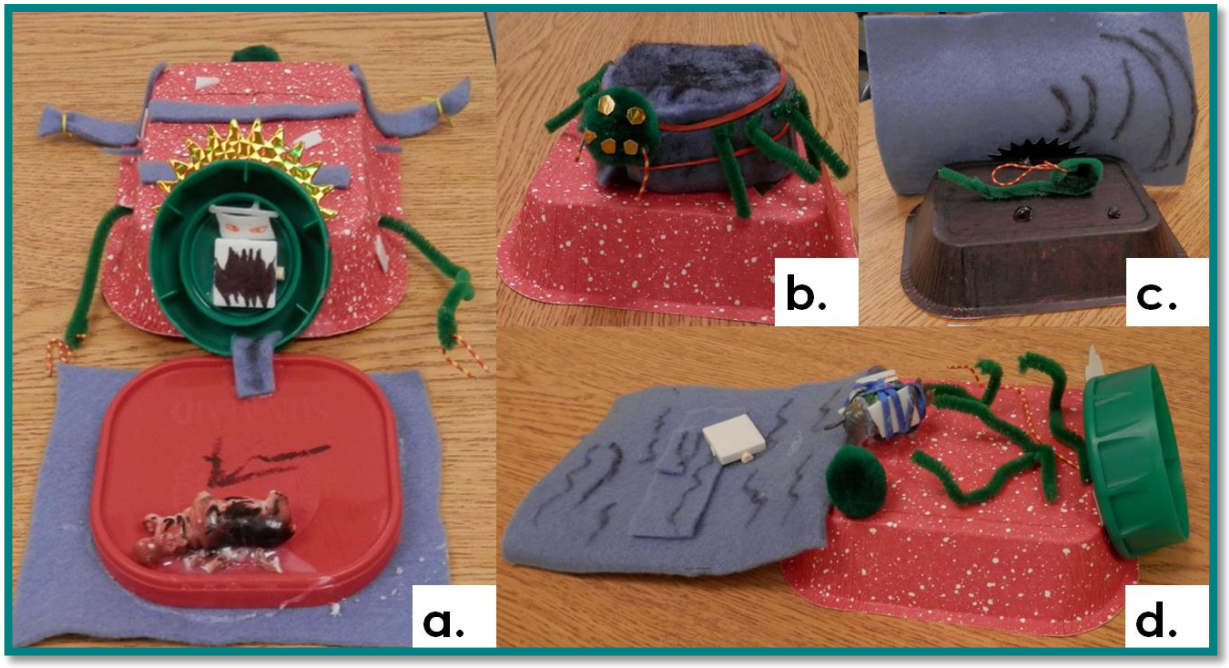

Figure 3. Example projects completed by students at School 1 during the experimental condition of the experiment. Figure 3a depicts the "Fossil of a Clam Killer Tortoise"; Figure 3b shows "The Great and Mighty Cotton Spider"; Figure 3c represents a "Pharaoh Snake"; Figure 3d is a "Snake Attack."

Figure 4 shows example projects made during the second set of inventions under the control condition at School 2. Figure 4a shows creative use of a speech bubble: the animal calls out, "Help!" as it was stung by a puffer fish. However, this is a definite example of premature closure of the student's ideas, evidenced by the written statement at the conclusion of his work that the plastic flag and the paper clip represent the Titanic. The student in figure 4b created a way to use all of the materials to protect the animal from every side. However, in written and verbal descriptions, he lacked specificity in the purpose of the materials, stating that each piece was used for protection. This also would be a form of premature closure, given that the materials held the possibility for being used for a variety of forms of protection. In Figure 4c, the student imagined the lion protecting himself on a floating fortress that would keep him safe from predators. Creative use of the pipe cleaners allows the lion to be suspended in the model. Figure 4d also shows creative use of the pipe cleaner, creating a model of a gazelle that is being hunted by a tiger. This student also gave careful consideration to detail through coloring and adding a written description

