AC 2010-1476: THE IMPACT OF ACTIVE LEARNING DURING OUT-OF-SCHOOL TIME (OST) ENERGY CLUBS ON ELEMENTARY SCHOOL STUDENTS

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The Impact of Active Learning during Out-of-School Time (OST) Energy Clubs on Elementary School Students

Abstract

Active learning during out-of-school time Energy Clubs, can positively affect students in grades 3-5 by improving their understanding of technology, what engineers do, the engineering design process, and how to improve a windmill. RAMP-UP assessed the impact through a pre- and posttest from the Engineering is Elementary workbook, "Catching the Wind."[2] After completing one activity where the students built windmills out of milk cartons, there were positive improvements in their understanding of technology, what engineers do and the engineering design process ranging from 3% to 8%. Significant gains ($p < 0.05$) were made in understanding how to improve a windmill where all the clubs had double-digit growth with an overall improvement of 26%.

RAMP-UP is a GE Foundation and National Science Foundation funded GK-12 Outreach Program at North Carolina State University and has established Energy Clubs at two, local, inner-city elementary schools for the 2009-2010 school years. A RAMP-UP Graduate Fellow with assistance from RAMP-UP Undergraduate Fellows and Teachers facilitates the Energy Clubs. These clubs provide an opportunity for students in grades 3-5 to meet outside of regularly scheduled class time to learn about renewable energy, water purification, energy conservation and recycling. The facilitator utilizes a combination of original activities and Engineering is Elementary activities during the fall semester. The spring semester is spent designing and building solar cars in preparation for the Junior Solar Sprint held on campus in May.

Introduction

In January of 2007, RAMP-UP, a GE Foundation and National Science Foundation funded GK-12 Outreach Program at North Carolina State University began its first Energy Club at one elementary school. Due to the demand to learn more about renewable energy, RAMP-UP increased the number of Energy Clubs to one club at three different elementary schools by the 2008-2009 academic year. For the 2009-2010 academic year, the program installed two clubs, one for fifth graders and one for third and fourth graders combined, at two elementary schools. These clubs are unique for this age group and were created through the collaboration between the RAMP-UP Graduate Fellow and a third grade RAMP-UP teacher.

The focus of the club is to use hands-on activities to teach math, science and engineering concepts related to renewable energy. This is in line with Dr. John Dewey, one of the founders of pragmatism in education who believed that learning was active and that math could be learned through everyday activities such as cooking.[1] Building upon this concept, RAMP-UP has created original activities that anyone could recreate in their home to help teach math. For example, one of RAMP-UP's most popular activities is the "Marshmallows and Toothpicks Activity" where students build two-dimensional and three-dimensional geometric shapes using marshmallows and toothpicks.

Following a pragmatist approach, it is believed that active learning is a fun and feasible teaching style that replaces words with activities as the means of communicating new concepts. RAMP-UP creates opportunities for active learning through many out of classroom learning experiences such as math clubs, Energy Clubs, tutoring, FAME (Fun Applications in Math and Engineering) and assistance with science fair projects.

This paper is an attempt to show how active learning, through RAMP-UP's Energy Clubs, impacts third, fourth and fifth grade students and their understanding of technology, what engineers do, the engineering design process and how to improve a windmill. We will assess the impact of active learning in Energy Clubs by comparing their growth through a pre- and posttest.

Definitions

For the purpose of this paper, any use of the word "student" refers to a child in grades 3-5, any use of the word "Fellow" refers to an undergraduate or graduate student from the university, and any use of the word "teacher" refers to a teacher in a Wake County public school.

RAMP-UP Fellows work in the primary schools when the university semester is in session, which results in a 12-13 week presence in the schools. The program has had a presence in three, inner-city elementary schools and one middle school for the past five years and continues today. This paper focuses on our assistance in two of the elementary schools hereafter referred to as elementary school 1 (ES1) and elementary school 2 (ES2).

