

**ED-MEDIA**  
World Conference on  
Educational Multimedia,  
Hypermedia & Telecommunications



# LON-CAPA

**An Open-Source Learning Content  
Management and Assessment System**

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Michigan State University



# LON-CAPA Overview

- LON-CAPA is
  - free
  - open-source
  - a learning content management system
  - an assessment system
  - around since 1992

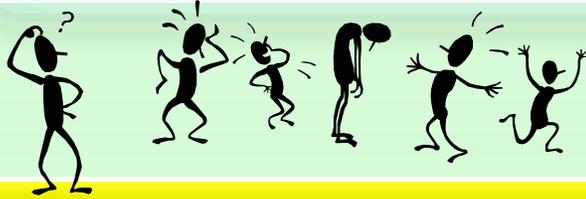


# Free and Open-Source

- Free:
  - “Free beer”: no licensing fees
  - “Free speech”: source code, Bugzilla, mailing lists, research results, all out in the open
- Open-source: you can read, modify, improve, adapt, etc, the original code of the system
- BUT: derivative must be distributed under same license, i.e., GNU General Public License

```
while ($line=<IN>) {  
    chomp($line);  
    $line=~s/\s+$//s;  
    $line=~s/\"//g;  
    $line=~tr/A-Z/a-z/;  
    @entries=split(/\/,\/,$line);  
    $username=$entries[4];  
    —
```

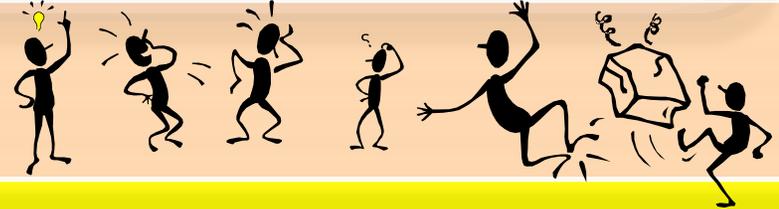
# LON-CAPA Architecture



Course Management

Campus A

Resource Assembly



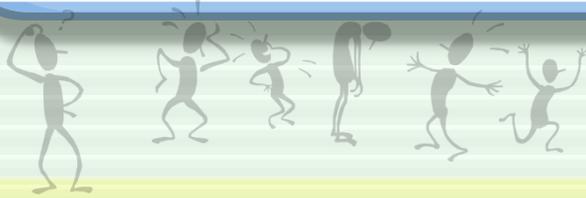
Course Management

Campus B

Resource Assembly

Shared Cross-Institutional Resource Library

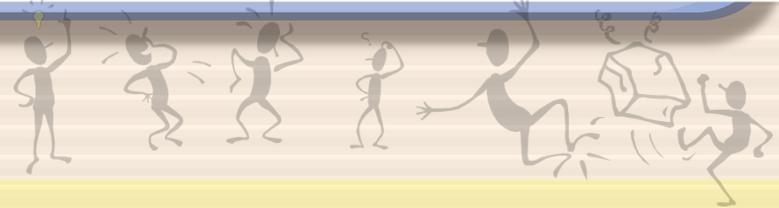
# LON-CAPA Architecture



Course Management

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Course Management

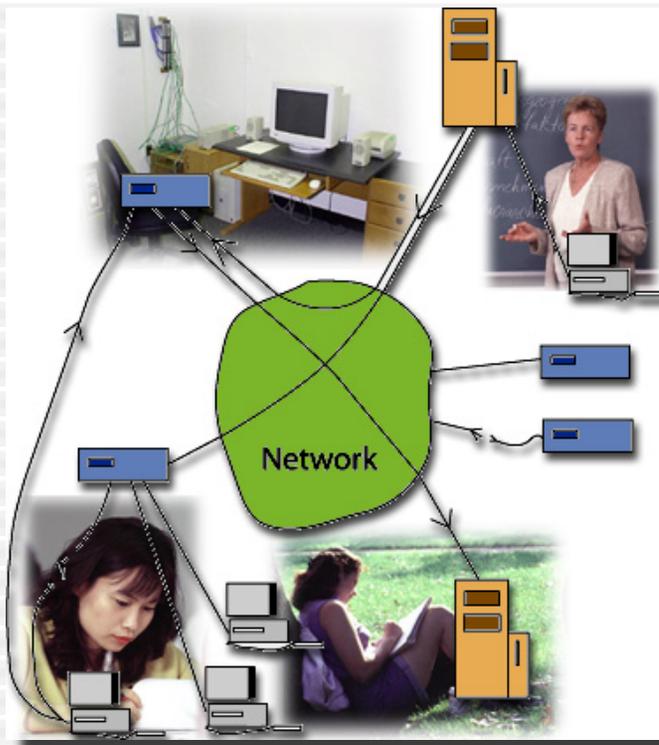
Campus B

Resource Assembly

Shared Cross-Institutional Resource Library

# Shared Resource Library

- The distributed network looks like one big file system



▶	Domain - sc (University of South Carolina)
▶	Domain - sfu (Simon Fraser University)
▶	batchelo
▶	chem281
▶	exafs
▶	hanlan
▶	mxchen
▶	slavieri
▶	vjungic
▶	Domain - sunysb (SUNY Stony Brook)
▶	Domain - tmcc (Truckee Meadows Community College)
▶	jensen
▶	mbauer
▶	souza
▶	Greenberg
▶	default.sequence (metadata)
▶	samples
▶	testuser1
▶	Domain - ucf (University of Central Florida)

# Shared Resource Library

- Resources may be web pages ...

EXAMPLE

## Example: Looping

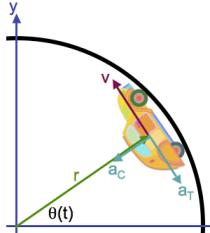
A toy car can go through a looping if it is fast enough. What are the forces that act on it? How fast does it have to be?

The motion is obviously circular, but non-uniform: the car will slow down on the way up, and speed up on the way down. With  $r$  being the radius of the looping, the  $x$ -axis horizontal, the  $y$ -axis pointing up, the origin being in the center of the looping, and  $\theta(t)$  being the angle, the position of the car is given by

$$\vec{r}(\theta) = \begin{pmatrix} r \cos(\theta(t)) \\ r \sin(\theta(t)) \end{pmatrix}$$

as long as it does not fall off the track.

The figure below illustrates the setup:



EXAMPLE

## Focal Length

The following pictures are taken from the same vantage point with three different zoom lenses:

- 17mm-35mm wideangle zoom
- 24mm-70mm normal zoom
- 70mm-300mm tele zoom

using a digital camera with an image sensor of 24mm x 36mm (standard so-called 35mm image format).

17mm extreme wide angle



35mm mild wide angle



24mm wide angle



48mm normal



## Impedance

The addition of the three currents (through the resistor, the inductance, and the capacitance), each of which is 90° out of phase with each other, in quadrature yields:

$$\begin{aligned} V &= \sqrt{V_R^2 + (V_C - V_L)^2} \\ &= \sqrt{(IR)^2 + (IX_C - IX_L)^2} \\ &= I \sqrt{R^2 + (X_C - X_L)^2} \\ &= IZ \end{aligned}$$

where  $I$  is the current,  $X_C$  and  $X_L$  are the [capacitive](#) and [inductive](#) reactances, respectively, and  $Z$  is the [impedance](#). Putting in the values of the reactances, we obtain for  $Z$ :

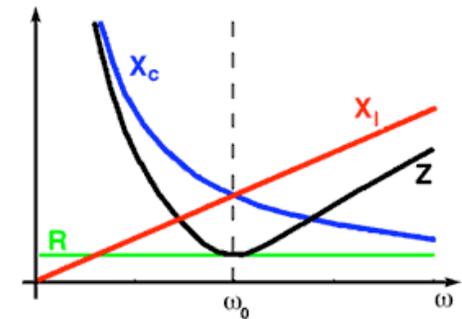
$$\begin{aligned} Z &= \frac{V}{I} = \sqrt{R^2 + (X_C - X_L)^2} \\ &= \sqrt{R^2 + \left(\frac{1}{\omega C} - \omega L\right)^2} \\ &= \sqrt{R^2 + \left(\frac{1}{2\pi f C} - 2\pi f L\right)^2} \end{aligned}$$