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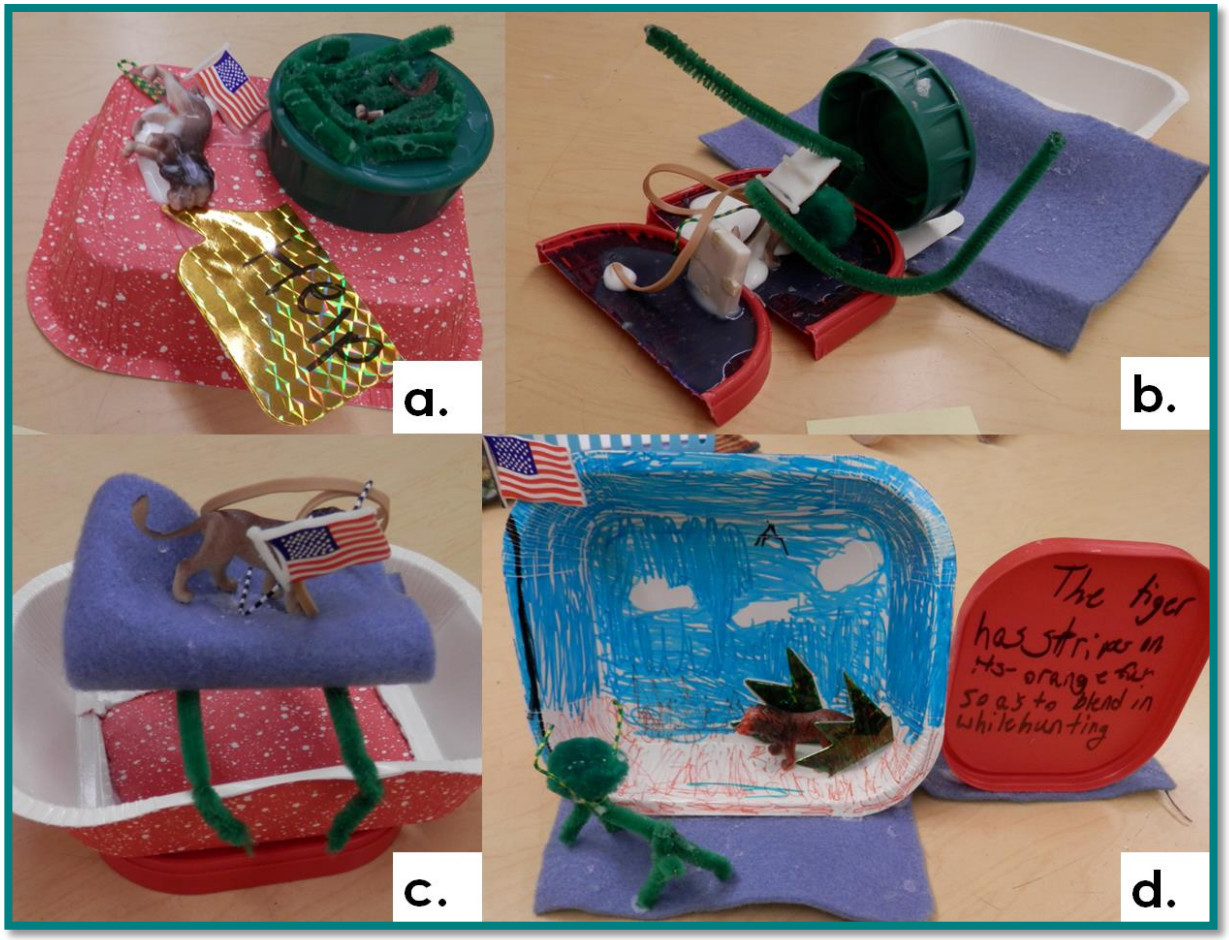

Figure 4. Example projects completed by students at School 2 during the control condition of the experiment. Figure 4a is called "The Puffer Fish"; Figure 4b shows an animal being protected from each side; Figure 4c represents "The Flying Lion Fortress"; and Figure 4d is "The Grass Cat."

Figure 5 shows example projects made during the third set of inventions under the control condition at School 1. Figure 5a shows a sea turtle that can go into its shell to protect it from predators. Creative use of the materials include: sections of the cardboard tray cut into shapes of fish, pipe cleaners used as kelp, rubber bands used as legs, as well as pieces of the plastic animal used as rocks on the ocean floor. Figure 5b is a humpback whale, utilizing frayed pieces of felt as water coming from the whales' spout. Figure 5c makes creative use of the materials to create a model of an angler fish, using the adaptation of light (the pompom) to attract the imaginative "rhino fish." Figure 5d is a fictitious creation of a microscopic creature that is caught in a small current (shredded pompoms), and uses its weighted tail (ceramic tile) to avoid being flung into danger.

