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Flipping Undergraduate Robotics and Creating Interactive Online Content

- Goals: Increase active learning to supplement traditional lectures
- Multi-media exposure to content before attending lectures
- Classroom activities based on student feedback of pre-assignments
- Create online robotics curriculum available to the public

Flipped Robotics Course Design

- Robot Kinematics and Dynamics (16-384) previously taught via traditional lectures and "paper and pencil" homework.
- In fall 2014, students watched pre-recorded lecture videos before class and provided feedback to instructor.
- Freed up classroom time for instructor to actively engage with students on concepts that most needed reinforcement.
- For fall 2016, videos are now part of a full online curriculum on the Open Learning Initiative (OLI) platform.
- Contains interactive exercises and specialized feedback for both students and instructor to make better use of classroom time.
- Will eventually be public to support instructors and self-learners globally.

Implementation and Evaluation

Classroom activity (below) vs.	Active	Peer-based	Problem-
Type of learning addressed (right)			based
Submitting short questions after	\checkmark		
watching videos			
Fast-paced interactive lecture and	\checkmark	\checkmark	
review session in teams			
Solving assigned homework	\checkmark	\checkmark	\checkmark
problem in teams			
Individual oral presentation of	\checkmark		\checkmark
homework solution			

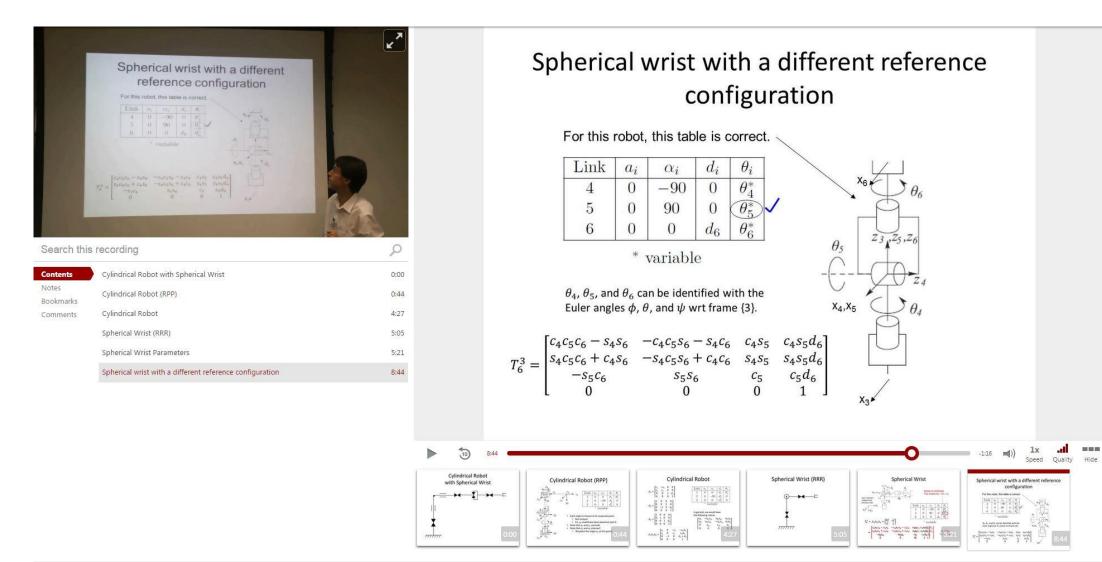
Findings and Lessons Learned

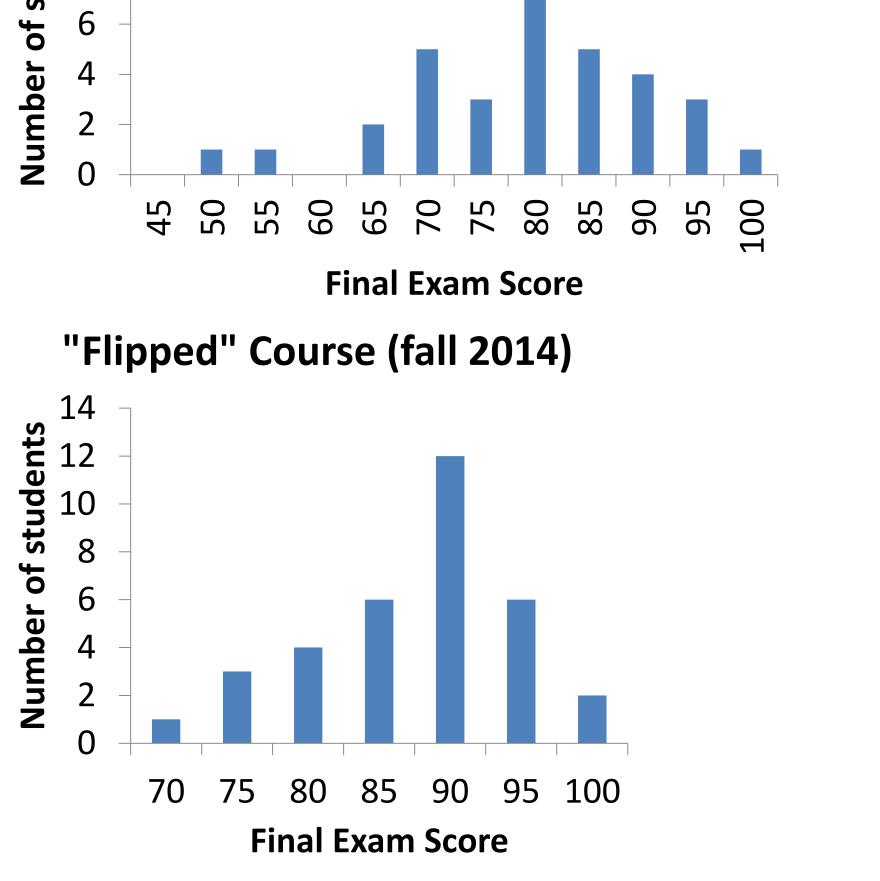
- Hit traditionally lacking learning methods: active, peer-based, and problem-based (as opposed to concepts only).
- Students reacted favorably to flexibility of lecture videos to control pace of learning, take notes, and review on their own schedule.
- Some performance improvement observed on final exam grades compared to previous semesters.
- Sizeable minority of students still preferred traditional teaching method.
- Videos and online content require constant maintenance and refinement based on student feedback and performance statistics.
- Course development workload comparable to creating a new course from scratch despite already having traditional format materials.