The Energy Club

Energy Clubs provide an opportunity for students in grades 3-5 to meet outside of regularly scheduled class time to learn about renewable energy, water purification, energy conservation and recycling. The Graduate Fellow utilizes a combination of original activities and activities developed by the Engineering is Elementary team of the Boston Museum of Science [2] to teach math, science and engineering concepts.

Since its conception, the program has increased the number of Energy Clubs from one club at one school the first year to one club at two schools in the second year and to one club at three schools in the third year. Each club consisted of an even mix of third, fourth and fifth graders. We found that there was a large gap in ability between third and fifth graders and therefore decided to create two separate clubs the fourth year: one for fifth graders and one for third and fourth graders combined. We planned to have two clubs at all three schools during the 2009-2010 academic year. However, due to time constraints, we had to postpone the start of the energy clubs at one of the elementary schools until the spring semester. Therefore, this report will only contain data from four clubs at two schools.

The students are recruited through letters taken home to the parents and returned to the teacher coordinator as soon as possible. Students are accepted on a first come, first serve basis into Energy Club. At one of the elementary schools, over 100 letters were returned within two days and only the first eighteen accepted into the 5th grade club and fifteen in the 3rd and 4th grade club. A similar recruiting process was done at the other elementary school, which resulted in seven students in the 5th grade club and fifteen in the 3rd and 4th grade club.

Because of the demand, Energy Club is considered a privilege and attendance is mandatory. Energy Clubs meet weekly for an hour either before school or after school. The students maintain a journal that contains their ideas, designs, data and material learned.

Experiment

All four clubs were given a pretest at the first meeting. The assessment at the back of the Engineering is Elementary workbook; "Catching the Wind" was used as the pretest. The students were sufficiently spaced to avoid cheating and the test took approximately 30 minutes.

At the second meeting, the students were introduced to the engineering design process (as described in the Engineering is Elementary workbook) and wrote it in their journal. The Graduate Fellow then showed them a prototype of a windmill made from a milk carton, dowel, foam, Popsicle sticks and index cards and explained the goal which was to see how quickly they could raise the "bucket" (a Dixie cup) off the floor to the height of the dowel. The students worked individually or in groups of two or three to ask, imagine, and plan (the first three steps of the design process) their windmill. The latter two steps involved drawing their design ideas in their journal and working together to decide which design to build. Once they had sufficiently performed the first three steps of the design process, they were allowed to proceed to the last two steps of the design process which were to create and improve.

They spent the next three to four weeks building the windmills, testing them and improving their speed. The number, shape and size of the blades evolved over time. All the teams went through each step of the design process numerous times. One of the first teams to successfully raise the bucket did so on their thirteenth try. At the end of four weeks, the fastest time recorded was 2.88 seconds by a fourth grader. Surprisingly, no one tired of trying to improve the windmill each week in order to beat the fastest time. At the last meeting, the students were given the posttest, which was the same as the pretest.

Data

The sample size consists of twelve 5th graders and thirteen 3rd and 4th graders from ES1 in addition to six 5th graders and twelve 3rd and 4th graders from ES2. Table 1 lists the average score for each Energy Club on the first two questions of the assessment. The

maximum possible score on both problems is sixteen. For the first question, "What is Technology?" the students were presented with pictures of sixteen objects and they had to circle the ones which they thought were technology. The second question, "What do Engineers do?" consisted of pictures of sixteen actions and they had to circle the ones showing the work that engineers do.

Table 1: What is technology? What do engineers do?

	What is Technology?		What do Engineers do?	
	Pre	Post	Pre	Post
ES1 5th Grade	10	10	7	8
ES2 5th Grade	10	11	8	9
ES1 3rd and 4th Grade	9	9	8	7
ES2 3rd and 4th Grade	9	9	6	7

There were five multiple-choice questions that assessed their knowledge of the design process. Each question was marked as either correct or incorrect. Table 2 shows the percentage of the class getting each multiple-choice question correct.

