

Use of Cliffhanger Contests in Teaching Creative Math Problem Solving

Introduction

Creative problem solving skills that are needed to solve unfamiliar problems are an essential part of standards for K-12 mathematics education developed by National Council of Teachers Of Mathematics (NCTM). (NCTM, 2000) One can think of a continuum from "learning" to "problem solving" to "creative problem solving." Learning is students' ability to show that they have mastered the material that they have been taught by using it in a similar context. "Transfer of learning" is demonstrated when the new situation differs somewhat from the original one. If the transfer situation is significantly different from the original, then they are challenged with problem solving. Creative problem solving is at the extreme of the continuum where the situation is so different that what has been learned has to be applied to a completely new context. It involves analysis of problems before attempting a solution using a wide variety of strategies such as finding patterns, guessing and checking, solving a simpler problem, experimenting and logical reasoning.

Mathematical problem solving that is done during scientific research on hard problems is a very important application of this creative problem solving process. It is an excellent real life example of the problem solving skills that students learn in the context of simplified problems as students readily appreciate the importance of products of scientific research. Thus, scientists serve as good role models as creative problem solvers.

Two major challenges in teaching problem solving skills in K-12 classes are lack of strong interest in school learning activities and lack of appreciation of the importance of effort in achieving mastery of these skills. The difference between the performance of top performing students and average students in schools is primarily due to disparity in academic motivation. The average student does not find learning activities in school to be very interesting. (Yazzie-Mintz, 2009) Furthermore, many students believe that mastery of problem solving skills depends much more on native intelligence than on effort put in studies. (Tobias, 1992)

Cliffhanger Competitions

In this paper, we discuss a learning experiment aimed at making the learning experience more enjoyable for children and helping them appreciate the importance

of working hard in studies. The experiment was carried out as a part of a class on creative problem solving that was taught to twenty-six students who were in the fifth, sixth and seventh grade in school. The class was taught as one-hour sessions on Sundays for thirty-two weeks. Classes prepared students to participate in a series of contests among teams consisting of 4 to 6 students. Cliffhanger competitions as described below were conducted as a part of class activities.

Scores on previous tests with similar problems were used as a predictor of performance of team members in the planned contest. Using these predictions, teams were created in such a way that all teams were expected to get about the same scores. This created a competition where a little extra effort by any team member had the potential of making a difference in the result of which team wins the contest. Secondly, problems used varied in difficulty so that there were some problems at an appropriate level of difficulty for each team member. Thus, there were problems that each team member had a reasonable chance of being able to solve. Finally, total team scores were updated after each question was corrected according to a scoring rubric. If three team members answered a question correctly, then the scoring rubric assigned the team three points. Updating the scores after each question resulted in frequent updating of team scores and made the contest very interesting to the students.

Table 1 below shows the scores of three teams at the end of each of five rounds of questions. As these teams were very close in skill level, the scores of the teams remained very close to each other. Team C led after first and second rounds, but Team B became the leader after the third round. Teams A and B were tied after the fourth round. At this point, team scores were very close to each other and any team could have won. After the last question, Team B won. Suspense about who would win in a close contest created lot of excitement similar to the excitement experienced by an audience watching a basketball game on TV where game scores are close. As the team scores were close to each other, individual team members, including those who were the least skilled, were motivated to try their best.

Question	Team A	Team B	Team C
1	3	4	5
2	8	8	9
3	9	10	9
4	11	11	10
5	21	24	22

Table 1. An Example of Scores In A Cliffhanger Competition

To assess how the students perceived these contests, a survey was carried out with all twenty-six students in the class who were asked to rate the perceived level of fun of various activities listed in column 1 of Table 1 on a scale of 1 to 10. The second column in the table below shows the average fun ratings of the different activities.

The third column shows p-values for T-test comparison of the fun rating of a particular activity with the fun rating of the Cliffhanger Contest.

