Introduction and Assessment of iNewton for the Engaged Learning of Engineering Dynamics

Rachel V Vitali[1] (vitalir@umich.edu), Noel C Perkins[1], Cynthia J Finelli[2]

[1]Mechanical Engineering, [2]Electrical Engineering and Computer Science

COLLEGE OF ENGINEERING MECHANICAL ENGINEERING UNIVERSITY OF MICHIGAN

ELECTRICAL ENGINEERING AND COMPUTER SCIENCE UNIVERSITY OF MICHIGAN

Introduction

Teacher-Centered

Expository teaching: knowledge passively transmitted from professor to student (e.g. lecturing) [1]

Learner-Centered

Discovery learning: student constructs knowledge by gathering/synthesizing information (e.g. active learning) [1]

Undergraduate students will explore engineering dynamics concepts using MEMS inertial measurement unit (IMU) technology called interactive-Newton (iNewton) (Fig. 1)

Table 1: Project design to systematically scale up iNewton learning intervention in an otherwise traditional (lecture-only) dynamics course (MECHENG 240).

Level	Intervention (and progress to date)	Description
1	**Instructor-Created, Instructor-Led (completed)**	**Instructors demonstrate two experiments with iNewtons in class for students**
2	Instructor-Created, Student-Led (in progress)	Students conduct two pre-defined experiments with iNewtons outside class
3	Student-Created, Student-Led (under development)	Students propose and conduct experiments of their own imagining (with instructor feedback) with iNewtons outside class

Hypothesis: iNewton will positively affect: 1) conceptual understanding, 2) self-efficacy, 3) intention to persist, and 4) feelings of inclusion

Results

Table 2: Mean (standard deviation) of scores on the 29-item DCI at the beginning of the semester (pre), end of the semester (post), and overall gain (defined in [4] as (post-pre)/(100%-pre)).

	pre %	post %	gain
Control	37.7 (14.6)	46.1 (18.3)	0.14 (0.22)
Intervention	40.6 (14.9)	46.9 (17.2)	0.10 (0.23)

Table 3: Results for t-tests conducted on gains and means (standard deviations) of gains for LAESE subfactors (engineering self-efficacy (ESE), inclusion (INC), persistence (PER), course-specific self-efficacy (CSE)).

	ESE		INC		PER		CSE	
	gain	p	gain	p	gain	p	gain	p
Control	-0.01 (0.12)	0.34	0.03 (0.13)	<0.01*	-0.01 (0.09)	0.75	-0.05 (0.25)	0.01*
Intervention	-0.01 (0.10)	0.08	-0.02 (0.14)	0.03*	0.02 (0.07)	<0.001*	-0.03 (0.21)	0.01*

*Significant at $\alpha = 0.05$.

Acknowledgements

This material is based upon work supported by the National Science Foundation under Award ID No. 1609204 through NSF's Division of Undergraduate Education (DUE) as a part of the Improving Undergraduate STEM Education (IUSE) program. We thank the course instructors and students for their participation.

Methods

Tools for Evaluating Hypotheses

1) Dynamics Concept Inventory (DCI) [2]
2)-4) Longitudinal Assessment of Engineering Self-Efficacy (LAESE) [3]

Figure 1: An iNewton with the sensor-fixed frame of reference etched on top. It contains a triaxial accelerometer and angular rate gyro, which measure linear acceleration and angular velocity, respectively.

Experiments

Control group DCI used to design experiments (Fig. 2 and 3) around concepts misunderstood at the end of the engineering dynamics course.