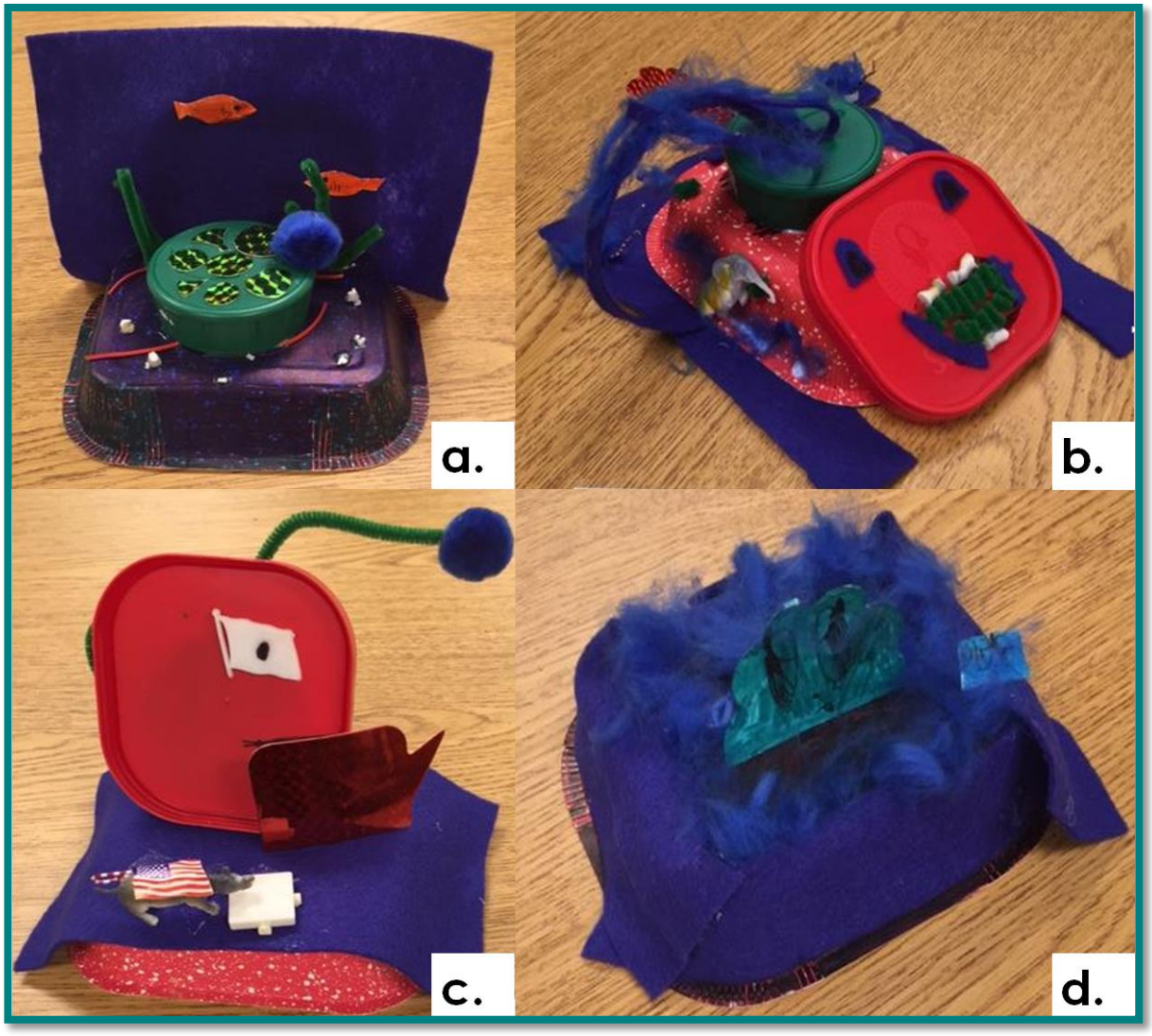

Figure 5. Example projects completed by students at School 1 during the control condition of the experiment. 5a is a sea turtle; 5b is a humpback whale; 5c depicts an angler fish; and 5d is a microscopic creature caught in the current.

Figure 6 shows example projects made during the third set of inventions under the experimental condition at School 1. Figure 6a shows a zebra's habitat. The sparkly cardboard piece is used to "scare predators," although the student does not elaborate on what this is or how this is used. Figure 6b is a shark (plastic zebra) that is about to eat a fish (pompom). The pipe cleaner is used to show the objects "floating" in the ocean (cardboard tray). Titled "Zebra Riverhouse," Figure 6c represents an imaginative adaptation of a zebra with a flipper (pipe cleaner) that would help it to swim in the water. Figure 6d is a fish (giraffe without legs) that is swimming in the water with a sleigh. The "sleigh" is the brain of a fictional animal, the paper clip shows the connection between the brain and the body, and the "fish" is actually an illusion! The sleigh is used to trap its prey.