and has its minimum of  $Z = R$  when

$$\omega_0 = (LC)^{-1/2},$$

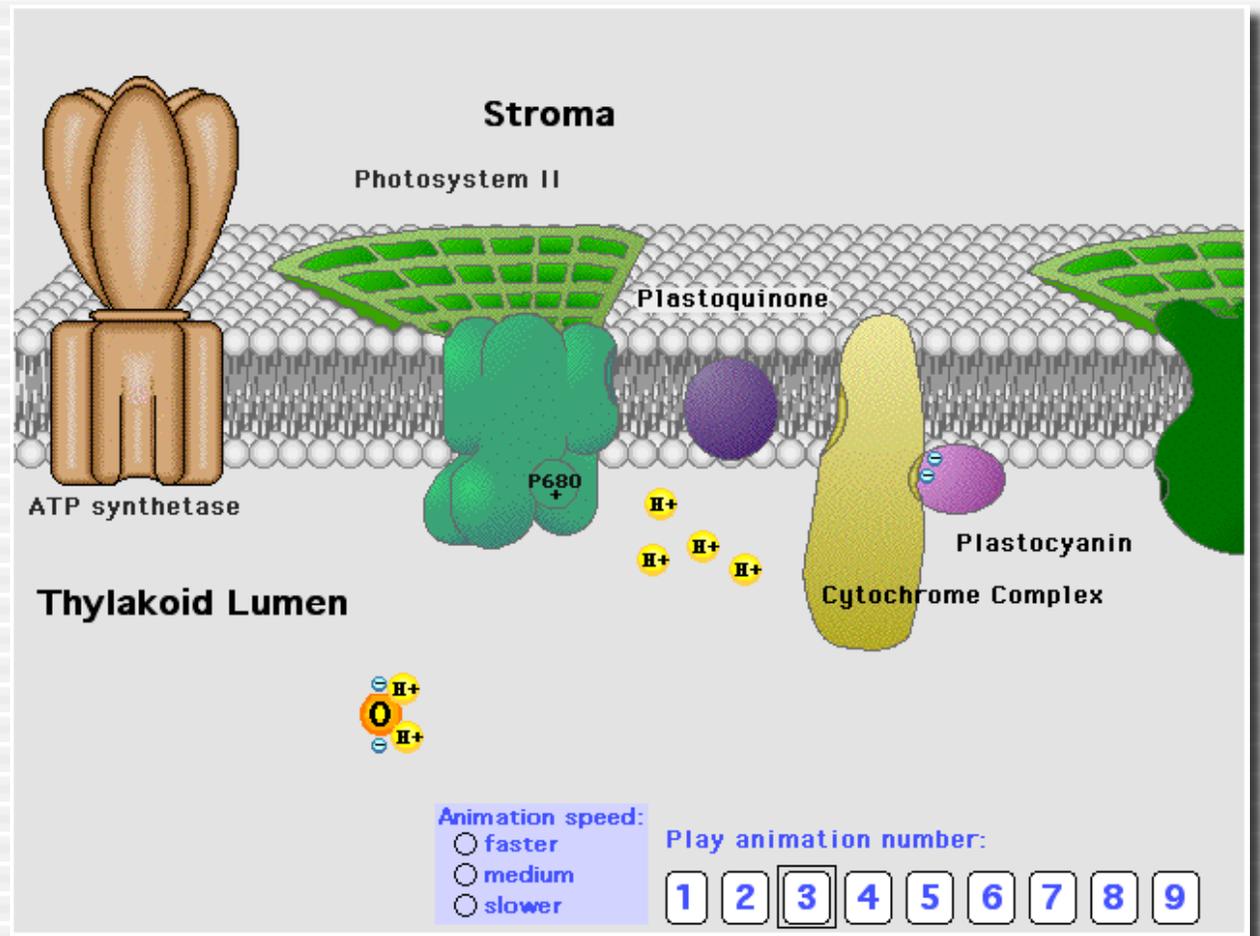
pure LC circuit. This is the [resonance frequency](#) of the RLC circuit. The reactance and of the reactances is shown in the figure.

have to be added in a special way. They end up as a single quantity  $Z$ , the [impedance](#).



# Shared Resource Library

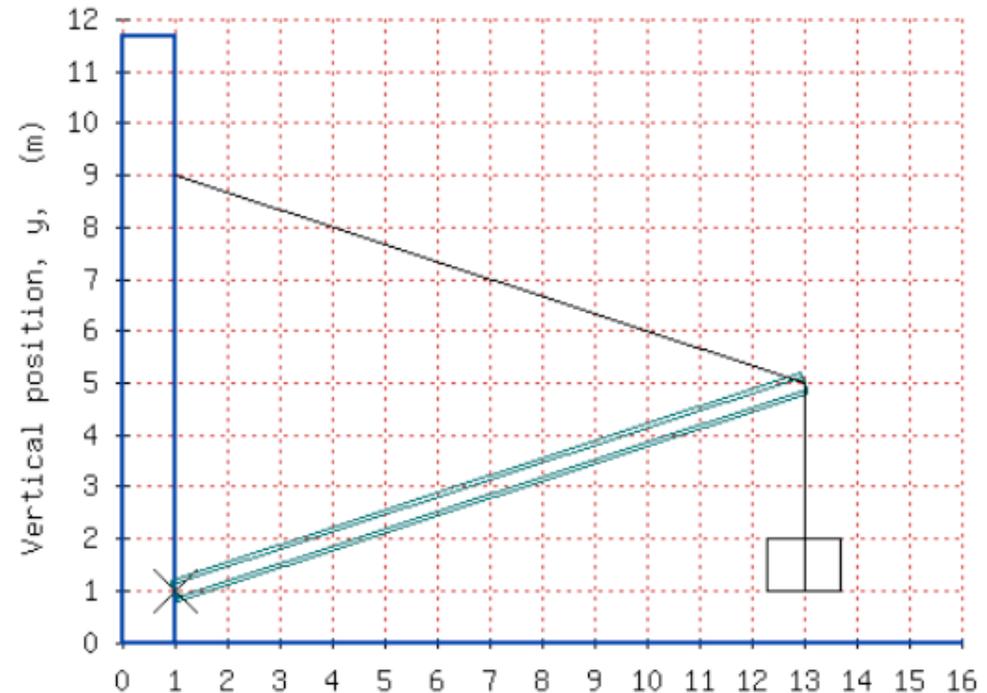
- ... or simulations and animations ...



# Shared Resource Library

- ... or this kind of randomizing online problems

A crate with a mass of 155.5 kg is suspended from the end of a uniform boom with mass of 89.5 kg. The upper end of the boom is supported by a cable attached to the wall and the lower end by a pivot (marked X) on the same wall. Calculate the tension in the cable.



# Shared Resource Library

- ...special emphasis on math
  - including support of
    - LaTeX
    - Maxima
    - R

Give an example of a function

1. which is orthogonal to  $6\cos(7x) - 2\sin(2x)$  with respect to the scalar product

$$\langle g | h \rangle = \frac{1}{\pi} \int_{-\pi}^{\pi} dx g(x) \cdot h(x)$$

2. whose norm is 1.

The function you have provided does not have a norm of one.

**Incorrect.** Tries 1

What is the derivative of

$$\begin{pmatrix} 4t^3 \\ 8t^8 \end{pmatrix}$$

with respect to  $t$ ?

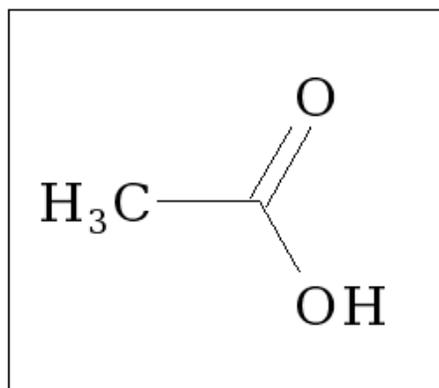
You need to multiply with the original exponent.

**Incorrect.** Tries 1

# Shared Resource Library

- ... chemistry ...

The image below is  $C_2H_4O_2$



Draw acetic acid.

Draw Molecule

Submit Answer Tries 0/99

[Post Discussion](#)

Untitled

Select substituent

☺ CLR DEL D-R +/- UDO JME

☞ — = ≡ ~ △ □ ◻ ◻ ◻ ◻

C

N

O

S

F

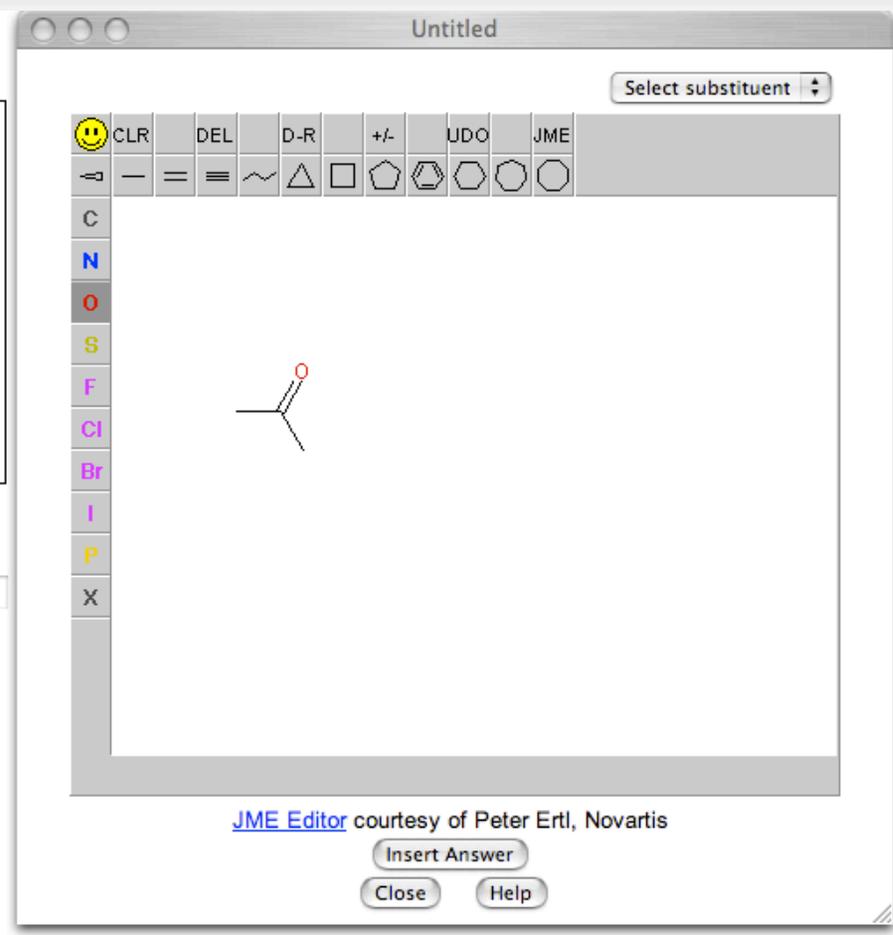
Cl

Br

I

P

X



JME Editor courtesy of Peter Ertl, Novartis

Insert Answer

Close Help

Detailed description: This is a screenshot of a web-based chemical drawing tool called JME Editor. The window title is 'Untitled'. At the top right, there is a dropdown menu labeled 'Select substituent'. Below that is a toolbar with various icons for drawing and editing molecules, including a smiley face, CLR, DEL, D-R, +/-, UDO, and JME. The main drawing area shows a skeletal structure of acetic acid (CH3COOH) with a red oxygen atom. On the left side of the drawing area is a vertical toolbar with buttons for elements: C, N, O, S, F, Cl, Br, I, P, and X. At the bottom of the window, there are buttons for 'Insert Answer', 'Close', and 'Help', along with a credit line: 'JME Editor courtesy of Peter Ertl, Novartis'.

