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Features of Creativity that Improve Student Science Learning

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ABSTRACT

Creativity can be described in ways that improve school science. A year-long workshop series offered designs to illustrate changes in teaching used for improving student learning. A research panel was formed to observe changes in the use and understanding of creativity by students in classrooms taught by teachers participating in year-long workshops designed for that purpose. Comparisons included observations at the beginning of the school year (October) and again near the close of the year (April) to indicate student learning involving the use and understanding of six facets of creativity. The focus was on middle school teachers and students. Results with teachers were statistically positive.

Keywords: Doing Science; Creativity; Use and Understanding

Creativity skills are recognized by many as examples of “doing” science. For this study the six features of creativity used were described in the publication *Assessing Student Understanding of Science* (Enger & Yager, 2001, p. 9). The six features also include an example of what the researchers used to identify creativity. These features illustrate how creativity is related to school science.

Divergent thinking (thought processes used to illustrate new student ideas from learning)

Open-ended questioning (often starts with “why” or “how”, or even “tell me about...”)

Generation of unusual ideas (the ability to imagine non-existent information or scenarios before they exist)

Generation of metaphors (a figure of speech that identifies something as being the same as some unrelated thing for some rhetorical effect such as “all the world is a stage”)

Solving problems and puzzles (start with known facts and add to them)

Designing devices and machine (involves combining new ideas for improving or developing new devices and machines)

Creativity in classrooms requires an openness where students can experience science via new ways where their ideas are accepted as indicators of learning. Creativity is generally experienced by students who have imaginative minds capable of seeking explanations for objects and events they encounter. These are often completely missing in traditional science classrooms.

Science has been defined by the National Science Teachers Association (NSTA) as ways that require students to be involved in the *human exploration of the natural world, as they seek explanations of the objects and events encountered, and then providing evidence to support their explanations* (NSTA Handbook, 2015-16, p. 228). This definition illustrates “why” and “how” creativity and science are related.

Many are anxious to improve science teaching and to improve student learning. These are enforced by ten features provided by both the National Science Education Standards (NSES) (1996) and the Next Generation Science Standards (NGSS) (2013). The ten are: 1) Working with students concerning their interests and ideas; 2) Encouraging students to work on questions and debates in teams of two to four; 3) Focusing on student questions with activities that are local, current, and personal; 4) Understanding and responding to individual student interests and needs; 5) Focusing on student understanding and use of ideas and inquiries; 6) Extending science efforts beyond classrooms and a prescribed curriculum; 7) Providing specific opportunities for discussions and debates among students; 8) Sharing responsibilities for student learning outside the school; 9) Supporting classroom study with cooperation and respect; and 10) Working with other teachers to improve the whole school instructional program. These ten features are used to define science in new ways and to encourage the use of creativity in classrooms.

The features of many funded National Science Foundation (NSF) workshops involve a full year-long series which have been successful for decades. They often begin with three-week summer workshops held in June and July. In Iowa, the workshops are held at Area Education Agencies (AEA) locations around the state. For this study the AEA regional organizations are dedicated to improving student learning in schools in their region. Therefore, AEA involvement is needed for the success of the initial summer workshops. They recruite teachers willing to participate for a full year to change science teaching and to improve student learning. Teachers are encouraged to work with students involving **their own** interests and ideas by using the NSES and NGSS reform efforts as well as the new Science, Technology, Engineering and Mathematics (STEM) efforts which go beyond science disciplines.

Creativity in classrooms is part of the Science, Technology, Engineering, and Mathematics (STEM) efforts to reform teaching. This is possible due to two of the creativity aspects: *Solving problems and puzzles* as well as *Designing devices and machines,* which relate to technology, mathematics, and certainly engineering, in addition to science per se.

For this study three day informal meetings (typically called Short Courses) were also held during the school year. They followed the June/July three week workshops involving only the teachers who participated during the summer. The time for these meetings was arranged during the summer by the participating teachers. Meetings are usually held after

school, in the evenings, or on Saturdays soon after the opening of the school year (October) and the second one before the close of the school year (April). The purpose of these meetings is to identify and discuss specific successes or failures concerning the reform efforts from plans developed during the summer workshops. Some of the most successful teachers from past workshops are invited to attend these meetings (Short Courses) and to offer further suggestions concerning their personal experiences with earlier efforts.

The final event of the year-long series is typically a celebration luncheon on Saturdays or Sundays at the end of the year to showcase exciting teacher and student accomplishments for other teachers, parents, and community leaders. Local media are invited to publicize examples of student learning.