The school math got an average rating of 2. This is consistent with the view that school math does not interest the average child. A contest when the student is on a team very likely to win got an average rating of 6.3 whereas a contest when the student is on a team very likely to lose got an average rating of 2. This is not a surprising result as winning boosts self-esteem whereas losing hurts it. Cliffhanger contest got average rating of 8 whereas the activities of playing games with a friend, chatting with friends and watching TV got average ratings of 7.6, 6.8 and 6.6 respectively. The third column shows that average fun rating of Cliffhanger contests was higher than all other activities except playing games with a friend when one uses statistical T-test.

	Average Fun Rating	p-value for T-test comparison with Cliffhanger contest
Typical School math	1.9	0.00
Cliffhanger contest	8.0	N/A
Contest when you are on a team very likely to win	6.3	0.04
Contest when you are on a team very likely to lose	2.0	0.00
Play a game with a friend	7.6	0.30
Chat with a friend	6.8	0.08
Watch TV	6.6	0.05

Table 2: Fun ratings of different activities

Another survey was done on students' motivation to put in additional effort for four activities listed in column 1 of Table 3. The third column in this table shows that the motivation to put in additional effort for cliffhanger competitions is higher than for competitions where the student's team is very likely to lose or win and for school math. National math contests such as MATHCOUNTS have an appeal to a select few who have a chance of winning in the competition but not to others. In contrast, Cliffhanger competition is found to be enjoyable by a broader spectrum of students.

	Average Motivation Rating	p-value for T-test comparison with Cliffhanger Contest
Cliffhanger Contests	8.0	N/A
Contest when you are on a team very likely to win	6.5	0.05
Contest when you are on a team very likely to lose	4.3	0.00
School Math	2.9	0.00

Table 3. Survey ratings on willingness to work hard

Analysis of Results

Malone (1981) points out that an important factor that makes games and other activities fun is the uncertainty of the outcome. There is more uncertainty about the results of a Cliffhanger contest than about the results of a competition where a team is very likely to win or lose. This explains why Cliffhanger competitions are rated as more fun than other contests.

Another result described in the previous section was that students are motivated to work hard for a Cliffhanger contest. This can be understood in terms of attribution theory (Heider, 1958; Weiner, 1974) that proposes that every individual tries to explain success or failure of self and others by coming up with certain "attributions." These attributions are either internal or external and are either under control or not under control. The following table shows the four attributions corresponding to combinations of location of control and whether control is possible.

	Internal	External
No Control	Ability	Luck
Control	Effort	Task Difficulty

Table 4. Attribution Theory

In a learning situation, it is desirable to help the learner develop a self-attribution explanation of effort. If the student who has an attribution of ability experiences some difficulties, she will conclude that success in learning is not achievable because

of her limitations. However, if the student attributes learning success to effort, then she would work harder when she encounters difficulties. Carol Dweck (2000) reports that willingness to put efforts correlates well with future success. Therefore, helping students value efforts would help them succeed.

Given the varied learning experiences of students, most students with the exception of a few do not have a reasonable chance of winning national math contests. As such, these contests encourage students to believe ability is far more important than effort in most academic goals. This generalization is not valid as these students who may find national contests hard would find that effort would allow them to excel in many other academic endeavors. Thus, incorrect inferences from the performance in these national contests have a potential of doing harm to self-esteem in reinforcing the negative view of student's abilities. In a Cliffhanger contest, small additional effort by any member contributes to the success or failure of the team. Thus, students get a very strong validation of attribution of success to effort. Even when a team loses in Cliffhanger contest, it loses by a very small margin and therefore students on the team would believe that their collective abilities are close to those of the other team. Therefore, there is not a significant danger of negative impact on self-esteem.

Conclusion

Two big challenges in the K-12 education are to motivate students to be more positive towards learning and to motivate them to put in extra effort. This paper describes a competition format called Cliffhanger contests that is aimed at achieving this. Results of a survey of 26 students was conducted showed that students find these contests very enjoyable and are motivated to spare more time for learning so as to do better in the contests.

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