# Shared Resource Library

- ... physical units ...

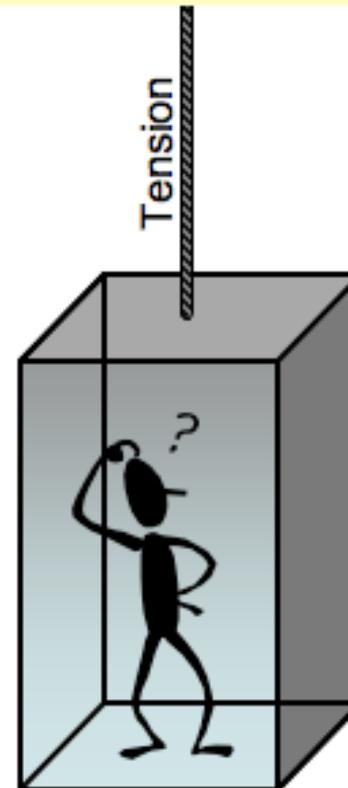
## Elevator Problem

Due never

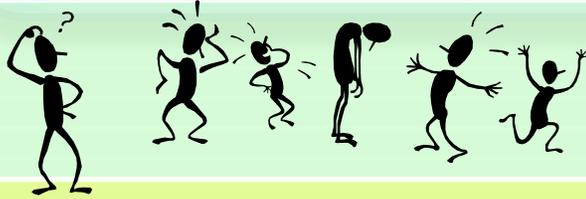
An elevator (cabin mass 500 kg) is designed for a maximum load of 2600 kg, and to reach a velocity of 3 m/s in 5 s. For this scenario, what is the tension the elevator rope has to withstand?

Submit Answer

Tries 0/99



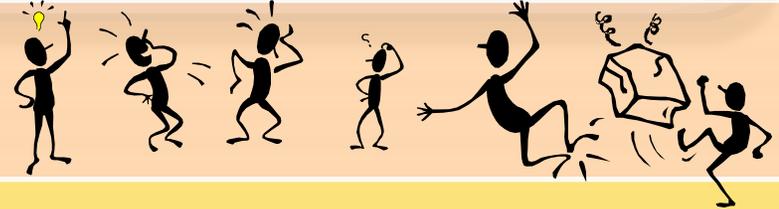
# LON-CAPA Architecture



Course Management

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Resource Assembly



Course Management

Campus B

Resource Assembly

Shared Cross-Institutional Resource Library

# Resource Assembly

- Shopping Cart

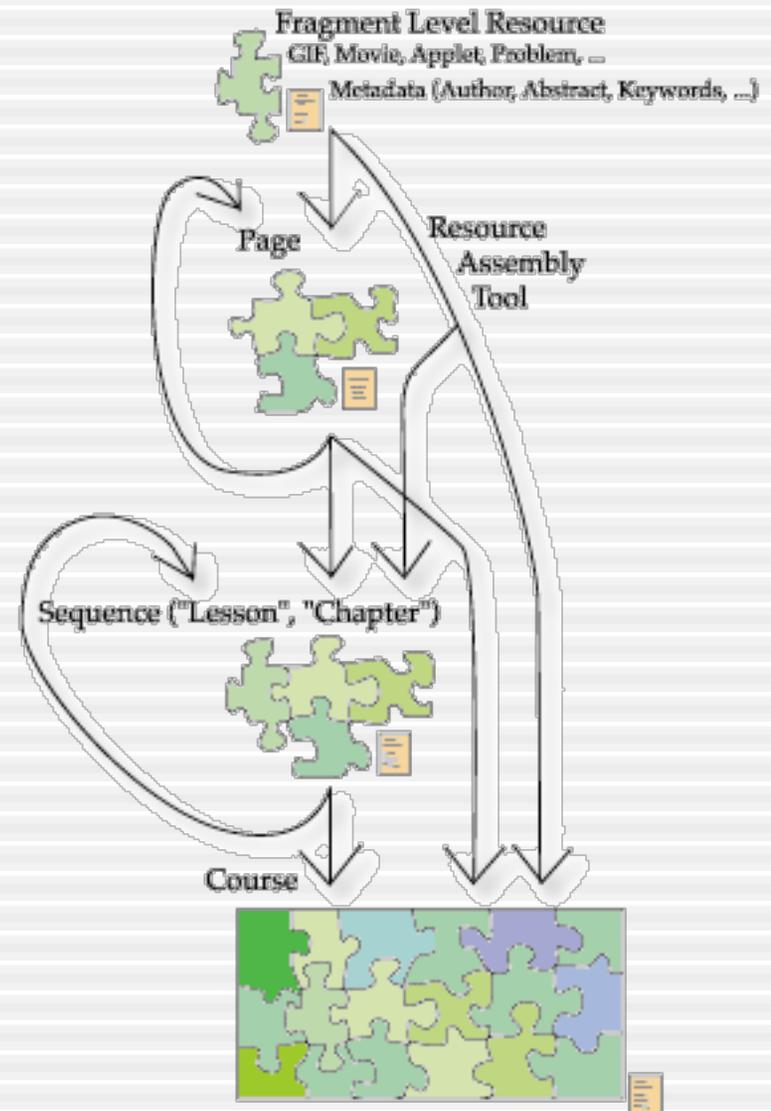


“Supermarket”

▶	Domain - sc (University of South Carolina)
▼	Domain - sfu (Simon Fraser University)
▶	batchelo
▶	chem281
▶	exafs
▶	hanlan
▶	mxchen
▶	slavieri
▶	vjungic
▶	Domain - sunysb (SUNY Stony Brook)
▼	Domain - tmcc (Truckee Meadows Community College)
▶	jensen
▶	mbauer
▼	souza
▶	Greenberg
	default.sequence (metadata)
▶	samples
▶	testuser1
▶	Domain - ucf (University of Central Florida)

# Resource Assembly

- Nested Assemblies
- No pre-defined levels of granularity („module“, „chapter“, etc)
- People can never agree what those terms mean
- Re-use possible on any level



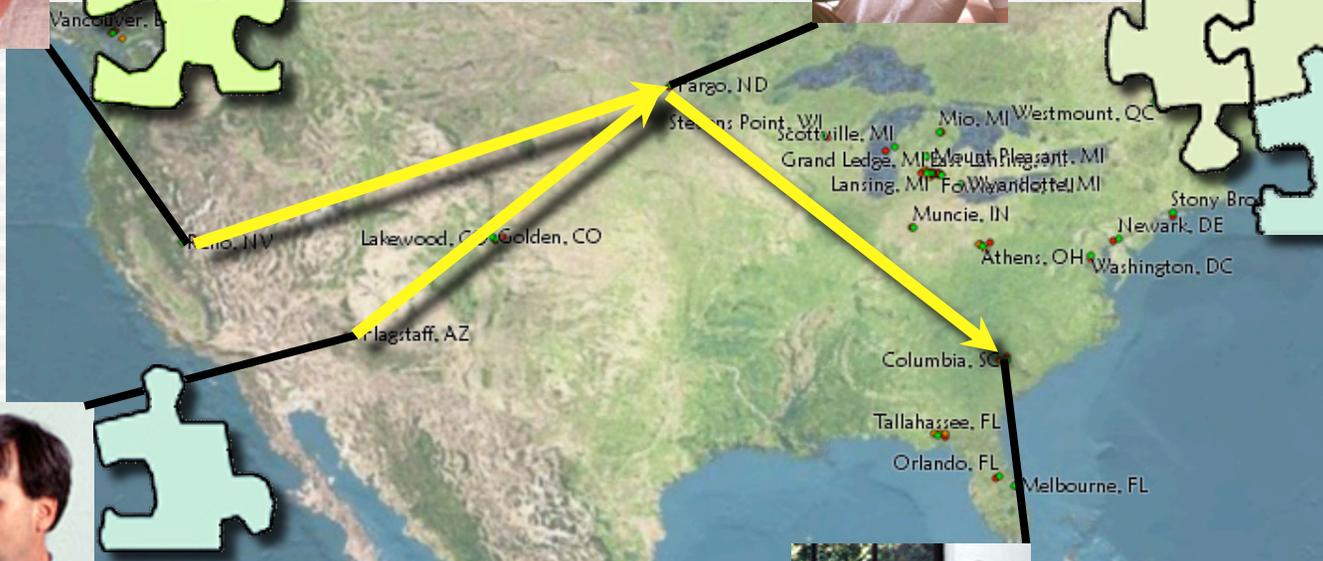
# Resource Assembly



Writes module about energy conservation



Compiles module about conservation laws

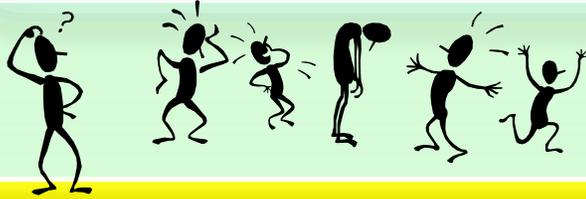


Writes module about momentum conservation



Uses whole assembly in his course

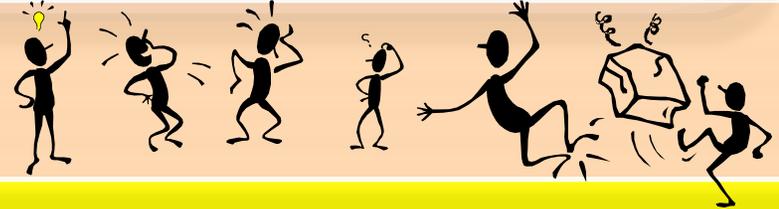
# LON-CAPA Architecture



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Course Management

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Shared Cross-Institutional Resource Library

# Course Management

- Instructors can directly use the assembled material in their courses
  - navigational tools for students to access the material
  - grade book
  - communications
  - calendar/scheduling
  - access rights management
  - portfolio space

