Redesign of computer labs for engineering students in a linear algebra course

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Abstract

As part of the Mathematics Department's involvement with CWSEI, the Matlab-based computer labs for Math 152, Linear Systems, were updated in the 2008-09 academic year and fully assessed the following year. Further elements that supported Matlab learning were also integrated into the locally developed course textbook and homework assignments. Over the two year span of this project, various data were collected in order to assess the effectiveness of the new labs, and retention of Matlab skills was studied by following a subset of students in their second-year program (Mech 2). Learning of basic Matlab knowledge was observed in the course, and a significant improvement in retention was measured after the introduction of the new labs.

The setting

- MATH 152: Linear Systems

  First course in linear algebra for Applied Science students
- ~700 students each year (all in same term)
- 3-credit course with six biweekly labs
- MATLAB
- Labs are worth 10% of final grade

The students

- Applied Science students (N=780 in 2009/10)
- Prior programming experience (self-reported, not exclusive, 632 respondents)

	C	**Java**	**C++**	**Matlab**	**Other**	**None**
% of students	53%	17%	41%	4%	17%	11%

Other: Maple (3%), Mathematica (2%), Visual Basic (2%)

- APSC 160: Introduction to Computation in Engineering Design

  58% already completed APSC 160 (C programming)

Motivation for project

- Lab and course content, especially applications, drifted apart over years.
- Some labs were too long.
- Some labs included activities beyond the difficulty students were expected to tackle at this novice level.
- Student frustration due to these factors.

The redesign process

First year (2008-09)

- Establish learning goals
- Make links to class material (applications)
- Have reasonable expectations of activity length
- Collect data

Second year (2009-10)

- Make revisions
- Collect more data
- Track retention

Assessment strategies

- Pre/post (online) Matlab quiz (participation mark) to measure learning of specific expertise developed in the labs.
- Short review quiz four months after the end of the labs (voluntary) to measure retention.
- Student surveys to assess perceptions of labs.
- Observations of student work during lab sessions to improve lab activities.
- Matlab-based questions in (midterm and final) exams and homework to further assess learning.

Lab learning goals

Students should be able to

- Operate and program in MATLAB at a basic level: entering and operating on vector variables and matrix variables, solving linear systems, and implementing loops.
- Solve an applied word problem using MATLAB computations given the associated linear system, where the problem may be impractical to solve by hand; in case of resistor networks and random walks, be able to extract the associated linear system from the word problem and solve.

Connections to course material

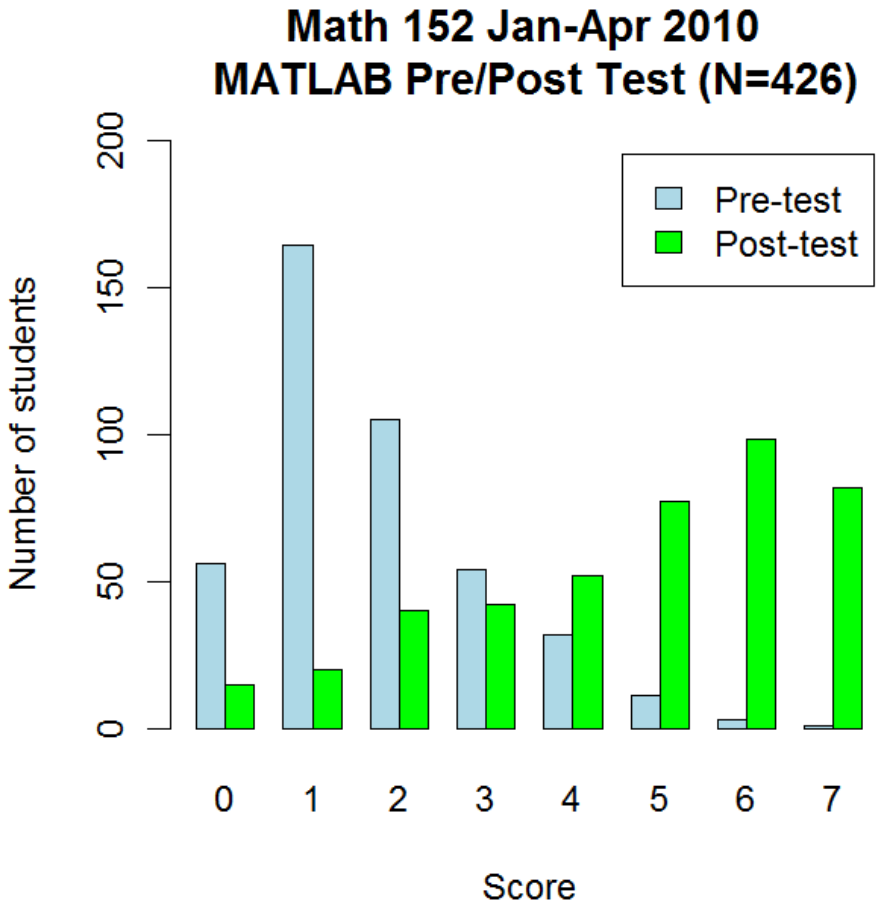
- Mathematical concepts are introduced in lectures (e.g. determinants, eigenvalues)
- Applied word problems involve applications introduced in class (e.g. circuit networks, random walks)
- Matlab computation examples included in online textbook (locally developed).