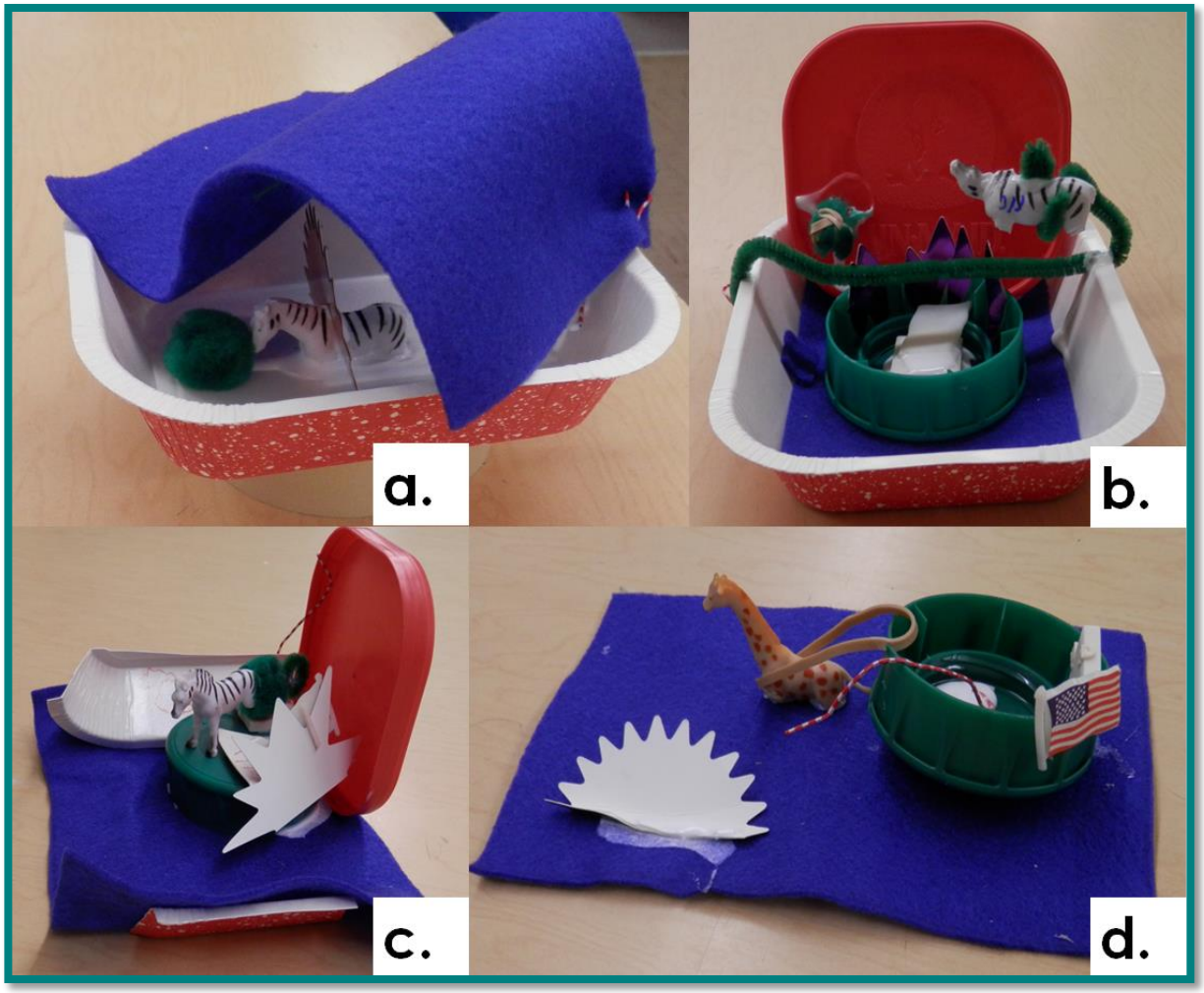

Figure 6. Example projects made during the third set of inventions under the experimental condition at School 1. 6a is a zebra's habitat; 6b features a shark about to eat a fish; 6c represents a flipper-bearing zebra; and 6d shows an imaginative brain sleigh pulled by a fish illusion.