The screenshot shows a web interface for navigating course contents. At the top, there are navigation links: [Main Menu](#), [Return to Last Location](#), [Navigate Contents](#), and [Course Documents](#). Below these is a header for "Navigate Course Contents". A search bar contains "Select Action" and a "Go" button. A "Sort by:" dropdown menu is set to "Default". The main content area lists course items with icons and status indicators:

	<a href="#">Syllabus</a>		
	<a href="#">Calendar Overview</a>		
	<a href="#">Electrostatics</a>		
	<a href="#">Electric Field</a>		
	<a href="#">Capacitors</a>		
	<a href="#">Capacitors</a>		
	<a href="#">Capacitors Materials</a>		
	<a href="#">Capacitors Homework</a>		
	<a href="#">Force</a>		Answer available
	<a href="#">Spherical Capacitor</a>		Answer available
	<a href="#">Separation</a>		Answer available
	<a href="#">Dielectric Constant</a>		Answer available
	<a href="#">Energy Stored</a>		Answer available
	<a href="#">Dielectric constant 2</a>		Answer available
	<a href="#">Energy Density</a>		Answer available
	<a href="#">Capacitance</a>		Answer available
	<a href="#">Capacitance 2</a>		Answer available

# Course Management

- Course management functionality is superset of course management functionality offered by BlackBoard™, WebCT™, and ANGEL™ (now all part of Blackboard™)

Course Action Items

Gerd Kortemeyer  
 Course Coordinator  
 LBS 272 - Spring 2006

LBS 272 - Spring 2006 -> Display Action Items
What's New?

Go to [first resource](#)  
 Page set to be displayed after you have selected a role in this course? Currently: *What's New?* page (user preference) [Change](#) for just this course or for all your courses.

[Hide all](#) [Show all](#)

Problems requiring handgrading		<a href="#">Hide</a>
Problem Name	Number ungraded	
Electric Field	4	

Problems with errors		<a href="#">Hide</a>
<i>No problems with errors</i>		

Problems with av. attempts $\geq 3$ or deg. difficulty $\geq 0.8$ and total number of students with submissions $\geq 4$							<a href="#">Hide</a>
							Change thresholds?
Resource	Part Num.	Num. students	Av. Attempts	Deg.	Diff	Last Reset	Reset Count?
Field Lines	single part	24	2.12	0.84			<input type="checkbox"/>
Net Force	single part	53	2.49	0.80			<input type="checkbox"/>
Pith Balls	single part	52	4.12	0.90			<input type="checkbox"/>

[Reset counters to 0](#)

Resources in course with version changes since last week				<a href="#">Hide</a>
				Change interval?
Resource	Last revised	New version	Version used	
Applet: Electron Orbit	Fri Jan 13 10:18:52 2006 (EST)	10	10	
Capacitance of a Sphere	Mon Jan 16 12:03:13 2006	8	8	

Unread course discussion posts				<a href="#">Hide</a>
				Change options?
Location	Type	Time of last post	Number of new posts	
<a href="#">Coulomb</a>	Resource	last Monday, Jan 16 at 04:55 pm (EST)	1	
<a href="#">Distance Change</a>	Resource	last Monday, Jan 16 at 07:00 pm (EST)	1	
<a href="#">Field Lines</a>	Resource	last Monday, Jan 16 at 07:49 pm (EST)	1	
<a href="#">Force</a>	Resource	on Wednesday, Jan 11 at 07:01 pm (EST)	3	
<a href="#">Net Force</a>	Resource	23 hours, 19 minutes ago	5	
<a href="#">Pith Balls</a>	Resource	last Monday, Jan 16 at 09:21 pm (EST)	6	
<a href="#">Point P</a>	Resource	last Friday, Jan 13 at 02:34 pm (EST)	5	
<a href="#">Potential</a>	Resource	last Sunday, Jan 15 at 03:15 pm (EST)	1	
<a href="#">Two Charges</a>	Resource	last Sunday, Jan 15 at 03:26 pm (EST)	1	
<a href="#">Vector</a>	Resource	last Saturday, Jan 14 at 01:32 am (EST)	1	
<a href="#">Vectors</a>	Resource	last Saturday, Jan 14 at 12:09 pm (EST)	2	

New course messages				<a href="#">Hide</a>
Number	Subject	Sender	Date/Time	
1.	<a href="#">Feedback</a> [msu/mmp/kap18/problems/cd460.problem]	@msu	Sat Jan 14 10:45:02 2006 (EST)	

New critical messages in course		<a href="#">Hide</a>
<i>No unread critical messages in course</i>		

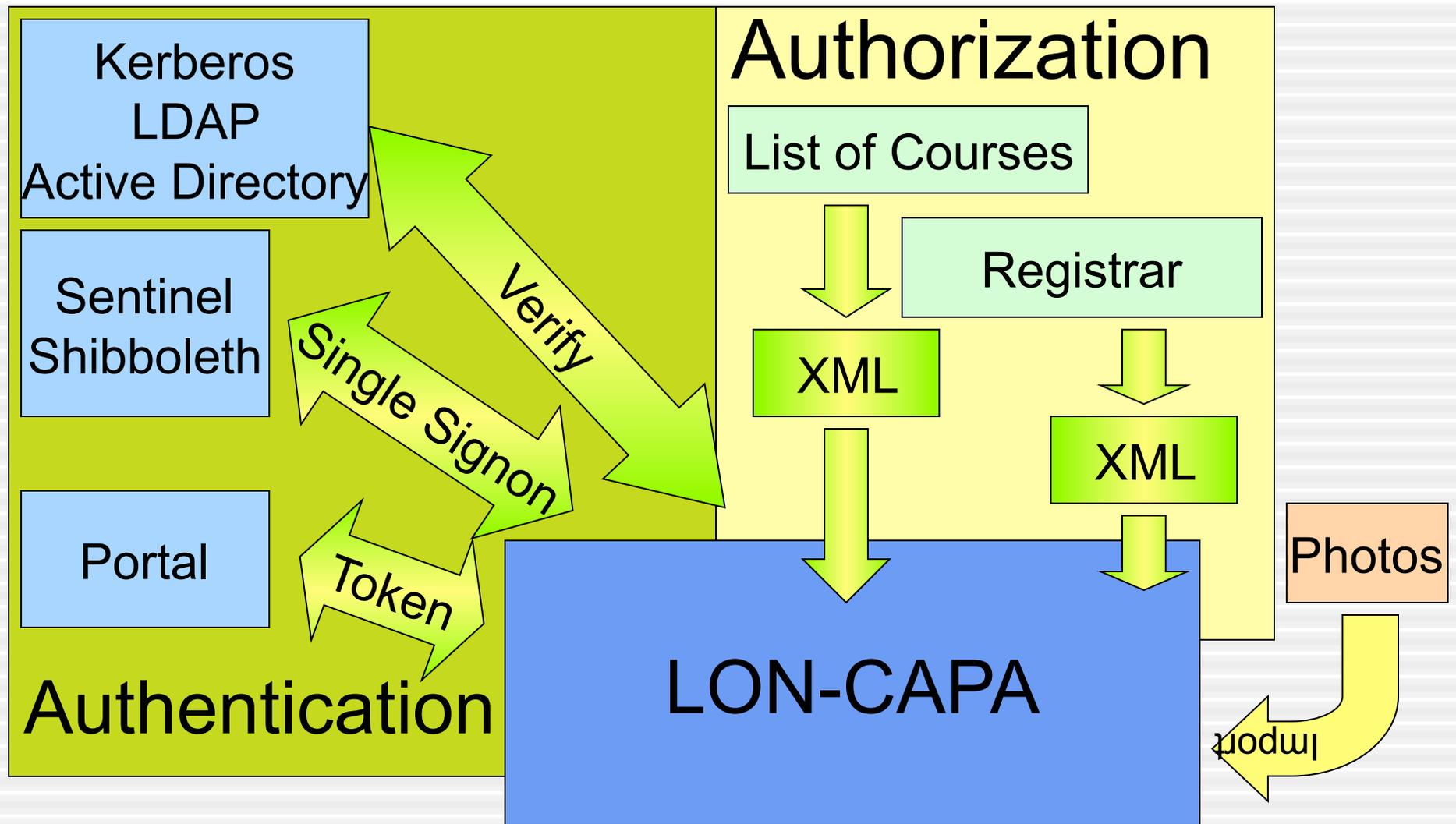
# Course Management

- Courses can be imported into LON-CAPA

The screenshot displays a Blackboard LMS interface. On the left is a navigation menu with buttons for MSU Tools, Announcements, Course Information, Staff Information, Course Documents, Assignments, Communication, External Links, Student Tools, Resources, Course Map, My Blackboard, Search, Logout, Control Panel, and Administer System. The main content area is titled 'Course Documents' and shows a list of course sections: Course Summary, Section 1: Introduction to Environmental Geol, Section 2: Earth system and Earth materials, Section 3: Plate tectonics, Section 4: Earthquakes, Section 5: Volcanoes, Section 6: Landslides and subsidence, Section 7: Rivers, Section 8: Coasts, Section 9: Soils, Section 10: Geology & Climate, and Section 11: Water resources and pollution. On the right, a 'Navigate Course Contents' panel shows a tree view of the course structure, including Syllabus, Course Information, Course Documents, and various sections with their sub-items like notes, images, and fulltext.

# Course Management

- Integrates well with central IT



# Course Management

- Interface can be translated

**Change Your Language Preferences**

Home Bookmarks The LearningOnline ... Welcome Set-Up Page

Remote Control

メインメニュー 最後に戻る コンテンツをナビゲートする リモコンパネルを使う LON-CAPA mentos Suplementares do Curso

**メインメニュー**

ROLES 他の役割に切り替える

DOCS このコースに含まれているドキュメントを

NAV コースの目次をナビゲートする

SPRS コースの成績を計算する(スプレッドシート

CHRT 成績の伸長グラフを見る

STAT コースのテストの統計を見る

ENRL コースに / から学生を追加 / 削除する

CUSR ユーザを追加、役割・権限を変更

PARM 締め切りを設定し、その他の試験のパラメ

RES 公開されたリソースを見る

Remove Rename <N>

Обновить но

**Importieren eines veröffentlichten Dokumentes**

Suchen Importieren ?