Table 2: Knowledge of the engineering design process

	Pre					Post				
Question #	1	2	3	4	5	1	2	3	4	5
ES1 5th Grade	33%	100%	42%	25%	75%	83%	92%	58%	58%	92%
ES2 5th Grade	100%	83%	67%	50%	83%	50%	83%	33%	50%	100%
ES1 3rd and 4th Grade	54%	62%	77%	69%	77%	62%	92%	62%	46%	85%
ES2 3rd and 4th Grade	42%	100%	33%	42%	67%	58%	92%	33%	42%	58%

Table 3 shows the results when asked how to improve your windmill. The maximum possible score is 4

Table 3: How to improve your windmill

	Pre	Post
ES1 5th Grade	2.25	2.92
ES2 5th Grade	2.33	3.00
ES1 3rd and 4th Grade	2.23	2.62
ES2 3rd and 4th Grade	2.33	3.00

Analysis

The percent changes from the pretest to the posttest are presented in Tables 4-6.

Table 4: What is technology? What do engineers do?

	What is technology?	What do engineers do?
	% Change	% Change
ES1 5th Grade	0	14
ES2 5th Grade	10	13
ES1 3rd and 4th Grade	0	-13
ES2 3rd and 4th Grade	0	17
Average Overall Change	3	8

Table 5: Knowledge of the engineering design process

	% Improvement per class
ES1 5th Grade	39
ES2 5th Grade	-17
ES1 3rd and 4th Grade	2
ES2 3rd and 4th Grade	0
Average Overall Change	6

Table 6: How to improve your windmill.

	% Change
ES1 5th Grade	30
ES2 5th Grade	29
ES1 3rd and 4th Grade	17
ES2 3rd and 4th Grade	29
Average Overall Change	26

A statistical analysis was performed on the data. The pre- and posttest scores were compared for the individual students giving a total sample size of 43. The results of the paired t-test analysis are listed in Table 7.

Table 7: Paired t-test analysis (N=43)

Question	Test	Mean	SE Mean	t	df	p
What is technology?	Pre	9.51	0.33	0.844	42	0.404
	Post	9.30	0.28			
What do engineers do?	Pre	7.28	0.36	-1.172	42	0.248
	Post	7.70	0.43			
Engineering design process	Pre	3.12	0.20	-1.044	42	0.303
	Post	3.35	0.20			
How to improve your windmill.	Pre	2.28	0.14	-3.411	42	0.001
	Post	2.86	0.13			

Of the four questions, only "How to improve your windmill" had statistically significant gains from the pretest ($M = 2.28$, $SE = 0.14$), to the posttest ($M = 2.86$, $SE = 0.13$, $t(42) = -3.411$, $p < .05$).

Conclusions

Overall, there were positive improvements in their understanding of technology, what engineers do, the engineering design process and how to improve their windmill just from having performed one activity over a period of several weeks. Their understanding of technology improved by 3%, what an engineer does by 8% and the engineering design process by 6%. Unfortunately, none of these three improvements were statistically significant. However, there were significant gains ($p < 0.05$) in understanding how to improve a windmill. All the groups had double-digit growth with an overall improvement of 26%. With a $p < 0.05$, there is a significant difference between the means of the pre- and posttests and one can conclude that active learning during out-of-school time Energy Clubs, can positively affect students in grades 3-5 by improving their ability to improve a windmill.

It is promising to see such positive results based on performing one activity. One can see that active learning during out-of-school time Energy Clubs, can positively affect students in grades 3-5. In the future, the students will be building a solar car for the junior solar sprint. This activity will take several months and we will assess their growth by giving the same pre- and post-test at the end of this activity.

References and Footnotes

[1] Neill, J. (2005). *John Dewey: Philosophy of Education.* Retrieved Jan. 5, 2010, from Outdoor Education Research & Evaluation Center, New Hampshire. Web site: http://wilderdom.com/experiential/JohnDeweyPhilosophyEducation.html.

[2] Cunningham, C. M. (2010). *Engineering Is Elementary.* Retrieved Jan. 5, 2010, from Engineering is Elementary, Boston, MA. Web site: http://www.mos.org/eie/index.php.