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Making Inventions Using SCAMPER and Animal Adaptation Ideas with Elementary Students

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ABSTRACT

The study employed repeated measures to explore the use of SCAMPER (Substitute, Combine, Adapt, Modify, Put to another use, Eliminate, and Rearrange) with or without animal adaptation ideas learned through form and function analogy activities to generate creative ideas. Twenty-four 4th graders, aged 9-10, at a suburban Midwestern elementary school were subjected to two conditions and measured under each treatment condition. In the experimental condition, students used SCAMPER charts with animal adaptation ideas to generate ideas to improve a product using limited materials; in the control condition, they used simple SCAMPER charts to improve a product with limited materials. A scoring rubric was designed to assess the utilization of the SCAMPER charts and students' inventiveness. Paired *t*-tests were done. Students' inventiveness scores showed a significant difference with a *p*-value of .003. Cohen's *d* was 0.64, a medium effect size, favoring the experimental condition. Student scores for completing the two types of SCAMPER charts favored the simpler control condition's chart. However, student products completed under the experimental condition showed more complexity and originality. Although the new technique was challenging, given the limited number of classes spread over a two-week period, the lessons promoted student engagement, creative thinking, and ability to recall content knowledge related to animal form and function.

LITERATURE REVIEW

Systematic application of SCAMPER (Eberle, 1972) to a problem promotes both creative thought process and engineering experience among students. Studies on students' use of inventive problem-solving methods, LEGO/ROBOLAB toolset in the context of engineering design, and hands-on activities related to both Eberle's (1972) SCAMPER technique and physics concepts, have all indicated development of thinking skills and heuristics and comprehension of physics, programming, and math concepts (e.g., Barak & Mesika, 2007; Rogers & Portsmore, 2004). Combination of creative techniques has been found to contribute to children's understanding of science content (e.g. Rule, Baldwin, & Schell, 2009; Rule & Rust, 2001). Because scientific problem-based activities engage elementary students in STEM content, earlier exposure for elementary students to STEM initiatives is necessary (Swift & Watkins, 2004) to motivate them to STEM careers eventually.

OBJECTIVE

- To explore how SCAMPER with animal adaptation ideas (Fig. 2) learned through form and function analogy activities (Fig. 3) can help 4th graders generate creative ideas for an innovation.

Simple SCAMPER chart		
SCAMPER operation		Applying ideas to improve:_____
S	Substitute	
C	Combine	
A	Adapt	
M	Modify, Minify, Maximize	
P	Put to other use	
E	Eliminate	
R	Reverse, reorganize	

Figure 1. Simple Blank SCAMPER Chart

SCAMPER chart with animal adaptation ideas			
SCAMPER operation		Animal Adaptation Idea	Applying ideas to improve:___
S	Substitute		
C	Combine		
A	Adapt		
M	Modify, Minify, Maximize		
P	Put to other use		
E	Eliminate		
R	Reverse, reorganize		

Figure 2. Blank SCAMPER Chart with Animal Adaptation Ideas (Adapted from Rule, 2014)

Figure 3. Form and Function analogy activities (Rule, 2015)

METHOD

Context: a suburban Midwestern elementary school; twenty-four 4th graders aged 9-10.

Research Design:

- Repeated-measures design: measured students under each treatment condition.
- Participants' use of SCAMPER chart (dependent variable) repeatedly investigated on 4 different days (independent variables). See Table 1 for experimental set-up.
- Experimental conditions: students used SCAMPER-animal idea technique (Fig. 2)
- Control conditions: students used simple SCAMPER charts (Fig. 1)
- Creativity and inventiveness were assessed using: (1) SCAMPER charts (Fig. 1 & 2) (2) Scoring rubric (3) Attitude survey (4) Field notes through class observation