Wähle Seite/Sequenz Lade Seite/Sequenz ?

**Spezielle Dokumente**

Neuer Ordner ?

External Resource ?

Kursüberblick ?

Inhaltsverzeichnis ?

Einfache Seite ?

Einfache Aufgabe ?

Formular zum Hochladen von Noten ?

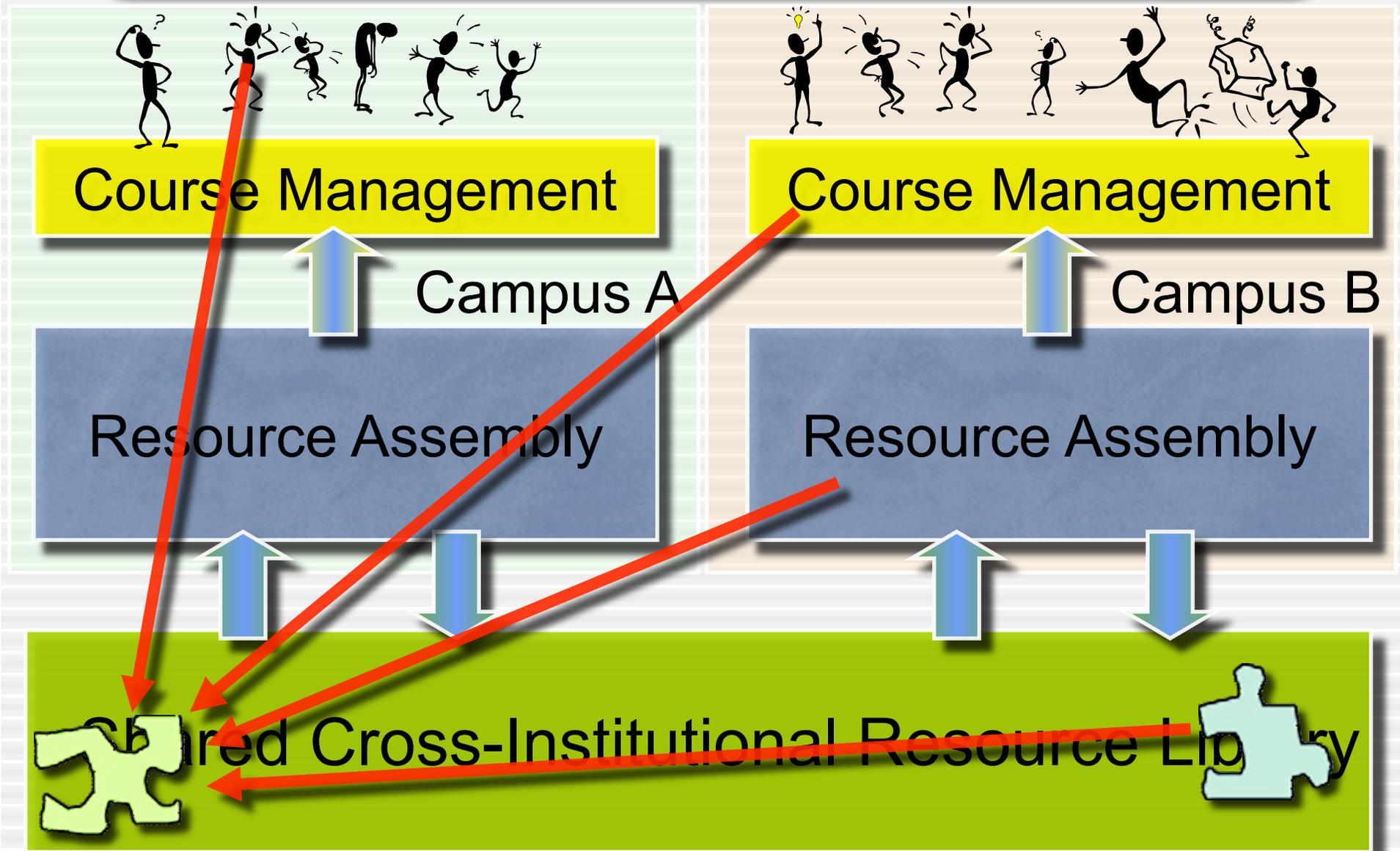
Schwarzes Brett ?

Meine persönliche Information ?

mentar para o cu

Browse...

# Dynamic Metadata



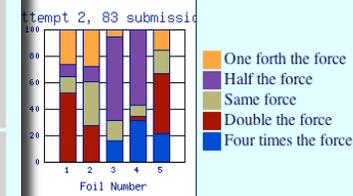
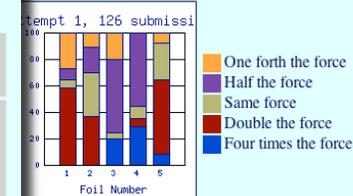
# Dynamic Metadata

- Dynamic metadata from usage
- Assistance in resource selection („amazon.com“)
- Quality control

Foil Number	Foil Name	Foil Text	Correct Value
1	1.6.1.1.2	The distance between the two charges is cut in half.	Four times the force
2	1.6.1.2.2	The magnitude of both charges is doubled.	Four times the force
3	1.6.1.3.2	The magnitude of one of the two charges is doubled.	Double the force
		distance between the charges is doubled.	One forth the force
		charges are placed in a medium with a factor two higher permittivity.	Half the force

## Access and Usage Statistics

Network-wide number of accesses (hits)	890
Number of resources using or importing resource	1 <ul style="list-style-type: none"> <li>• <a href="#">Eukaryotic Gene Control [msu/bio/Gene Expr/111f03GeneCtr1.sequence]</a></li> </ul>
Number of resources that lead up to this resource in maps	1 <ul style="list-style-type: none"> <li>• <a href="#">Back to the Original Question [msu/bio/Gene Expr/problems/originalquestion.problem]</a></li> </ul>
Number of resources that follow this resource in maps	1 <ul style="list-style-type: none"> <li>• <a href="#">Eukaryotic vs Prokaryotic Gene Expression II [msu/bio/Gene Expr/problems/eukvsprokII.problem]</a></li> </ul>
Network-wide number of courses using resource	3 <ul style="list-style-type: none"> <li>• <a href="#">LBS 145 - Spring 2004</a></li> <li>• <a href="#">ZOL 341 - Fall 2003</a></li> <li>• <a href="#">BS 111 - Fall 2003</a></li> </ul>



## Assessment Statistical Data

Total number of students who have worked on this problem	291
Average number of tries till solved	1.37
Degree of difficulty	 (0.36)



Research

# Research

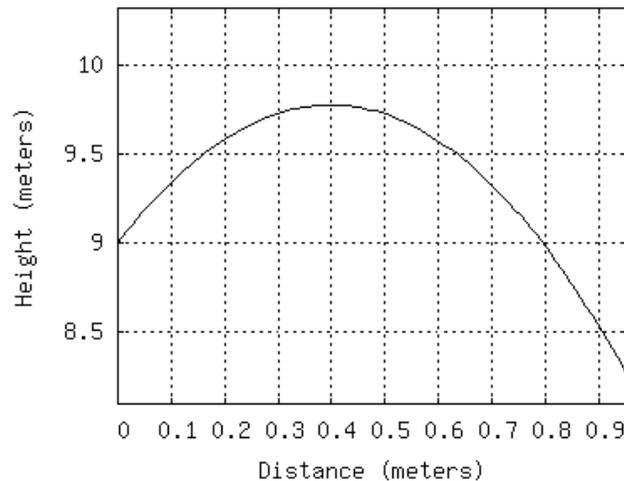
- In spite of being very much a production system, after all based at universities
- Over the years, research on ...
  - resource sharing
  - effectiveness of online homework
  - online student discussions
  - gender differences
- Not enough time to go into details

# Resource Sharing

- Online communities of practice
- Contributors versus users (institutions)

		U01	U04	PR01	U06	U17	U05	U03	HS20	U12	PR06	U11	U08	U
Available	144418	17545	10809	8799	7635	7037	5120	4439	4066	3750	3283	2989	27	
Used	38245	7596	340	4821	2908	4880	3411	3842	2841	1502	1231	2102	3	
Used externally	17099	1804	339	974	276	3507	1735	1035	1997	1502	415	62	3	
Using														
U01	38855	34790	301	105	17	49	1621	294	74	102	298	137	3	
U05	11668	4881	23	14	3	33	4357	866	29	500	328	5	3	
U04	10343	2393	6969		10		207	374	8	128	2	18		
U06	10089	2261	64	13	4755		305	1001	8	10	2	72	2	2
U03	9973	4053	58	27	5	84	1213	3173	7	728	14	166		
U08	8578	2014	1078	6	2	2	720	5					2097	
HS20	6465	2138	1	47			40	350	3767	21	70	4		
CC04	6356	1156	25		2	31	1586	789	197	1522		64	7	
U17	6270	2689	4	7		2813	188	205	94	140	4		2	
HS40	5251	3899	22	5		40	65	293	388	70	27	16	1	
U14	5135	1682	213	42	12	1	665	42		3	7	114		
U09	4246	3409	7		1			15		1		1		
U12	3768	184					136	760		2684				
HS39	3467	2101	19	20	5	2	68	26	29	1	808	71		

# Online Discussions



## Discussions

Encouraged, since all students have different versions. Peer-Teaching.

The plot shows the trajectory (height versus distance) of an object launched at an angle of 75.6 degrees. What was the initial speed of the object? **4.0 m/s**  
Computer's answer now shown above. Tries 0/12

[Threaded View](#) [Chronological View](#) [Sorting/Filtering options](#) [Export?](#)

*Anonymous 1* (Fri Sep 22 01:26:29 2006 (EDT))

any hints to start?