Reasonable expectations of activity length

- Labs are 50 minutes long
- Regular 3-credit course, no extra credit for labs
- Students are expected to hand in their work at the end of the lab session
- No lab homework assignments

Data: Learning in the labs

Online Pre/Post Test on basic syntax and “for” loops.

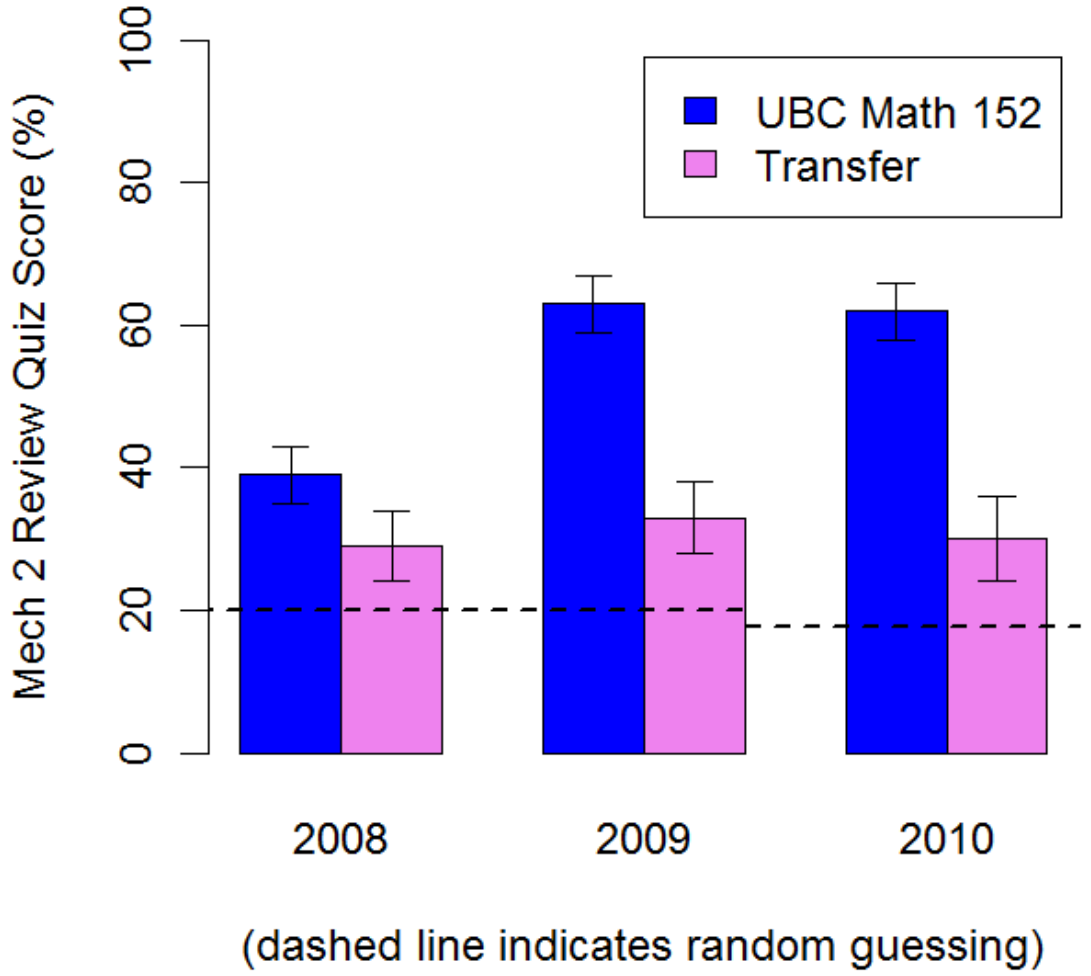


Sample question:

Suppose the variable `A` is defined as a 3x3 matrix with nonzero entries. In what way is the matrix `A` changed by the following lines of Matlab code?

```
for i = 1:3
 A(i,:)=A(i,:)/A(i,1)
end
```

