Move Your Body, Animate the Movement, and Learn Computer Science

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Introduction

When I was young, my father taught me fun dance moves [1] that teach the body's synchronization skills. It is hard to forget learned physical activities like the dance steps. According to a WebMD article, exercise is really for the brain, not the body [2]. Harvard medical school reports that regular body movements (exercise) changes the brain to improve memory, thinking skills [3]. Brain-based learning, a new teaching paradigm, based on the latest scientific research about how the brain learns [4] suggests “Move Your Body, Grow Your Brain” [5]. Huffpost had an article entitled, “Dance Lessons Could Keep You Two Steps Ahead of Memory Loss.” [6] This also suggests that dancing may boost brain functions.

This article is about experiences in incorporating physical activities such as dance into STEM+CS curriculum to provide an effective learning environment for young students.

In order to promote Computer Science and coding, I launched an annual autonomous robotics competition called Robofest (www.robofest.net) in 1999. While teaching robotics workshops, I learned that young students are interested in making physical objects move by programming, however, teaching classes with multiple moving robots is costly and complex to manage.

How about asking students to move like robots, for example black line following algorithm, and then teach how to animate their movements by writing programs in a simulated environment? That’s how the idea of CS+PA^2 (learning Computer Science with Physical Activities and Animation) started [7]. It extends the embodied learning approaches that emphasize the use of action to support pedagogical goals, by adding animation components.

CS+PA^2 is also based on an integrated curriculum framework where integrated lessons help students make connections and see the relevance between subjects. In CS+PA^2 students first learn various physical activities, and then illustrate and animate the activities by writing code, while learning concepts of computer science. Examples of physical activities include dance,, Zumba, Yoga, Tai-chi, martial arts training, fitness boot camps, and cheerleading.

MathDance 1st Experiment

As an instance of CS+PA^2, we introduced "Mathematical Dance (MathDance)" then taught to animate photographs of themselves dancing using SCRATCH.

We worked with the University Prep Science & Math Middle School in Detroit. Eighteen 7th grade students came for the first experiment. We set up a room for them, and had them pair off into teams of two, with one laptop computer assigned to each team. Then, we gave them a pre-assessment test. For math questions, the students were shown simple graphs ($y = x^2$, for example), and asked to identify the correct equations for each graph. For computer science questions, the students were given simple decision problems with a variable and nested loop questions. They were also asked two additional questions to gauge their interest in STEM fields. Once all the pre-assessments were complete, we taught them about graphs of some equations. After that, we walked them through basic coding concepts such as variables, operators, loops, nested loops, conditional loops, and decisions using the Scratch Cat as a Sprite (a character on the screen that the code manipulates). To play dance music, the concept of multi-tasking was also introduced. These were designed to prepare the students for creating their own MathDance animations in the program.

After the initial tasks, we sent them to another "station" to have their pictures taken in 9 different poses. Each pose represented a mathematical function as shown in the following Figure. For example, a pose in a "T" shape represented the function $y = 0$. After that, we taught them how to remove the background of the photos, then import the 9 photos into Scratch as Sprites.

$y = 0$ $c = x^2 + (y - a)^2$ $y = a^x$

$y = |x|$ $y = -|x|$ $y = -x$

$y = x$ $y = x^2$ $y = -x^2$

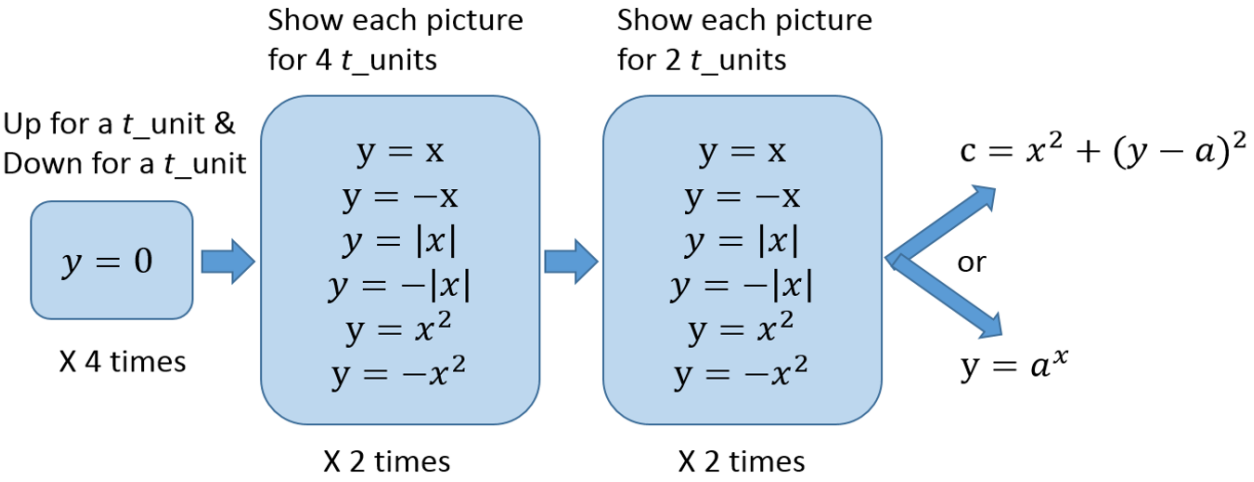
```
Play music concurrently;
Set delay as 0.495; // t_unit
Up-down moves using y = 0 for 4 times;

Set counter = 4;
Repeat until counter < 2
    Repeat twice the following
        Show y = x;
        Wait delay*counter seconds;
        Show y = -x;
        Wait delay*counter seconds;
        Show y = |x|;
        Wait delay*counter seconds;
        Show y = -|x|;
        Wait delay*counter seconds;
        Show y = x^2;
        Wait delay*counter seconds;
        Show y = -x^2;
        Wait delay*counter seconds;
    End of Loop;
    Decrease counter by 2;
End of Loop;

Choose a number (either 1 or 2) randomly;
If the number is 1
    Show “circle”;
Else
    Show y=a^x;
Play cheering and clapping sound;
Stop all;
```