Student Responses to Questions about Products and Project

Students responded to questions about the uniqueness of their products, their utility, and their meaningfulness to the intended audience. Responses for these questions are shown respectively in Table 9, Table 10, and Table 11. In general, students understood the concept of originality and were able to apply this to products by making them have unusual features and by making them very different from the products of peers. Most students were able to connect usefulness to the requirements given for the products as being examples of animal adaptations for teaching or as plans for the animals themselves. Students found it more difficult to answer the third question on meaningfulness to the audience. Some were able to state how an audience member would use it, but others resorted to reiterating that the product was creative.

Table 9. *Student Responses Concerning How their Products were Original or Unique*

Frequency	How Product was Original or Unique
11	The animal I made has specific unusual features
7	No one else made a product like mine
3	Because I changed everything into something new and made everything into exactly what it's not.
2	Used randomness in making the product
1	Because the colors are not realistic
1	I did it my own way and didn't have or give any feedback.
1	I used all the materials in my product

Table 10. *Student Explanations of How their Products are Useful*

Frequency	How Product is Useful
9	Useful as a teaching example on adaptations.
5	Animal is helped by invented adaptation
5	Decorative usefulness or ornament
3	An example of creativity
1	Attractive appearance or cool
1	Can be used as a cereal bowl
1	Great conversation starter
1	Helps ecosystem by eating overpopulated animals

Table 11. *Student Explanations of How Products are Meaningful*

Frequency	Way Product is Useful
10	Useful for teaching animal adaptations and animal behaviors
7	The product is original and/ or creative.
2	Motivates people to learn more about the animal
1	Can be used as a cereal bowl
1	Exciting action fight between a squid and whale
1	Represents a story as an ornament
1	Symbolizes hope
1	The product has details
1	The project is for librarians and features a book worm

Students generated a variety of aspects of the project that they considered to be the most fun including generating the product idea, building it, and using imagination or humor. These ideas are shown in Table 12. The aspects of the project that students viewed as helping them learn about creative articulation included taking the audience's viewpoint and listening to peer advice, among other ideas, shown in Table 13.

Table 12. *Student Perceptions of the Most Fun Part of the Project*

Frequency	Part of the Project Perceived as Most Fun
6	Generating the idea for the product
6	Making/building the product
5	Using my imagination and being creative
3	Adding humor to the product
3	Finding out how to do and use things in different ways
1	Being able to create anything is exciting.
1	Seeing the image in your head actually come real

Table 13. *Project Aspects that Taught Students the Most about Creative Articulation*

Frequency	Project aspect that taught students most about creative articulation
7	Think of the audience's point of view to make it appealing to them
5	Other people's advice gave me good ideas
3	Constraints on materials caused creativity
3	Transforming an object into something else
2	Communicate with the audience through ads or flyers
2	I learned to be original
1	Not everything works out

Students' Product Advertisements

Table 14 presents students' mean scores on the advertisements determined using a rubric. Overall, students scored slightly better when working in the experimental condition. A paired *t*-test comparing each student's performance when creating advertisements under the each condition showed no significant difference with $p = 0.14$. A significant difference between conditions exists between the control and experimental conditions for being able to state reasons in the advertisement telling why the product would appeal to a specific audience. A paired, two-tailed *t*-test produced *p*-value = 0.04, with Cohen's $d = 0.53$, *a medium effect size.* This portion of the activity, creating an advertisement, was the most unfamiliar to the students. Although they were quite comfortable with using a computer as their tool, they lacked previous knowledge in how to structure and organize an advertisement, especially how to consider the needs of an audience when creating an advertisement.