Data: Retention of learning

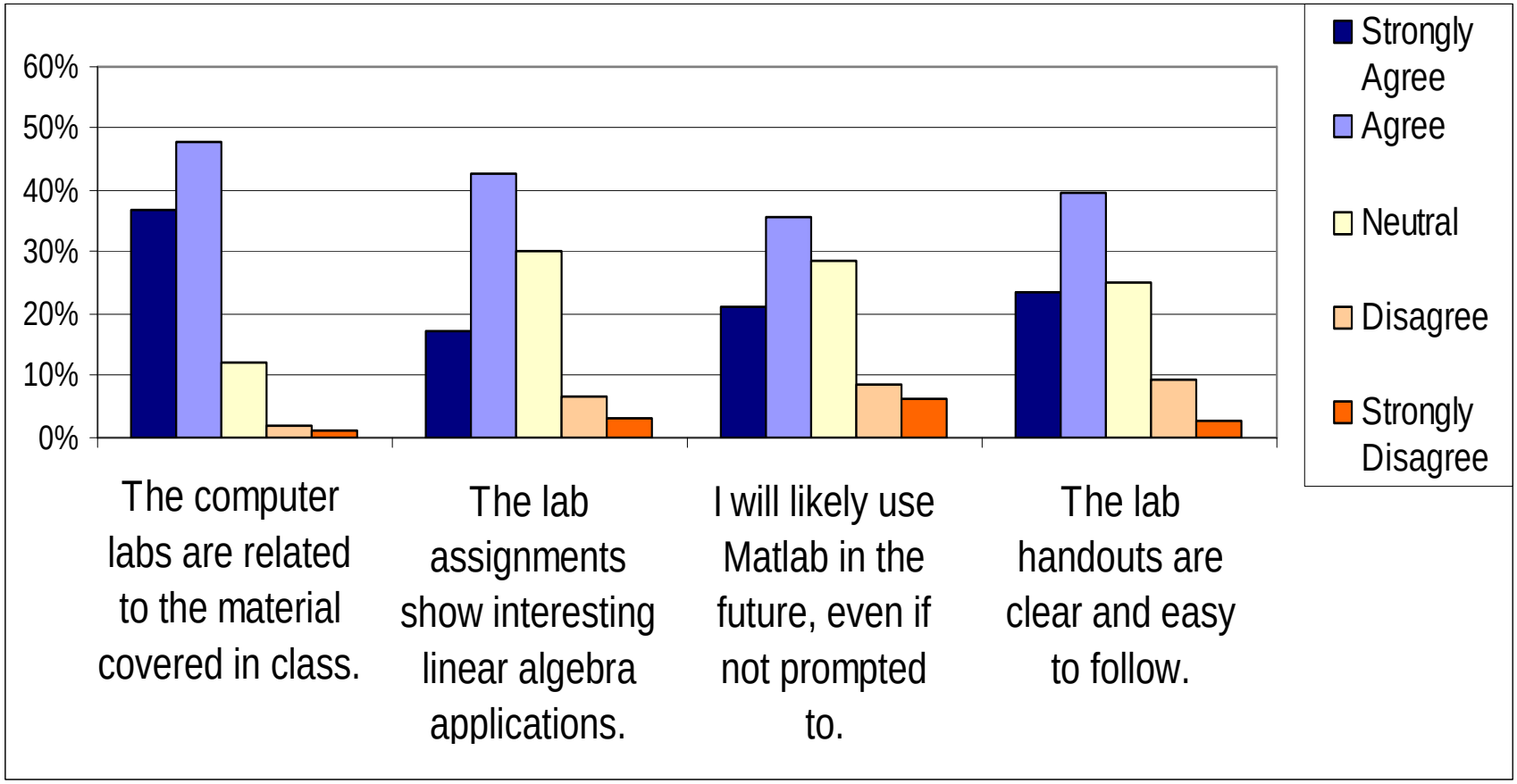


Matlab questions are asked on a quiz at the start of Mech 2 (Mechanical Engineering 2nd Year Program), four months after the end of Math 152. Here, we compare average scores of Math 152 students with those entering Mech 2 without Math 152 ("Transfer").

The redesigned labs were introduced in 2009.

Data: Student Perceptions

End of term, paper survey (N=263, 38% of enrolment)



Conclusions

The redesign process was based on setting clear and reasonable expectations of learning and making explicit connections between labs and lecture materials.

Students met the desired lab learning goals and measurements of retention indicated improved learning as a result of the new labs.