**Re:** *Anonymous 2* (Fri Sep 22 01:56:48 2006 (EDT))

You need to find the Y component of velocity... you can do this by finding the height traveled (notice it does not start on the ground) and combining that with acceleration in a kinematics equation. From there use trig to get the original velocity.

**Re: Re:** *Anonymous 1* (Fri Sep 22 12:10:37 2006 (EDT))

how can we find the height traveled and how can we get the acceleration if we don't have the time?

*Anonymous 3* (Fri Sep 22 16:41:27 2006 (EDT))

i'm lost on this one... can anyone help?

**Re:** *Anonymous 4* (Fri Sep 22 20:02:45 2006 (EDT))

Use the squared kinematics equation - so  $V_f^2 = V_i^2 + 2a(X_f - X_i)$ .

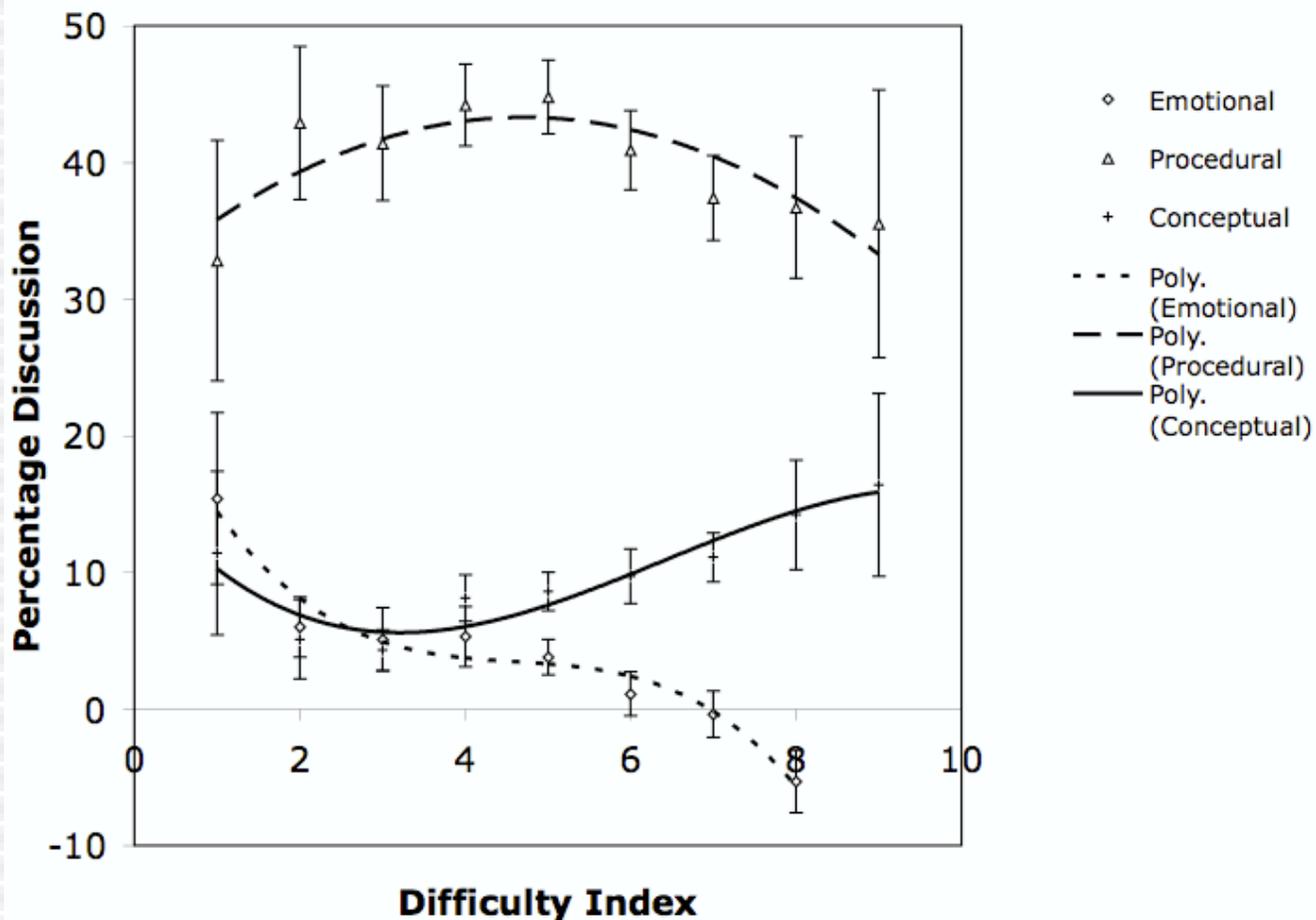
# Classification

- Classification of discussion contributions

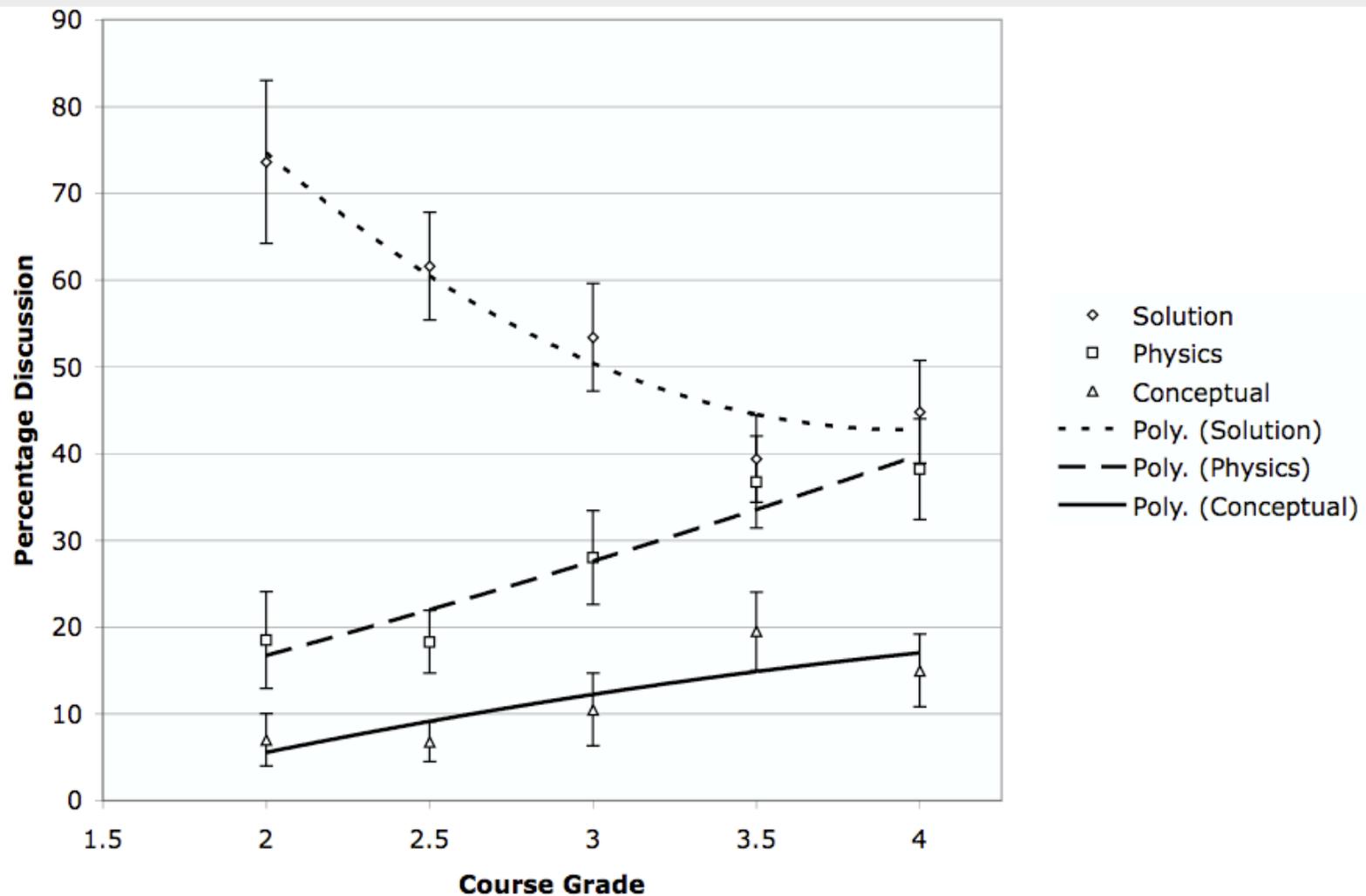
	Emotional		Surface		Procedural		Conceptual		
	Pos	Neg	Q	A	Q	A	Q	A	
Unrelated	71	54	10	1			1		137
Solution	279	185	601	341	353	456	12	3	2230
Math	1	6	49	36	73	87	3	6	261
Physics		14	85	81	170	190	100	126	766
	351	259	745	459	596	733	116	135	3394

# Influence of Problem Difficulty

- More difficult than 0.6: “more pain, no gain”