Table 14. *Students' Advertisement Mean Scores*

Rubric Category	First Trial of Experiment		Second Trial of Experiment		Control Condition Both Trials Mean Score	Exper. Condition Both Trials Mean Score
	Control Condition Mean Score	Exper. Condition Mean Score	Control Condition Mean Score	Exper. Condition Mean Score		
	Group 2 School 2	Group 1 School 1	Group 1 School 1	Group 2 School 2	Both Groups	Both Groups
Effective communication	2.4 (1.4)	4.0 (0.0)	3.3 (1.2)	2.6 (1.0)	2.9 (1.3)	3.2 (1.0)
Best features	1.7 (1.0)	2.5 (1.0)	2.2 (1.5)	2.1 (1.2)	1.9 (1.2)	2.3 (1.1)
Reasons for specific audience	2.3 (1.1)	3.8 (0.4)	3.0 (1.5)	2.7 (1.1)	2.6 (1.3)	3.2 (1.0)
Humor or word play	1.6 (1.0)	1.5 (0.8)	1.8 (1.2)	2.1 (1.2)	1.7 (1.0)	1.9 (1.1)
Emotional appeal	2.0 (1.2)	2.0 (1.3)	2.5 (1.4)	2.6 (1.3)	2.2 (1.2)	2.3 (1.3)
Aesthetic appeal	2.3 (1.4)	2.8 (1.2)	3.3 (1.2)	2.4 (1.3)	2.8 (1.4)	2.6 (1.2)
Different from other ads	2.9 (0.9)	3.0 (0.6)	3.3 (0.5)	2.9 (1.2)	3.1 (0.8)	2.9 (1.0)
Endorsements, testimonials, slogans, jingles	1.0 (0.0)	2.0 (1.5)	2.0 (1.5)	1.4 (1.1)	1.5 (1.1)	1.7 (1.3)
Spelling conventions	3.6 (0.5)	4.0 (0.0)	4.0 (0.0)	3.9 (0.4)	3.8 (0.4)	3.9 (0.3)
Organization, logic, neatness	2.9 (0.9)	3.8 (0.4)	3.7 (0.8)	3.3 (1.0)	3.2 (0.9)	3.5 (0.8)
Overall Mean Score	2.3 (0.6)	3.0 (0.4)	2.9 (0.6)	2.6 (0.7)	2.6 (0.6)	2.8 (0.6)

Student Reflections

Students were asked to provide insights on aspects of the project. Table 15, Table 16, and Table 17 show the tabulated advice given by students. For insights into making the product (Table 15), students' remarks focused on originality, confidence, and adapting things to make them work. For tips about creative articulation (Table 16), students suggested communicating with others to obtain ideas, considering the audience for the product, and using the feedback to generate better ideas. Top reasons advice from peers or considering the audience was helpful (Table 17) included the idea that feedback helped in improving the product, knowing audience wishes helps in designing a product to match, and talking about ideas helps one better form good ideas. These three ideas encompassed the major creative articulation ideas being taught to students; clearly, students learned much of the message.

Table 15. *Students' Insights about Making Products from a Set of Given Materials*

Frequency	Insights or Tips
8	Do something different than others.
7	Have confidence and don't be discouraged.
6	Adapt what you have to make it work.
3	Think and plan before you build.
2	Add details to make it interesting.
2	Consider all ideas.
2	Use all of the materials.
2	Use all of the time wisely.
1	Be creative.
1	Make it random.
1	Use real world uses.
1	You don't have to use everything.

Table 16. *Students' Insights about Creative Articulation.*

Frequency	Insight or Tip about Creative Articulation
9	Communication with others about your product will improve it
7	Consider the audience throughout the project
6	Use feedback to help you generate new, better ideas
5	The people in the audience are important to listen to because they are like the customer
2	Don't let other people's ideas take over your project.
2	Enjoy the work
2	Have confidence
2	Make sure you understand what your audience is saying or wants
1	Be flexible and open to changing ideas
1	Save creative articulation for the advertisements.
1	Use the materials in a different way.

Table 17. *Reasons Students Provided for Helpfulness or Lack of Helpfulness of Considering the Audience and Receiving Feedback*

Frequency	Reasons Why Considering the Audience and Receiving Feedback was Helpful
8	Feedback helped me make my product better
8	Knowing the wishes of the audience helped me design a better product to match these
8	Talking with others helps you better form ideas and gives you new ideas
3	Fun to generate ideas for a real or imagined audience
3	Making an advertisement allowed me to think about and explain why my product was great
1	The feedback helped so I knew what to do next time if I didn't understand it.
1	You should consider the age of your audience.
Frequency	**Reason Why Considering the audience and Receiving Feedback was not Helpful**
1	Sometimes it can ruin the idea you had in mind if you ask other people.

Teacher Observations

The teacher recounted many observations that support the findings reported in earlier sections of this paper. During the pretest, much frustration was noted with each group, as well as lack of confidence and negative self-talk. One student from School 1 stated, "I hope it doesn't look this dumb when it dries." At School 2, one student remarked, "I don't know what to do." Another student declared that he knew he was not going to do well because he is not very creative. Overall, students from both schools were hesitant and unsure about how to begin or what direction to take with their creations. Many found the restrictions to be highly frustrating as evidenced by overheard conversations with peers. One student at School 1 remarked that the time constraint made the task somewhat exciting, by saying, "This is like a cooking show because you only have limited time."

