Kinesthetic Learning Activities in an Upper-Division Computer Science Course
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Abstract
We have developed a set of KLAs for teaching concepts in distributed computing at the graduate and senior undergrad level.

Topic Area: Active learning in the classroom

Objectives
1) Improve student understanding of distributed algorithms
2) Encourage assertional thinking about these algorithms.
Level: Senior undergrads and grads

Developmental History of Innovation
Many KLAs already exist for introductory computer science courses.
(1) People as processors: Students act out algorithms (eg sorting, merging)
(2) People as memory: Students form data structures (eg trees, stacks)
But these KLAs often encourage an operational view (i.e., algorithms as sequences of actions).
In 2002, we developed a KLA for middle school girls attending a computer science workshop. Subsequently, we designed many new KLAs, focusing on assertional reasoning for students in an upper-division course in distributed computing.

Terms
Kinesthetic Learning: Students learn by carrying out a physical activity rather than passively listening to a lecture or watching a demonstration.
KLA: Kinesthetic Learning Activity
Distributed Computing: Many programs running concurrently, communicating over a network.
Assertional Thinking: Understanding an algorithm in terms of invariants, rather than as a step-by-step sequence.

Example: Nondeterministic Sorting
Algorithm: Randomly select a pair to compare and swap if out of order. Repeat.

Example: Parallel Garbage Collection
Algorithm: Mark root as reachable. Mark any node that is reachable from a marked node. Repeat.

Example: Self-stabilizing Mutual Exclusion
Algorithm: Continuously compare value with left neighbor. If they differ, use the resource. To release the resource, change one’s value to equal left neighbor.

Learning Objectives:
1) Operational reasoning is dangerous
2) Termination detection is difficult
3) Proving termination requires a metric
Convincing argument needed for progress.

Myths vs Reality
Myth: KLAs take too much class time
Reality: KLAs can be short and effective. They have an excellent return on investment!
Myth: KLAs are too disruptive
Reality: KLAs are controlled and directed student engagement. Energizing the class is a positive outcome!
Myth: Engineers are not kinesthetic learners
Reality: Research shows all learning styles are represented in significant proportion.
Myth: KLAs work only in small class sizes
Reality: Some KLAs actually benefit from greater numbers of participants!

Tips for Success
1) Design KLA to achieve a specific learning objective. Avoid KLAs that only illustrate.
2) Plan KLA carefully ahead of time.
3) Use KLAs throughout the semester. Introduce them early and include often.
4) Be sensitive to physical disabilities (e.g., restricted mobility, blindness, deafness) and differences in cultural norms.

Discussion
KLAs can be effective tools in teaching, so long as they are carefully designed to target specific learning objectives.
Designing good KLAs is a significant effort. By sharing successful KLAs, we can amortize this effort over many people.
These KLAs leverage the specific nature of distributed computing. Can KLAs be equally effective in other disciplines too?

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