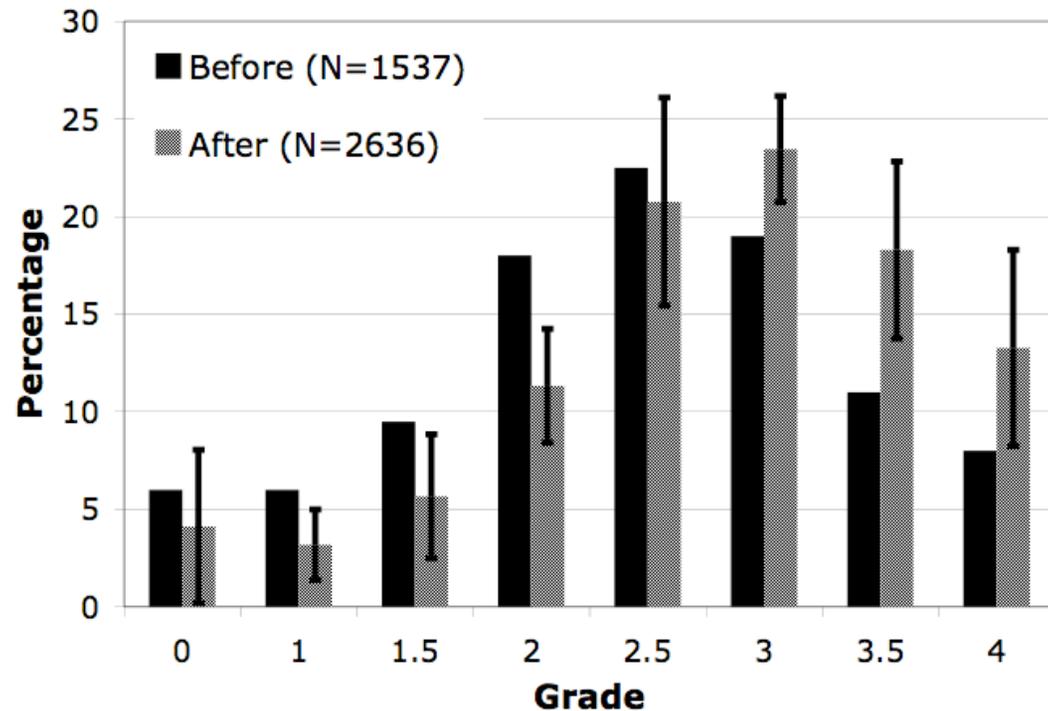


# Do better students discuss better?



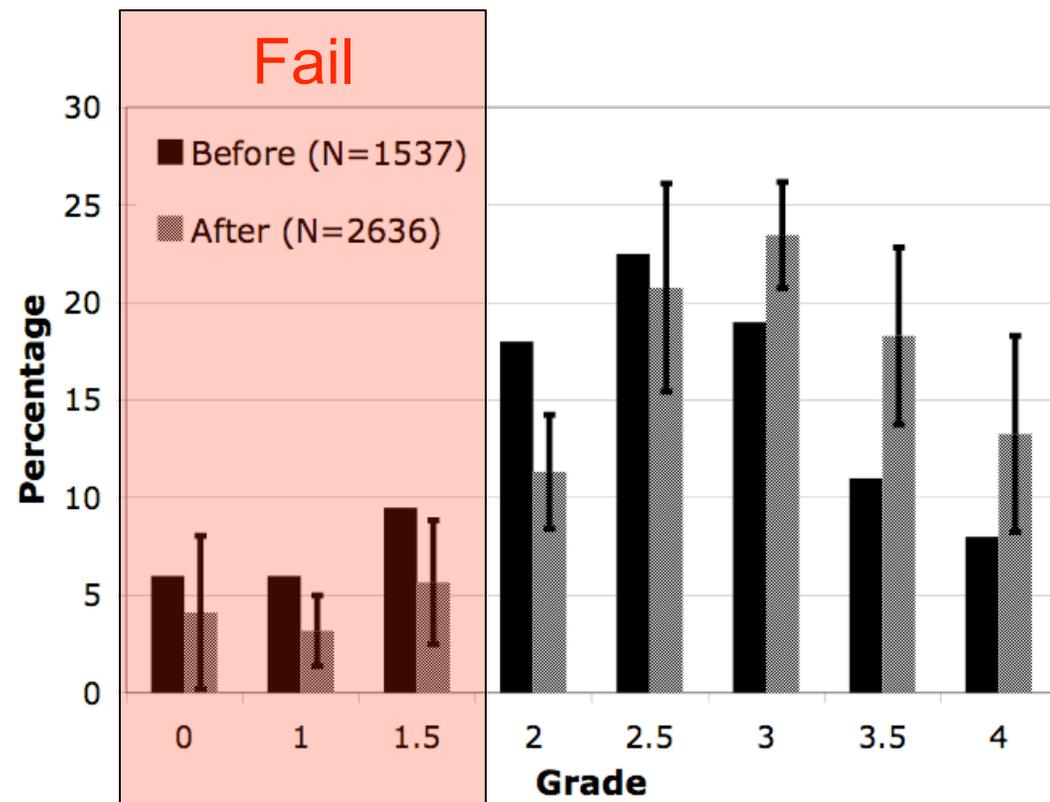
# Learning Success

Same course,  
first semester  
with, second  
semester  
without online  
homework



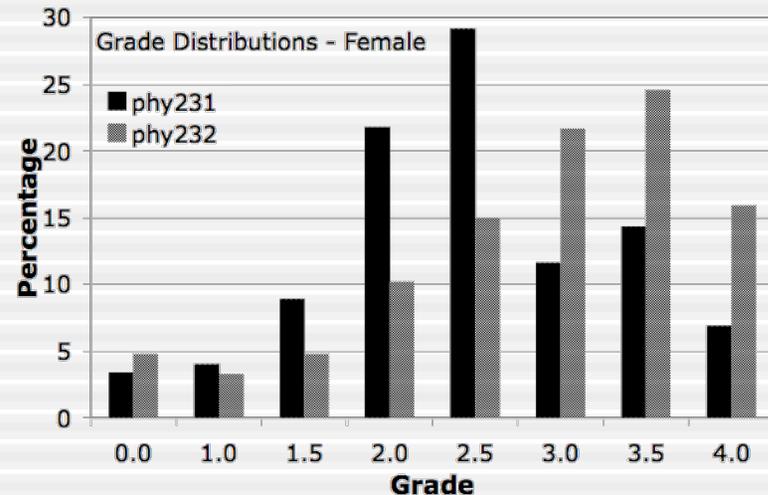
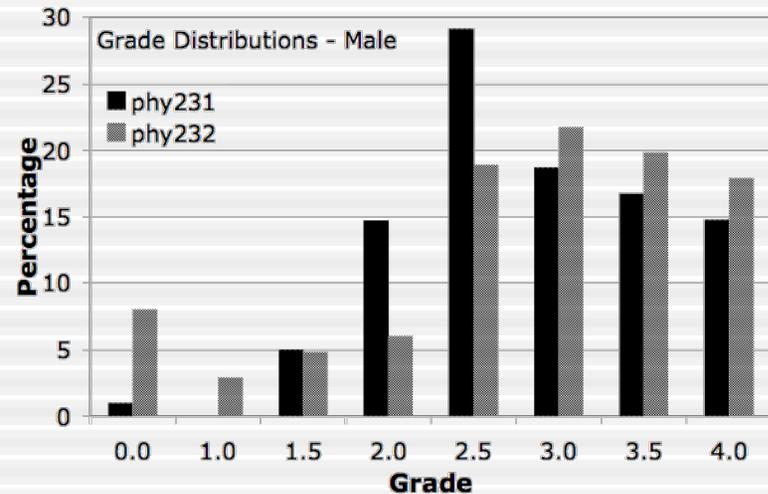
# Learning Success

Mostly helps students who are on the brink of failing the course.



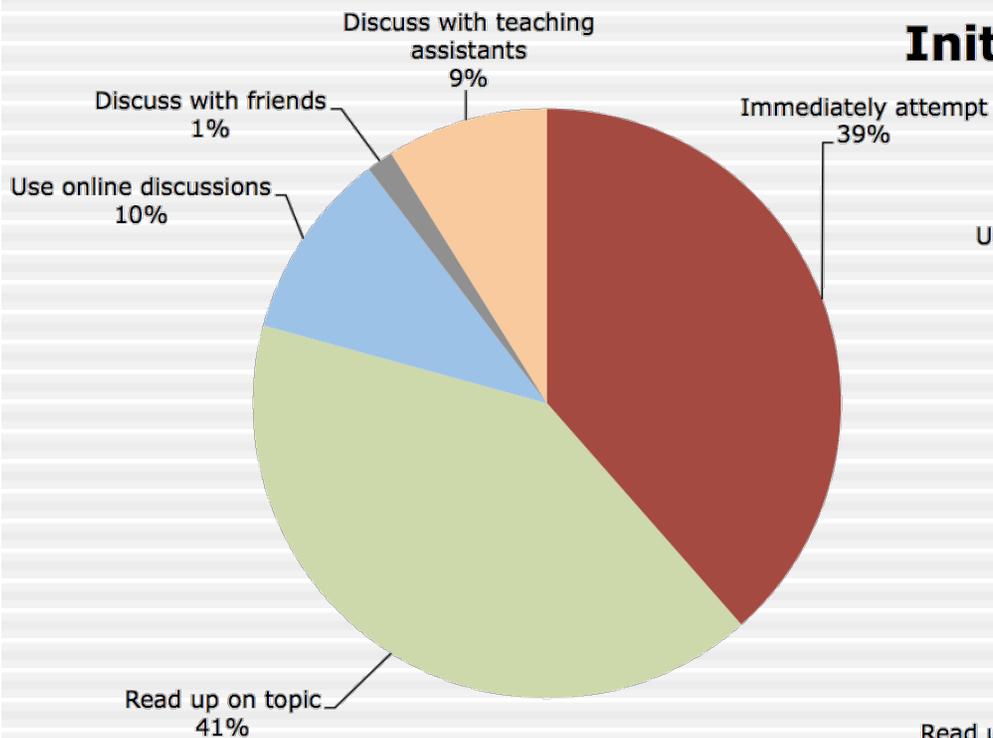
# Gender Difference

- phy231:  
without LON-CAPA
- phy232:  
with LON-CAPA
- Gender difference
- But why?

