# Physical Activity in a Theory of Computing Class

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**Abstract**

Physical activity breaks, sometimes called brain breaks, are beginning to gain attention among K-12 teachers as a way to keep their students alert and engaged in the classroom. In the Fall 2014 semester, faced with the task of teaching an introductory course in Theory of Computing in a once-a-week, $2\frac{1}{2}$-hour format, I decided to try incorporating physical activity into my own classroom. Time is precious in the college classroom, so any physical activities have to be directly related to the course material. I will describe some physically active exercises that I used in the classroom to teach students about regular expressions, finite automata, and other theoretical concepts. During the semester, I found that these exercises helped students to have fun and to stay connected to the material, even at the end of this long, late-night class. I also found that the exam averages and the overall course average were higher in Fall 2014 than they had been during the previous four years of teaching this night class. This invites further experimentation with the technique in future semesters.

## The Challenge

In the Fall semester of 2014, I was assigned to teach a course called Foundations of Computer Science. In the Rowan University curriculum, this is an introductory course in the theory of computing: students learn to use regular expressions, finite automata, context-free grammars, and elementary symbolic logic.

The challenge of the course was the time slot: In most Fall semesters, my section of Foundations of Computer Science is held once a week, from 6:30-9:00 p.m. The students have probably just had dinner, after a long day of work and classes, and they are now settling in to study mathematics for $2\frac{1}{2}$ hours. Even the most dedicated students will have trouble holding their concentration for that long.

Physical activity breaks have started to become popular in some K-12 classrooms as a way to increase students' attention. The idea is to have students physically get up and move around during classroom time, so that the physical energy will lead to increased mental energy. Lengel and Kuczala [1] and Sladkey [2] are among the many authors who have designed activities for elementary and secondary classrooms.

I wanted to try this in my own classroom. Contact hours in a university setting are precious and few, however, so any activities we do should be related directly to the content. With this in mind, I developed a few physical exercises to use in the Fall 2014 Foundations of Computer Science class. The students had fun with them, were better able to pay attention during class, and showed improved mastery of the concepts by the end of the semester.

## The Activities

### Activity 1: Catch!

This exercise uses two or three small, soft balls, such as Koosh balls, that are easy to throw and catch, but soft enough that they won't do damage if someone misses a catch.

Pose a question for the students to think about, then throw a ball out into the classroom. Whoever catches the ball tries to answer the question. If the student is obviously stuck and can't come up with the answer, then after a short time tell the student to throw the ball to someone else in the class; the new student then tries to answer the question. Repeat until the question has been answered, or until it's clear that the students are lost and that the professor needs to take a few minutes and talk about the question and its answer directly.

This works best with short questions that require attention from the students but that do not involve lengthy problem-solving. Examples from the Foundations class included:

> *If $L = \{ab, c\}$ and $M = \{a, ab\}$, what is $LM$?*
>
> *Tell me one string that's accepted by the grammar that's currently on the board.*
>
> *What states can you reach from state 0 on a $\Lambda$-transition, in the finite automaton that's currently on the board?*

This activity is both physical and mental: It requires students to look for a ball in the air, catch it, and throw it, waking up their bodies; it also requires figuring out the answer to a question, waking up their minds.

### Activity 2: Find Your Match

In this family of exercises, two or more different descriptions of an assortment of formal languages are written on pieces of paper, which are then distributed to the students. The students try to find the other students in the class who are holding the pieces of paper that describe the same language as the paper they are holding.

#### Variation 1: Regular Expressions and Languages

Write regular expressions on green pieces of paper, and write corresponding strings from their languages on yellow pieces of paper. Give half the students green pieces of paper, and the other half yellow. Tell the students to get up, walk around, talk to each other, and find the student with the piece of paper that matches theirs. For example, the student with

b* a

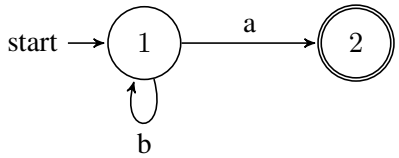
and the student with

IN: bbba, a  OUT: baba, bb

should walk around until they find each other.

#### Variation 2: Finite Automata, Regular Expressions, and Languages

As before, write regular expressions on green pieces of paper, and strings from their languages on yellow pieces of paper. Additionally, include blue pieces of paper with nondeterministic finite automata on them, such as this one:




Distribute the green, yellow, and blue pieces of paper, and tell the students to walk around until they find the two pieces of paper that match theirs.

## What Worked Well

These activities require that the students in the class be willing to try something that is lighthearted and out of the ordinary. I asked the class at the beginning of the semester whether they would be willing to try some experimental physical exercises during the semester, and they agreed.

We found that the exercises did help the students to be more attentive, especially as we moved into the second hour of the evening. Besides the physical alertness, we also found that the exercises lightened the mood of the class. Throwing a ball around the room is a silly thing to do, after all, as is walking around asking your classmates what's on their papers. The students had fun, and this made learning easier.

I also found that playing catch with the ball eased the pressure of being called on. If a student is stuck trying to figure out an answer, then never mind: toss the ball to someone else, and they'll help you out. The random element of the ball toss means that no one is really being singled out, and being able to throw the ball means that no one has to figure out a hard question alone.

Occasionally, students started to get lazy with throwing and catching the ball: they would ask for a volunteer to help with answering a question, and gently hand the ball to the volunteering student. This makes the activity much less physical, and thus less useful. On these occasions, I switched to asking the students to throw the ball back to me after attempting to answer, and I then tossed the ball back out into the class to be caught by a new student. Usually, this was enough to raise the physical activity level, while still keeping the mood light.

## Grade Improvement in Fall 2014

I have taught the Foundations of Computer Science class every Fall semester since 2010, in this once a week, $2\frac{1}{2}$ hour format. While I have always incorporated active elements in class, such as interactive problem-solving and students presenting homework solutions on the board, Fall 2014 is the first semester in which I used the physical exercises described in this paper. I had expected to find that students would enjoy the class more when we incorporated physical activity, and I did indeed see this. However, I was pleasantly surprised to find that the students' average semester grades also increased in Fall 2014:

| Semester | Mean Semester Grade |
|---|---|
| Fall 2010 | 83.8 |
| Fall 2011 | 79.9 |
| Fall 2012 | 81.9 |
| Fall 2013 | 83.5 |
| **Fall 2014** | **86.7** |

The mean semester scores increased several points over the scores in the previous semesters. I found a similar increase in the students' average exam scores. This is an encouraging preliminary result, and I plan to repeat the exercises in upcoming semesters to see if the pattern holds.

## References

[1] T. Lengel and M. Kuczala. *The Kinesthetic Classroom: Teaching and Learning Through Movement*. Corwin, Thousand Oaks, CA, 2010.

[2] D. Sladkey. *Energizing Brain Breaks*. Corwin, Thousand Oaks, CA, 2013.