Involved in this study was a six person evaluation panel formed at the end of the summer workshops to observe and interview teachers and students to indicate successful student learning at the two locations in one Area Education Agency during the year. This panel observed middle school teachers and students at the two sites in October and again in the spring (April). The evaluation panel consisted of an Area Education Agency consultant, the University project director, two of the most successful teachers from the most successful previous workshops, and two PhD students. The observations included both teachers and students to indicate the changes in their use and understanding of the six features of creativity over the academic year. The observations were collected during one week in mid-October (soon after the opening of school) and one week in mid-April (near the end of the school year) to provide the results for this research. The panel was interested in determining if students taught by teachers who participated in summer workshops were more successful with using and understanding creativity over the period of one school year.

Middle grade levels (5-8) were selected for this research since they have science every day, unlike in elementary grades where science teaching is only one of several classes taught by the teacher during the day. High school was also not considered for this research because science is identified by specific disciplines which include biology, chemistry and physics where most aspire to college preparation (not for all students).

Research Question

The following research question indicates specific results for this study.

- **How often are each of the six features of creativity used by middle school science students when taught by teachers who participated in NSF summer workshops at two locations in one Area Education Agency?**

The teachers who participated in the summer workshops were encouraged to try new reform efforts for a full academic year. The evaluation panel focused on the use and understanding of creativity by students in science classes taught by teachers who participated in summer workshops. The workshops encouraged use of reform efforts designed to change typical teaching.

The observations recorded by the evaluation panel were collected in October and again in April. Since the new teaching efforts had only been introduced for a few weeks in October, the use and understanding of creativity was much less than the observations noted in April near the end of the school year.

It was also noted that students were not taught as a whole class group, which is typical of most classrooms. Instead, students were divided into small groups (usually three to five in number) as determined by their interests in solving specific problems. The only time the classes were directed as a whole was to make announcements that were relevant for all students or to encourage groups to use and understand what others were doing.

Procedures

Observations for this study involved only the middle school level teachers and their students. The students worked on specific projects they defined to utilize the use of the six creativity features. Observations were also recorded as students talked among themselves outside regular classrooms, i.e., after school or during the lunch hour. They worked on projects that were personal, local, and current issues involving the whole community. Students were encouraged to ask questions and to discuss and debate among themselves. They often used outside resources to help deal with their problems. They were encouraged to consider the thoughts and ideas of others.

The observations at two locations in a single AEA location involved the same observation panel and the same six features of creativity. The number of students in classrooms differed in size but included no more than twenty students. The students at Location One were 181, while Location Two involved 162 students.

Results

Figures 1 and 2 illustrate the number of times the observation panel viewed students using and understanding the six features of creativity at two locations in one Area Education Agency. Members of the observation panel observed small groups of science students working on different problems in their classrooms. They also asked questions to help understand which of the six features of creativity the students felt they were using.

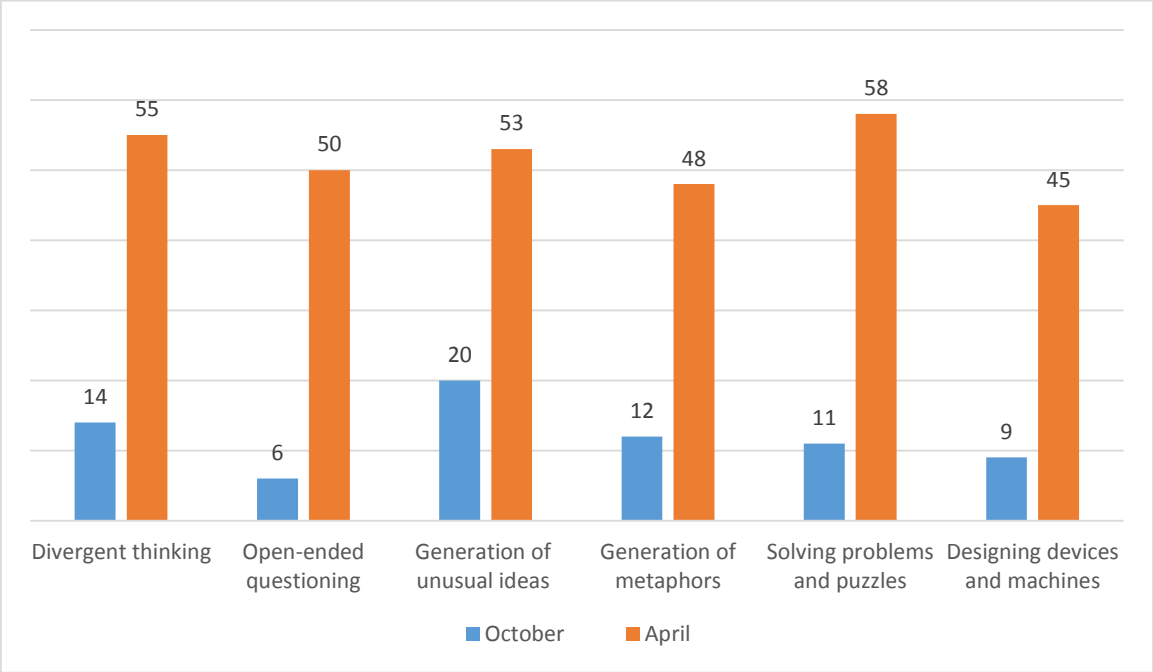

Figure 1: Comparisons of Use of Six Features of Creativity by Students during the Academic Year at Location One