Once the experiment began, students from the experimental group (School 1) showed their enthusiasm during their interactions. After the directions were given, one student reminded the group, "Feedback should be nice, not mean, but should be helpful. Like if something doesn't make sense, ask questions to have them explain it. Also give them suggestions on how they could improve." Students began to cut up the materials and use them for a variety of non-traditional purposes. One student said to her classmate, "Cool! Those [cut up pieces of the hippo] look just like rocks!" The classmate replied, "I know! I'm so happy! And this [piece of felt] shows the snakes' echolocation! (by means of drawn arcs of moving sound waves)" As they left the classroom, students chatted with each other about how much fun the activity was.

Once students began their advertisements for their projects, there were noticeable differences in their comfort with this part of the assignment. Two students, who are very outgoing and proficient with the use of technology, eagerly began right away. Two other students worked quietly with a very serious attitude toward the task. One student was slightly hesitant, but solicited feedback from his peers. Another student, who strives for perfection, was paralyzed by her fear of uncertainty. She spent most of the class time thinking of what she wanted to do, rather than diving in to create an advertisement for her project.

Students from School 2, under the control condition, were relieved to hear that they would have two class periods to work, although they were not allowed to talk to each other during their work time. They readily began to create, but with less enthusiasm than the experimental group. Several of the students quietly whispered things under their breath as they worked. At the end of the first day, one student looked at his project and announced, "This is sad!" Another student replied, "Is it sadder than mine?" The second work time yielded more satisfaction with their work. Students did not feel rushed, and often spent several minutes quietly thinking and planning before making additions or adjustments to their projects. At the end of this project, one student said, "I feel like it's so much easier this time." Students felt comfortable creating their advertisements on computers during the next class time.

As students began the next phase of the experiment, the students from School 1 were now in the control condition. They seemed to enjoy the freedom of the unstructured work time. One student said, "Yay! I *love* quiet work time!" Another student announced, "Oh, my gosh! I worked so hard on this; I'm so happy!" There was no hesitation when it was time to begin the advertisements. Students worked quietly on their ads for their projects.

Students from School 2 were also happy with the new guidelines, as they were now operating under the experimental condition. One student asked, "So we can talk this time? Awesome!" During their construction, there was much conversation among the students: "This is going to be the best adaptation project ever, because I actually have an idea this time!" "I know! This will be my best one!"… "So do you just fold the felt here and glue it?" "Yeah, you could. I used mine as a flower." Although students were excited to talk, there were not many comments observed that were specifically directed toward helping others improve their projects. One student was so excited about his creation that he enthusiastically announced what he'd created at the end of the class period. Someone said, "I have no idea what you just said, but that's awesome!" This continued during the second work time, as one student asked his classmate, "Isn't that supposed to be creative for an art teacher?" but did not follow up with where he considered a disconnect in the intent of the project, nor offer suggestions for revision. These student conversations indicate that, although students had made progress in incorporating creative articulation ideas into the project, there was more for students to gain through future experiences.

Discussion

Connections to the reviewed literature are provided in this section to place the findings of the study in context. First, the experience of flow is discussed, followed by creative articulation skills. Finally, the importance and implementation of complexity is addressed.

Developing Creative Skills to Achieve the Mental Zone of Flow

Analysis of data from teacher observations, rubric evaluations of students' work, and student self-reflections showed evidence of students in various stages of mastery of skills. The invention problems presented to students were challenging; in the initial invention activity related to plant adaptations, most students voiced anxiety at not being able to create an effective product. This finding is consistent with Csikszentmihalyi's theory of creative "flow" (Csikszentmihalyi, 1990). Later, during the second and third opportunities to create inventions from given materials, students felt more comfortable and expressed that the challenges aroused their desire to use their developing creative skills to meet them. Teacher coaching along with the results of scoring with a rubric can help students consider creative strategies and areas for improvement.

In the second and third invention trials, many students evidenced a mental state of flow in which they were fully immersed in the activity with energized focus and enjoyment. This enjoyment is a critical factor for motivation (Csikszentmihalyi, 1990). Previous studies on students making inventions from given materials also report the total positive involvement of elementary students in the activities (Borsay & Foss, 2016; Hussain & Carignan, 2016; Smith & Samarakoon, 2017, Webb & Rule, 2012) and adult participants (Rule et al., 2012; Rule et al., 2011).