Above: Summary of "flipped classroom" activities from Fall 2014. **Below**: Screenshot of lecture video player Panopto, with video recording and corresponding slides side by side for fast navigation.





Comparison of grades from identical final exams in two course offerings. Improvement in average and individual question performance was observed.

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textbook-alternative		
ion to topic that can be		
based on class progress Now that we have reviewed forces and	torques let's bring manipula	tors back into the nicture As you can
probably infer, revolute joints exert tor		
		et force and torque at the end effector.
-	· · ·	ing the end effector still, particularly in
		en we require a robot to be able to hold
tself up in the presence of gravity, for e olvable problem.	example. It turns out that the	Jacobian will again make this a very
olvable problem.		
Lecture 10c: Statics and Manipulat	ors	Carnegie Mellon University
Ctatio	Foress and M	
Static	Forces and M	anipulators
T I 6 11 1		- to to to
The following	two problems are e	quivalent:
	n ₀	\bigcap $-n_0$
Q		
Ψ		
	7777	777
Find joint forces		pint forces and torques
necessary for en a wrench (f_0, n_0)		sary for end effector to resist nch $(-f_0, -n_0)$.
		hat can be played
		in the page or in
	a new full-scree	en window
learn by doing		
		Low-stakes exercises that reint
Suppose we have the following Jacobian	n matrix for a planar 2-DOF robot.	and check students' understand
		of subject material
	$J = egin{bmatrix} 1 & -2 \ 0 & 3 \end{bmatrix}$	5
	$\begin{bmatrix} 0 & 3 \end{bmatrix}$	
If we would like our robot's end effector	to resist a force $[f_r, f_v]^T = [2, -]$] ^T , what torques should be applied at
each of the joints?	(a ~ / a H) [-1]	
outer of the jointo:		-] ,
$\tau_1 = 2$		-1
-		-1
$\tau_1 = \boxed{2}$ $\tau_2 = \boxed{-7}$		
$\tau_1 = \begin{bmatrix} 2 \\ \tau_2 \end{bmatrix} = \begin{bmatrix} -7 \\ \end{bmatrix}$ Incorrect. First recall the relationsh	ip between end effector torques and we want the end effector to resist v	I joint torques. Second, note the
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Screenshot of online OLI curriculum currently being tested for Fall 2016.