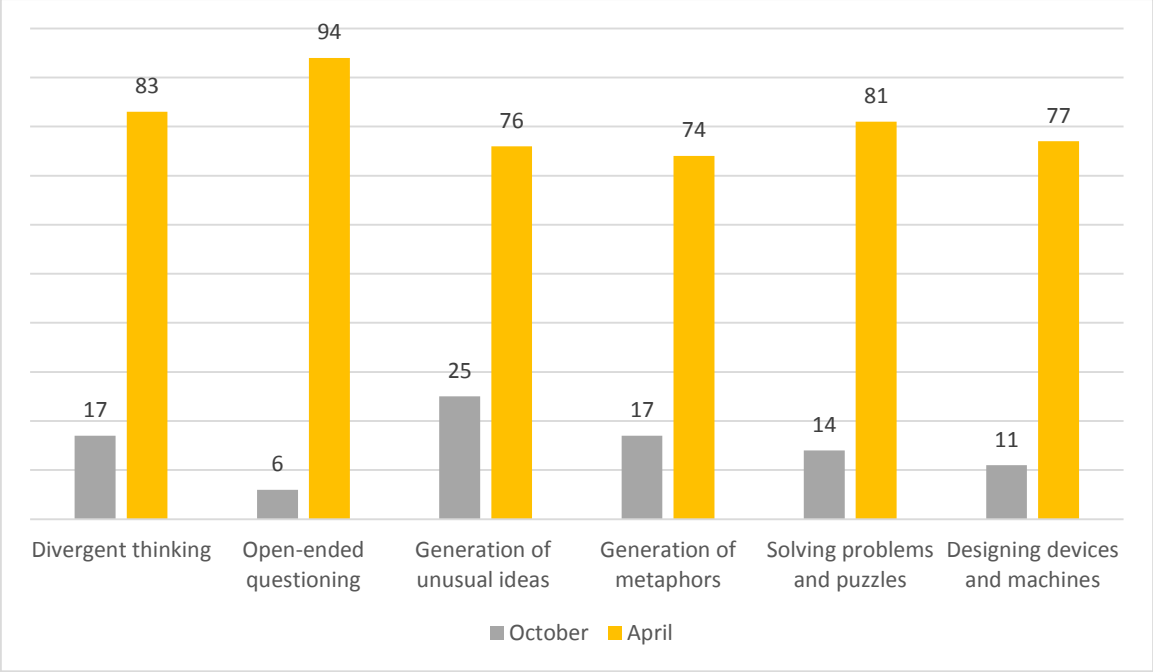

Figure 2: Comparisons of the Use of Six Features of Creativity by Students during the Academic Year at Location Two

As shown in Figures 1 and 2 all six features of creativity significantly increased at both locations over the academic year, indicating new teaching efforts can improve student learning. Creativity in the classroom allows students to become more curious about the natural world and encourages them to find new ways of exploring it. Students see science as a way of dealing with problems and how they can become more involved in their own learning.

The results indicate that use of **Open-ended questioning** increased in use nearly eight times between October and April at Location One and nearly sixteen times at Location Two. This indicates more usage of “asking questions” which start with “Why”, “How” and “What” as a way to encourage discussions, brainstorm to solve problems, and create opportunities for thinking outside the box. It engages students in thinking and learning, where students must synthesize information, analyze ideas, and draw their own conclusions.

Generation of unusual ideas increased nearly three times over the same time period at Location One and just over three times at Location Two. This indicates that teachers introduced activities that encouraged the students to generate numerous solutions to problems. They used the previously acquired knowledge, simple ideas, and new information to transform information into something that could apply to new situations or problems. During classes, students generated a multitude of ideas that were unique and unusual, yet practical and useful for solving problems, learning new content, and developing new products. The process of idea generation is supported by students exhibiting skills such as new ideas, originality of thought, and flexibility in thinking.

The results indicate **Divergent thinking** and **Generation of metaphors** increased in usage by students around four times more from mid-October to mid-April at Location One. These same features increased five and four times respectively at Location Two. This is an indication that students used divergent thinking to generate many different ideas about a creativity feature over the academic year. Divergent thinking involves breaking a creativity feature down into its various component parts in order to gain insight about the various aspects of the topic. It encourages coming up with multiple solutions to a single problem and coming up with new and valuable ideas. Students were also able to use generation of

metaphors, as a source concept, to understand that which is unfamiliar considerably more at the end of the school year.

