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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® ROM® block, 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 comprehensiveness of physics, programming, and math concepts (e.g., Barak & Mesika, 2007; Rogers & Parmenton, 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 invention.

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)

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 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): STL59 & STL511 for grades 3-5

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 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 control condition. Student products completed under experimental condition showed more complexity and originality.
- A combination 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.

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, Siti, & Piyakan, 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). Findings revealed elementary students to be open to challenges, the new techniques rather than familiar traditional approaches better supported idea generation.
- Challenges 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 provokes innovation and remote analogies; demands more skills to create new ideas.
- Classroom preparation requires extra time.

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REFERENCES

Haugaasen, A. T., Thulstrup, B. M., & Stromnes, S. (1997). Systematic application 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. Mahjabeen Hussain & Anastasia Carignan University of Northern Iowa

Table 4 provides a summary of students’ reasons for enjoying/ not enjoying SCAMPER chart.
- Created a technique difficult: students’ level of enjoyment impacted.
- Showed resistance to writing when using SCAMPER-animal-idea technique.
- Experienced discomfort having to “write so much” and not enjoying it all as it required effort.
- Enjoyed the process if found helpful: “It helped me think what I should add or eliminate.” The enjoyment was simply because it was “fun.”

Table 5 provides a summary of students’ explanations for how much they felt the animal form and function ideas helped with the invention during the experimental condition.
- Found process of thinking of ideas related to an animal ‘challenging’. "Because of the animals, it made me think in different ways”.
- Experienced 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 4. Reasons for Enjoying or not Enjoying Using the SCAMPER Chart

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

Figure 1. Simple Blank SCAMPER Chart

Figure 2. Blank SCAMPER Chart with Animal Adaptation Ideas (Adapted from Rule, 2016)

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

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

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 the 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.”

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

Table 2. List of Student-Made Inventions

Table 1. Frequency of students completing SCAMPER charts (Fig. 1 & 2)

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