At-Home System and Controls Laboratories  
William Durfee, Perry Li, David Waletzko  
Department of Mechanical Engineering, University of Minnesota, Minneapolis, USA

**Purpose**
For engineering students in introductory system dynamics and controls courses who need to gain intuitive feel for physical systems, the distributed laboratory is a way to explore basic concepts through a hands-on experience that uses inexpensive, computer-controlled hardware kits. Unlike traditional laboratory experiences, the distributed lab is brought home by each student and tackled on a self-paced schedule in much the same manner as a homework assignment, thus allowing the student to customize the laboratory experience to his or her learning style. Recent advances in low-cost microcontrollers and sensing components, coupled with careful mechanical design make it possible to replicate hardware for each student at a parts cost of under $100. Almost all students have powerful home computers that can be harnessed for supervisory control and data analysis. Laboratories can be treated as homework assignments that are done entirely at home just like a problem set. 

**Hypotheses**
1. Exploring and understanding physical hardware individually results in a deeper and more intuitive understanding of the subject matter
2. Take-home lab kits provides same or better learning as traditional labs, but for lower cost and lower resource use.

**Design requirements**
1. Demonstrates fundamental principles (for high learning impact)
2. Rugged (to survive trips back and forth to school in a backpack)
3. Small (about the size of a large textbook for portability and storage)
4. Simple (operation is easily understood)
5. Inexpensive (under $100 parts cost per unit in lots of 100 units)
6. Easily manufactured by unskilled labor (for in-house assembly)

**Modular architecture**
- More rugged
- Simpler
- Lower cost
- Easier setup

**Objective of the project**
Develop two lab kits for undergraduate system dynamics course. Fabricate 30 kits. Pilot test. Create improved, second generation system.

**Evaluation**
Methods
- Thirty of each module constructed and distributed to 35 students randomly chosen out of the 67 in the course.
- Post use survey.
- With smaller sample, conducted pre-test, treatment, test, post-test experiment

Quotes
- “The more you play the more you LEARN”
- “It exposed me to something real rather than just words and pictures in a book”
- “Seeing results easily without getting lost in too much mumbo-jumbo”
- “Hands on!”
- “I am too lazy to read, this helps bunches”

**Next Generation**
Second-order spring-mass-damper system. Rotary motion. PIC18F2455 CPU. USB interface to PC.

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