Table 1. *Experimental Set-up of Lessons 3 through Lesson 6*

Lesson # and Condition	Given Product and Directions for the Invention		Bag of Materials for Making the Product
	Group A	Group B	
1. Control Condition: SCAMPER – No animal adaptation ideas	Product = Paper Plate Make a product for a camping trip	Product = Paper Cup Make a product for a camping trip	Half-sheet of colored paper, 2 pipe-cleaners, 6 Pony Beads, 2 plastic spoons
2. Experimental Condition: SCAMPER with animal adaptation ideas	Product = Paper Cup Make a product to be used during or after a tornado	Product = Paper Plate Make a product to be used during or after a tornado	Patterned wrapping paper, 2 Popsicle sticks, 1 foot of yarn, 6 dried beans
3. Experimental Condition: SCAMPER with animal adaptation ideas	Product = Cardboard tray Make a product to use at school	Product = Paper bowl Make a product to use at school	6" by 6" aluminum foil, 2 twist ties, 2 wooden sticks, 6 small pompons
4. Control Condition: SCAMPER – No animal adaptation ideas	Product = Paper bowl Make a product to be used at a lake or pond	Product = Cardboard tray Make a product to be used at a lake or pond	6" by 6" fabric, 2 straws, 1 foot curling ribbon, 6 sequins

STANDARDS ADDRESSED BY THE LESSON ACTIVITIES

Lessons focused on engineering design that involved innovation, improvement, and problem solving. The following Standards were addressed:

- Next Generation Science Standard (NGSS) 3-5-ETS1-1 for Engineering Design (Achieve Inc., 2013, p. 46) for 4th graders
- National Core Arts Standards for 4th graders: Visual Arts: Creating 2.1.4a; Visual Arts: Creating 1.1.4a; Visual Arts: Creating 1.2.4a; Visual Arts: Creating 2.2.4a; Visual Arts: Creating 3.1.4a
- Standards for Technological Literacy (2000): STLS9 & STLS11 for grades 3-5
- Common Core State Standards for Mathematics (CCSS: M) (2010) emphasizing process standards

Lesson Procedures:

- With a constructivist learning approach, 5 E instructional model that included engagement, exploration, explanation, expansion, and evaluation (Bybee et al., 2006) was used.
- Lessons 1 and 2: engagement, exploration, and explanation phases introducing simple SCAMPER technique and then combining it with animal adaptation ideas.
- Lessons 3, 4, 5 & 6: elaboration and evaluation phases requiring students to adapt new knowledge and build and design using products and limited materials they were given .

DATA ANALYSIS AND RESULTS

Data analysis: using spreadsheet; spreadsheet functions provided calculation tools for means, standard deviations, paired *t*-tests, and Cohen's *d* effect sizes).

Results: Students' inventiveness scores showed statistically significant difference with a *p*-value of .003; resulting Cohen's *d* was 0.64, a medium effect size, favoring the experimental condition.

- Student scores for completing two types of SCAMPER charts favored simpler condition. Student products completed under experimental condition showed more complexity and originality.
- Application of SCAMPER-animal-idea technique lead to production of a variety of inventions. Figure 4 shows inventions produced under control conditions and experimental conditions by three different students. Table 2 shows the list of student-made inventions from the study.

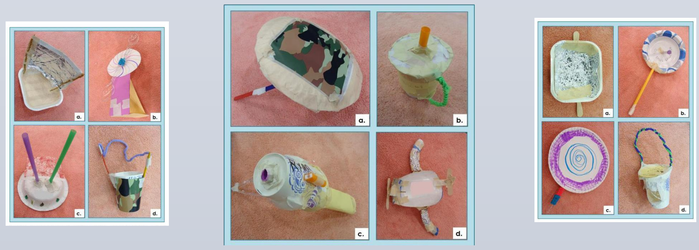

Figure 4. Inventions produced in Control conditions (a & c) and Experimental conditions (b & d).