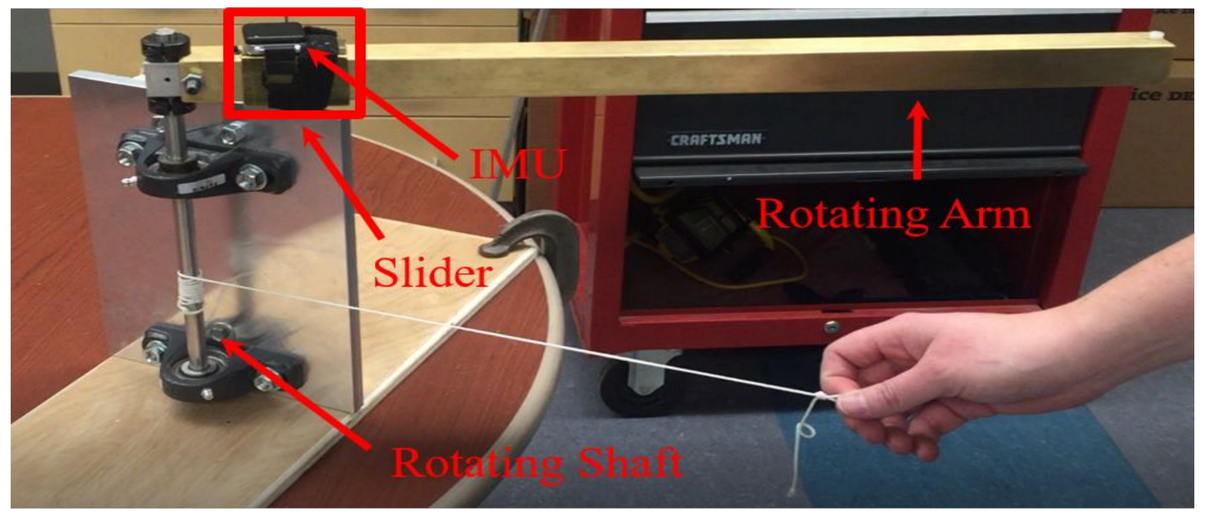

Figure 2: Experiment 1 set-up of a rotating arm with a slider that demonstrates the Coriolis acceleration.

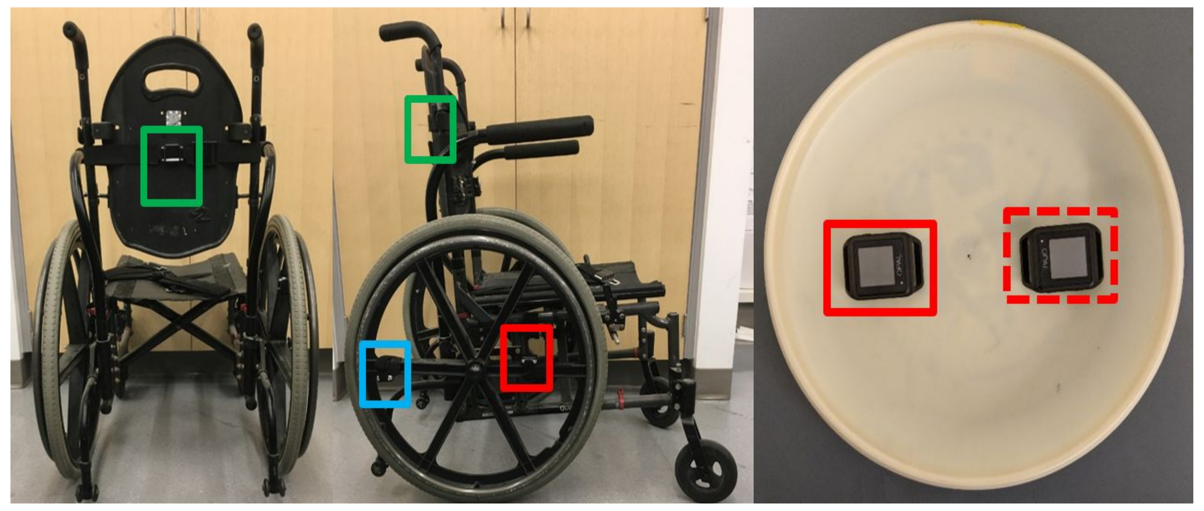

Figure 3: The two versions of experiment 2. (a) The wheelchair version included three IMUs located on the back of the chair (green), on a wheel near the outer perimeter (blue), and on the same wheel near the axel (red). (b) The Frisbee version included two IMUs located radially-symmetric on the underside. The IMU in the solid red box collected data for the assignment whereas the IMU in the dashed red box was added to minimize eccentric mass effects.

Conclusions and Future Work

Hypothesis 1) — DCI — Limited impact on improving understanding

Hypothesis 2) — ESE, CSE — Limited impact on improving self-efficacy

Hypothesis 3) — PER — Significantly improved intention to persist

Hypothesis 4) — INC — Significantly decreased feelings of inclusion

First level of intervention not enough to improve significantly over the control group.
Next levels require more engagement with iNewton, which will hypothetically improve results.

References

1. Huba, ME and Freed JE. (2000) Learner-Centered Assessment on College Campuses: Shifting the Focus from Teaching to Learning. Boston: Allyn and Bacon.
2. Gray, G. L., Costanzo, F., Evans, D., Cornwell, P., Self, B., Lane, J. L. (2005). The dynamics concept inventory assessment test: A progress report and some results. Proceedings of the 2005 ASEE Annual Conference and Exposition, Portland, OR.
3. Marra, R. M., Rodgers, K. A., Shen, D., & Bogue, B. (2009). Women engineering students and self-efficacy: A multi-year, multi-institutional study of women engineering student self efficacy. Journal of Engineering Education, 98(1), 27-38.
4. Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. American Journal of Physics, 66(1), 64-74.