After explaining a segment of pseudo code shown above Figure for the complete MathDance, we showed & assisted them with the first steps in creating the MathDance code with a pre-recorded music loop, called “drum_jam”. Then, we let them continue on their own to complete the MathDance. At the end of the event, we gave them a post-assessment with a similar difficulty level and similar questions to the first and the common STEM interest questions. Notice that the first group of 17 students, as a control group, did not perform the actual dance in class.

MathDance 2nd Experiment

For the second group, a different group of sixteen 7th grade students came from the same school. They were given the same setup as the 1st group. The 2nd group followed the same agenda explained in the previous section. In addition, they performed the actual MathDance 3 times as shown below for 3 min x 3 = 9 minutes.

When they danced, we first projected our pre-made dance animation as well as choreography notes on the screen as shown below.



Our first goal of this research project was to show that CS+PA^2 approach improves math and CS learning. The 2nd goal was to show that those students who learn and practice the MathDance would do better on a mathematics and computer programming test than those students who do not.

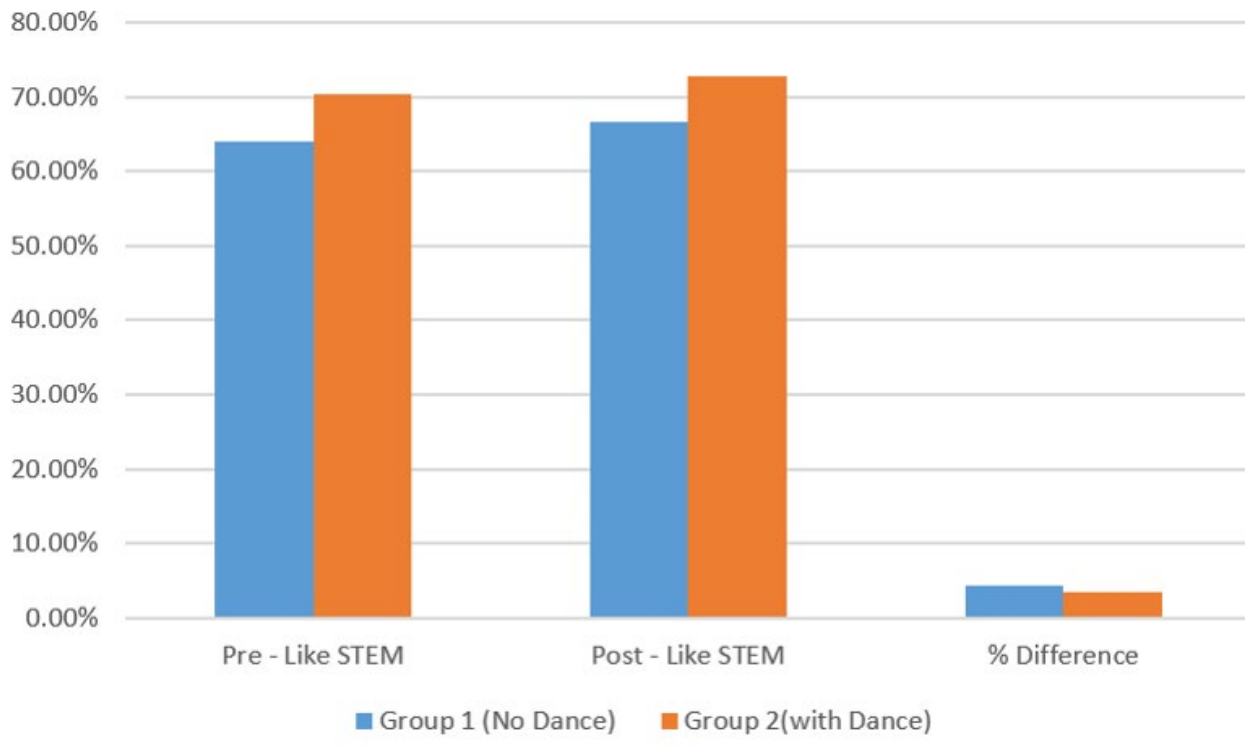
Results

Please first watch 3 animations created by students.
https://youtu.be/abqRCTdFwUg
https://youtu.be/goYiHV6Ojvw
https://youtu.be/McrcjzC6mU8

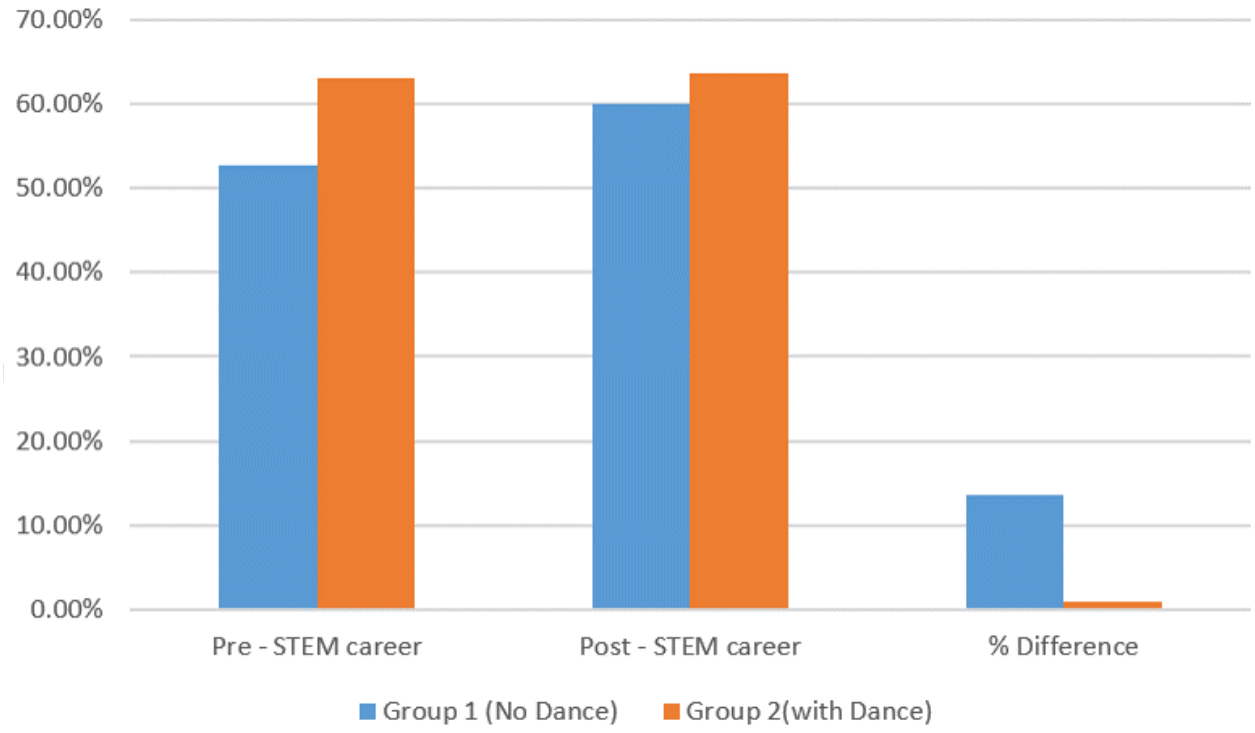
Group 1 students who did not dance improved their scores from the pre and post test by 104.8% on average (from 1.17 to 2.39 out of 5). A paired t-test showed that the significance of this increase was less than 0.0001, which is statistically very significant. Group 1's average interest in STEM fields and careers also increased..

Group 2 students who did dance improved their scores from the pre and post test by 136.4% on average (from 1.38 to 3.25 out of 5). A paired t-test showed that the significance of this increase was 0.0003, which is very significant. Group 2's average interest in STEM fields and careers also increased.