This creative invention project allowed students to think for themselves and develop their divergent and original thinking as Couros suggested (2015). Business executives have identified creativity as a pivotal component of business success (Kern, 2010). Creative articulation skills can assist students in thinking about consumers and other audiences to produce better products and services.

Creative Articulation Skills

The creative articulation skills addressed in this project included considerations of audience viewpoint, needs, and desires; creative trait identification of products, such as originality and utility to an audience; and communication of creative product characteristics through advertising messages and peer feedback. These processes interact to result in acceptance or rejection of the creative product (Plucker, 2017). Students learned how to make their work original or divergent and relevant to a specific social group (Smith & Yang, 2004), given as a choice of two by the teacher. These articulation skills were new to the students involved in this project, and, as mentioned previously, they struggled at first, but eventually became more skilled. The finding that students in the experimental condition were significantly better able to articulate the reasons their products fit a specific audience with a medium effect size indicates the success of the intervention. Obtaining a significant difference with such a small sample and with possible carryover of experience from the experimental condition to the subsequent control condition for one group, reinforces the efficacy of the intervention.

Complexity

The incorporation of science concepts of plant and animal adaptations into the inventions was a positive way to make the inventions more meaningful while reinforcing science content. The majority of students (68%) interpreted the overall meaningfulness of their projects to be either useful for teaching animal adaptations and animal behaviors or valued for their originality and creativity, which align with the objectives that were given to the students for their projects. This rich project integrated concepts and skills from many subject areas and challenged students to think in a complex manner, an important component of curriculum (Heacox and Cash). The 21st Century Skill category of meta knowledge includes creativity, innovation, problem-solving, communication, and collaboration (Kereluik et al., 2013); the combination of these skills into a complex project allowed students to practice skills important to their future home and employment lives. Often, teachers do not implement creative invention projects because they involve pedagogical skills and experience they do not yet have. Perhaps the detailed

descriptions of the lessons in this article will help teachers gain confidence to try some new, creative invention approaches with gifted and all learners.

Conclusion

Although there were few differences between the control and experimental conditions in student products and student attitudes, likely affected by the small sample size, there were learning outcomes that were observed. Students made significant improvements in creating products from the pretest to the first trial of the experiment and maintained that improvement to the second trial of the experiment. Students found the new creative activity, with its constraints and unfamiliar given construction materials, quite challenging. At the time of the experiment, students were more experienced because they had completed the pretest product and were in a position to evidence growth in skills. After becoming more accustomed to making creative products, students found generating the product idea, building the invention, and using imagination or humor as enjoyable aspects of the project. They learned to design products that were original by incorporating unusual features or ideas peers did not generate. They successfully connected their work to the plant and animal adaptation science concepts they had been studying.

Advertisement mean scores showed a small advantage for the experimental condition but this was not statistically significantly different. A significant difference was found between conditions regarding students being able to furnish reasons that the product would appeal to the chosen audience in student advertisements with a medium effect size. This difference was predicted because the intervention focused on creative articulation and understanding the point of view of the audience. Many students evidenced their learning about creative articulation when responding to open-ended questions. Most frequently-given insights about creative articulation included the ideas that peer feedback and discussion of ideas with others helps in obtaining ideas to improve the product, knowing the wants and needs of the audience assists people in designing a product to match, and talking about ideas aids one in forming good ideas.

Implications for Practice

According to Csikszentmihalyi, activities are conducive to flow when they include the following: learning of skills, clear goals, opportunity for feedback, and offer a sense of control (Csikszentmihalyi, 1990, p.72). Although these appear to be common facets of education, and may be implied in classroom lessons, it is important to note that these four components must also be clear to the learner. For example, the skills included in the activities must fit the readiness and interest of students in order to be most meaningful. If an activity is perceived to be “too easy” or “too hard,” it is viewed as meaningless and often frustrating. An underlying factor to all of these conditions is that the student must be aware of the challenges ahead, and motivated to accept them because of the confidence in his/her own skills that will allow him/her to be successful. This motivation also contributes to the student feeling receptive to receiving and offering effective feedback, and can impact the level of students’ creative articulation.

Recommendations for Future Research

For future research, similar instruction and activities that promote creative articulation could be extended and evaluated over a longer period of time, such as an entire academic year, and with a larger student sample. Another consideration would be to not expose a control group to any of the lessons incorporated into the experimental condition, thereby reducing the potential carry over of influential ideas for the activity.

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