Table 2. *List of Student-Made Inventions*

Inventions created in the control condition	Inventions created in the experimental condition
Food transporter, fire work box, houseboat, storm siren, dog's bed, lunchbox, quick hat, crayon box, tray, multi-holder, Lanie's pencil holder, and fishing-pole, breathing blowhole, googley eye holder, shooting game	oil spill collector, bug catcher 3000, killer, fun fan, rain protector, ball basket launcher, multi holder, solar panel, butterfly basket, DIY fan, reflector boat, danger detector, canopy boat, breather, soup finder, and amazing underwater piece, and shield sword, sand breather, filter express, plane bed

Student attitudes Concerning SCAMPER technique

Table 3 presents a summary of student responses to why chart was/ was not helpful.

- Students' recognition of its value in facilitating their creative thinking: "It helped me think of ideas," "It made me think of a lot of ideas," "Because I stopped and looked at it and made my idea."
- Students' impression of complex nature of the combined process : "It was hard to come up with stuff," "I tried to use it."

Table 3. *Reasons for Why the SCAMPER Chart was or was not Helpful in Generating Ideas for Invention*

Student Reason Given	Frequency	
	Control Condition	Experimental Condition
The chart guided my decisions and process	11	4
The chart helped me think of ideas	8	12
Difficult to generate ideas to fill out chart	6	10
I didn't really use the chart	6	6
Limited usefulness	4	2
SCAMPER Chart was confusing	4	5
Thinking about the animals helped me.	1	1

RESULTS

Table 4 provides a summary of students' reasons for enjoying/ not enjoying SCAMPER chart.

- Found creative technique difficult: students' level of enjoyment impacted.
- Showed resistance to writing when using SCAMPER-animal-idea technique.
- Expressed discomfort having to "write so much" and not enjoying it all as it required effort.
- Expressed enjoyment if found helpful: "It helped me think what I should add or eliminate." The enjoyment was simply because it was "fun".

Table 4. Reasons for Enjoying or not Enjoying Using the SCAMPER Chart

	Frequency	
	Control Condition	Experimental condition
Enjoyable when it helped generate ideas	12	9
Not enjoyable at all	11	12
Difficult to understand	6	1
Felt comfortable	4	7
Fun to use	4	7
I enjoyed it but didn't love it	2	0
Enjoyed the independence of doing it by self	1	0
Not enjoyable to write so much	1	5
The chart gets in the way	1	0

Table 5 provides a summary of students' explanations for how much they felt the animal form and function ideas helped with the invention.

- Found process of thinking of ideas related to an animal 'challenging'.
- Expressed animal form and function ideas to be helpful in thinking from different perspectives: "Because of the animals, it made me think in different ways".

Table 5. Reasons for rating how much animal form and function ideas helped with invention during the experimental condition

Student Reason	Frequency
Animal form and function ideas were helpful	13
Challenging to think of ideas that go with an animal	5
Animal form and function was a new perspective that helped with ideas	5
The technique isn't helpful	5
Fun to think of the invention like an animal	3
Helped to learn about new animals	3
Don't like writing ideas on paper	2

DISCUSSION AND CONCLUSION

- Participants attained growth with a medium effect size in inventive abilities which was consistent with prior invention studies that showed improved inventiveness when students used creative techniques (e.g., Barak & Mesika, 2007; Rule, Baldwin, & Schell, 2009; Wongkraso, Sitti, & Piyakun, 2015).
- Findings support Rule and colleagues' (2009) findings in a study conducted on 2nd graders taught using SCAMPER-animal-idea analogy. There was a higher mean score during the experimental (24.8) as opposed to control condition (22.8) in the present study just like the previous study.
- Findings revealed elementary students to be open to challenges; the new techniques rather than familiar traditional approaches better supported idea generation.
- Challenge is a desirable component for fostering creative thinking, inventive skills, and engineering skills. Experience and exposure were important for students to confront that challenge.
- Students should be allowed adequate time to explore the SCAMPER-animal-idea technique so that time constraints do not result in cognitive overload.

LIMITATIONS

- Children inadequately equipped with engineering skills; require skill development from young age.
- Technique involves provocation and remote analogies; demands more skills to create new ideas
- Classroom preparation requires extra time.

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SCAMPER Lessons

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