The use and understanding of **Designing devices and machines** and **Solving problems and puzzles** increased four and five times respectively between October and April at Location One. These two features increased seven and six times at Location Two over the same period of time. Students used their new understanding for using simple machines to design and build their own machines to perform simple tasks as a part of STEM efforts. They also used creativity to define new and innovative ways for completing difficult tasks involving the building of new machines. Students applied their scientific and engineering understanding to solve problems and to test possible solutions for carrying out investigations. They applied their new creativity skills to analyze data by using mathematics and technology as part of their STEM efforts.

These results indicate an increase of student ability to use and understand the six features of creativity for actually "Doing" science. Specifically, this means the more the teachers use and apply creativity in their classrooms the more their students increase their abilities to generate using and understanding creativity features in their personal lives. Therefore, engaging teachers in summer workshops and follow-up meetings is an indication that more needed changes in teaching can be defined as enhancement of learning.

Overall, the results suggest that the two three week summer workshops followed by the informal meetings (Short Courses) involving teachers from the summer workshops provided more generation of creative features with students. This then encouraged increased depth of student use and understanding of creativity skills. These skills encourage students to actually do science instead of merely reading about what others have done in the past.

Implications

The actual "Doing" of science does not come from textbooks but from students doing activities in classrooms and using their skills in their everyday lives. The professional development programs not only invite changes in teaching, but more than that, they encourage it. They encourage students to find solutions to solve problems, encourage students to work in teams, as well as providing opportunities for students to discuss and debate with others as they work together to solve problems. "Doing science" is more of a hands-on/minds-on way for students to learn from their mistakes. As a result, students become more active participants in their own investigations and more involved with their own learning. Creativity allows students to reach their own conclusions that include trials and errors!

This study is consistent with other research dealing with changes in science teaching and student learning (Hacieminoglu, Ali, Yager, Oztas, & Oztas, 2015; Ali, Hacieminoglu, Yager, & Caliskan, 2013). Torrance (1981) has reported his work dealing with creativity indicates that students prefer to learn in creative ways by exploring, questioning, experimenting, and testing their own ideas. Torrance also reported that creative learning improves motivation, alertness, curiosity, concentration, and student achievement. Other research by Wilson & Livingston (1996) has reported that students can direct their own learning to situations that are meaningful, relevant, and developmentally appropriate for them. They generally enjoy questioning and using ideas creatively.

Other researchers have reported that students enjoy science when they become active participants, have opportunities to generate their own questions, and deal with real-world problems. Consequently, interest and motivation to study science increases as creativity skills are developed. Erez (2004) has argued that freedom is a necessary condition

for developing creativity skills. He pointed out that "a student who does not act in an atmosphere of freedom will never express a new idea or ask questions in ways never asked before".

Conclusion

The results of this study indicate major increases in the use of six features of creativity over one academic year at two separate locations in one Area Education Agency. Students are more creative when they extend what they experience in their classrooms involving situations outside the classroom. Results of this study indicate strongly that professional development programs designed to change teaching also improve student learning. Teachers encourage students to use different strategies by getting them more involved in their use and understanding of creativity. Creativity is one of the "enabling domains" which helps science teachers accomplish reform efforts (McCormack & Yager, 1989). Such teaching reforms should be encouraged in all classrooms, *not just science!*

Students excel in illustrating and improving their creativity skills when encouraged to "do" science rather than merely reading about science and what others have accomplished. Students report that creativity also affects their daily lives for solving problems as well as motivating them in other studies. Geraldine Richmond (2016), current President of AAAS, stated in a recent editorial in *Science* that we must continue to encourage diversity in opinions, ideas, and experiences to fuel creativity and innovative thinking. This research effort verifies that creativity becomes a more personal learning experience for both teachers and students. We need to expand use of creativity in other ways with other teachers, especially for early elementary and high school students in addition to middle school, which was central to this research!

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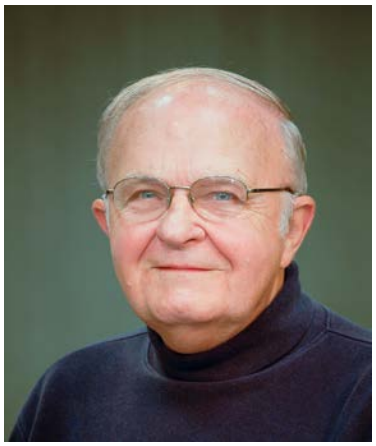

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