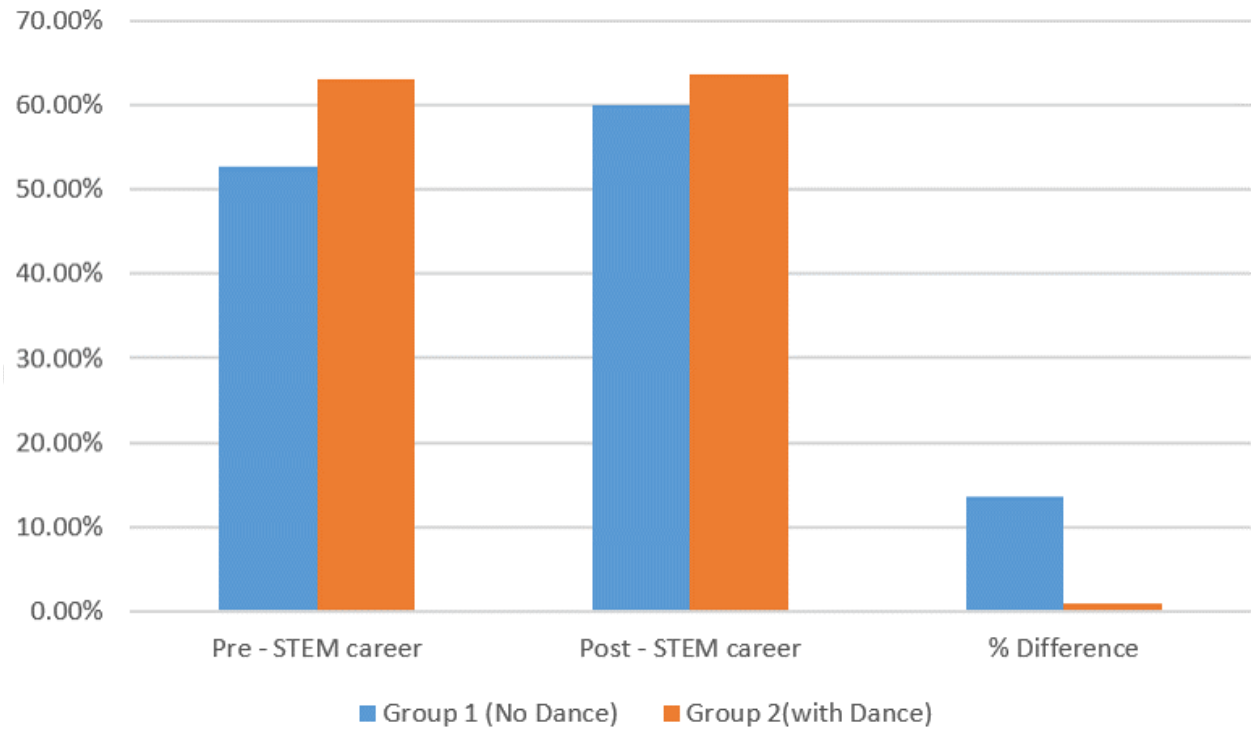
Another t-test was then performed on the two post-tests. Although Group 2 did perform better on the second exam than Group 1, and increased their average score by a larger percentage, the unpaired t-test showed a significance of 0.0935. This means that Group 2 almost performed significantly better than Group 1, meaning that the MathDance did amplify the students' ability to remember the information we taught them. The results are shown graphically on the following Figures.



Assessment of Math & CS



Assessment of STEM class Interest



Assessment of STEM career interest

Summary and Conclusion

MathDance as an example of CS+PA^2 is an integrated, interdisciplinary, and synergistic approach to integrate math, computer science, technology, and physical education. Assessment data show that students did significantly better on the post-assessment than on the pre-assessment. The group who performed the "MathDance" in class was better than the group who did not. We think the improvement was possible because the body movement can be an effective cognitive strategy to strengthen learning, improve memory and retrieval, and enhance learner motivation and morale. While they are working on animation, the math learning was reinforced through visual information they created.

In addition, we know that physical activity before, during and after school is good for students' heart, brain, and whole body. By incorporating physical activity and STEM+CS classes into the school curricular, we can provide an effective learning environment for students' well-being in general. Since some school districts have done or may be considering cutting back on physical education to add more STEM related classes with the aim of improving academic performance, a compromised solution could be adopting programs like CS+PA^2 approach such as MathDance.

Move your body to learn math, animate the movement to learn coding and reinforce the math learning. Play each students' animation through circuit TV and let them do the MathDance before classes.

Currently we are working on combining MathDance and Music. Let them mathdance to the music composed by themselves.

I still remember the dance steps my father taught me more than 50 years ago. Hope MathDance students will remember the shapes of math functions learn through MathDance and Scratch animation.

Acknowledgements

- Howard Hughes Medical Institute, Course-based Research Experience (CRE) Grant
- University Prep Science & Math Middle School: Mrs. Brienn Frederick and Mr. Neal Maclellan
- Mark Kocherovsky, LTU Computer Science student, co-instructor and co-author of IEEE ISEC paper
- Dr. Lior Shamir and Dr. Sibrina Collins
- Mirit Shamir, Shannan Palonis, and Elmer Santos

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