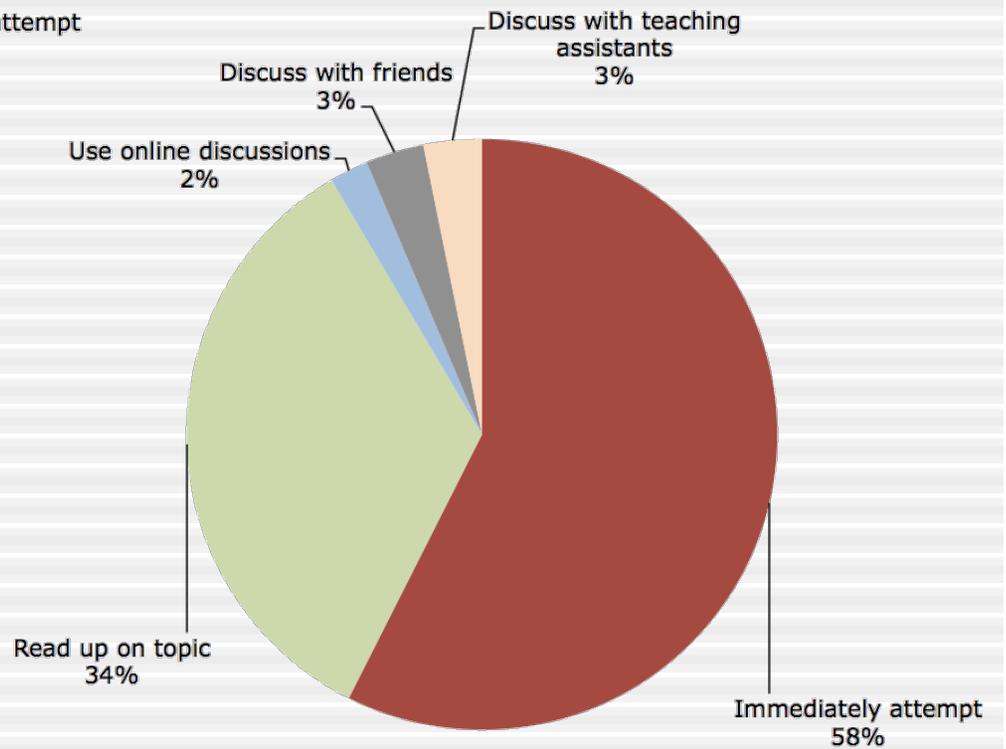


# Gender Difference

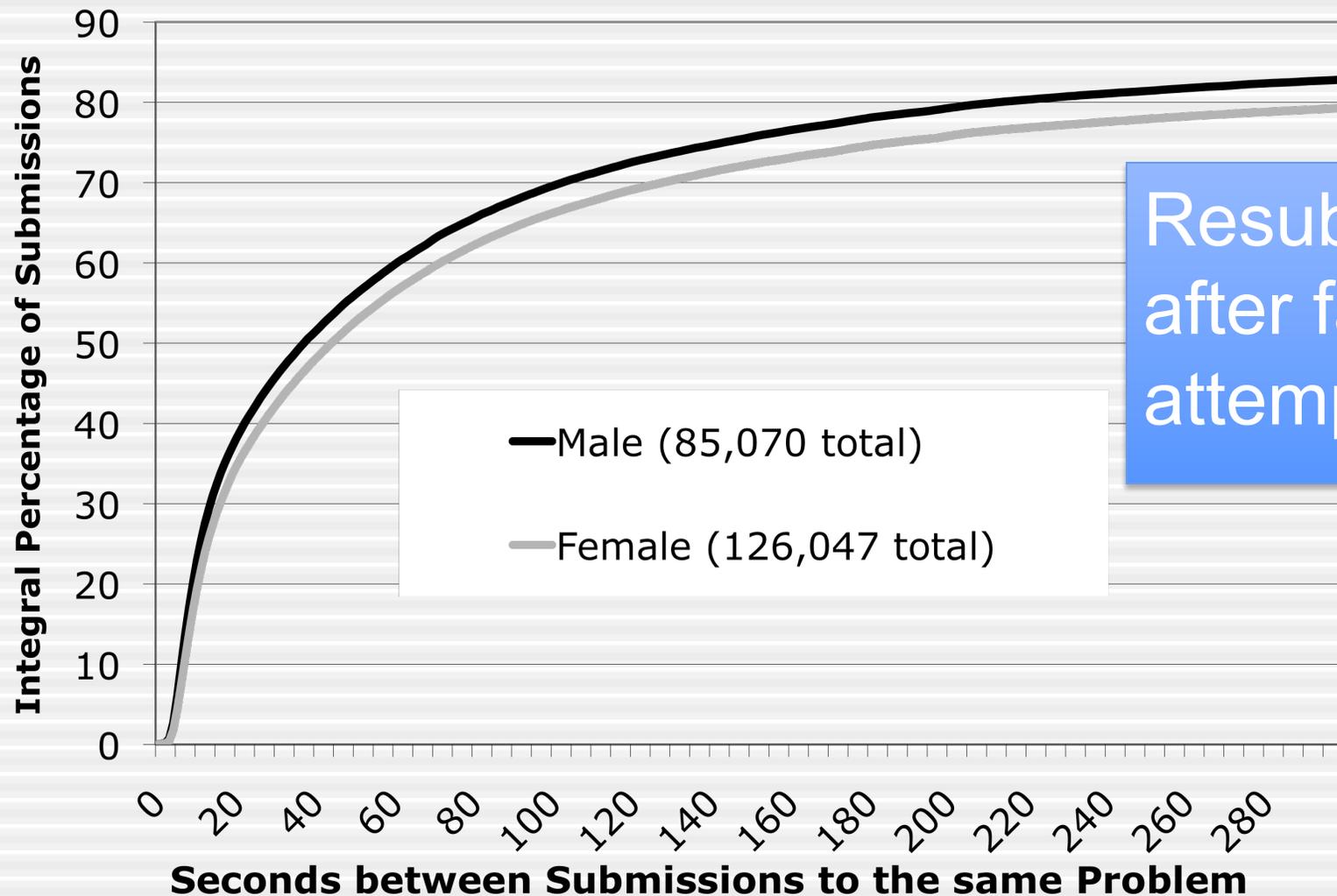
## Initial Action on Homework: Female



## Initial Action on Homework: Male



# Gender Difference



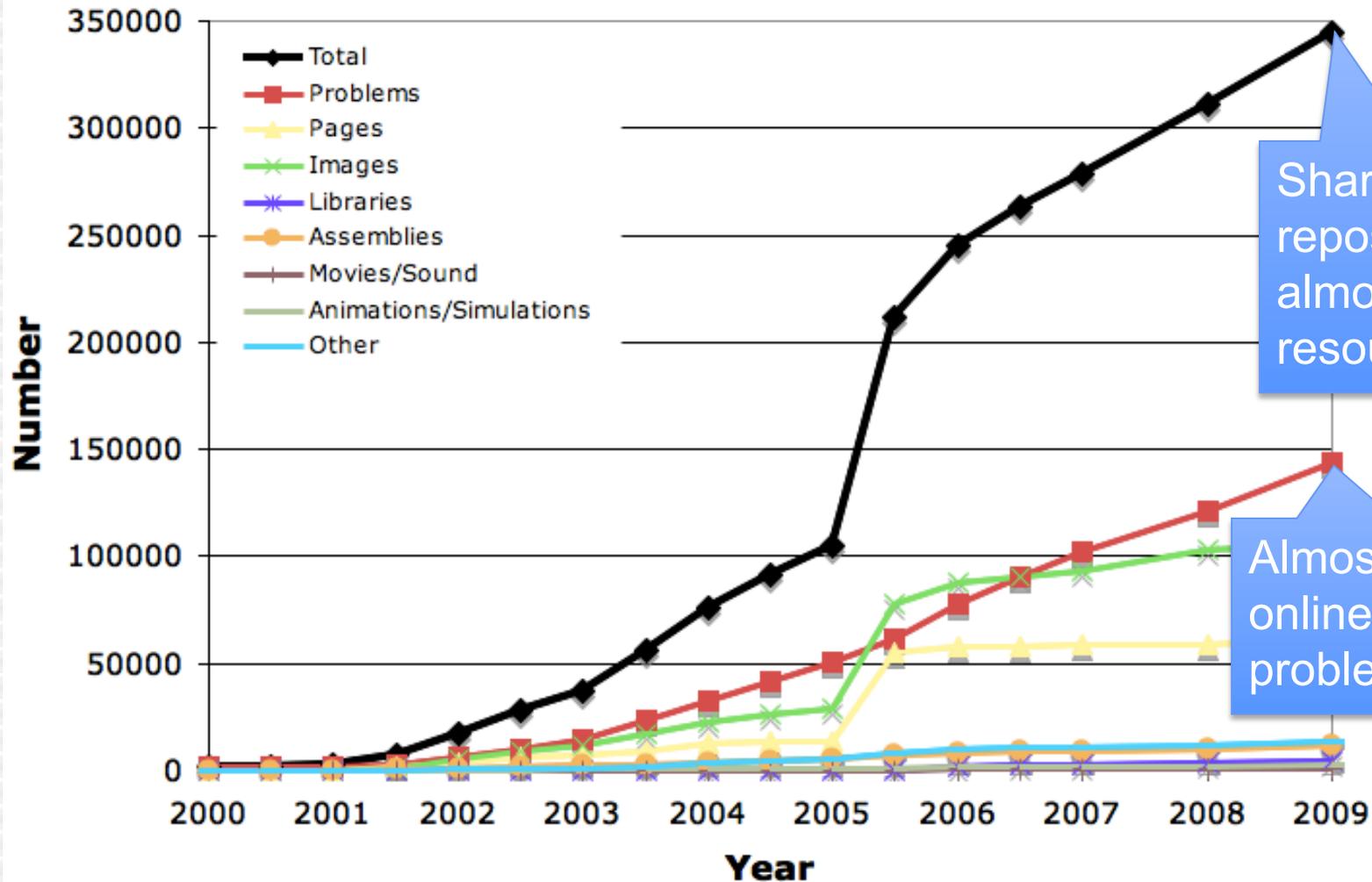
Resubmission  
after failed  
attempt

A blue pill-shaped button with a white border and a slight shadow, centered on a light gray background. The word "Community" is written in white, sans-serif font in the center of the button.

Community

# The LON-CAPA Community

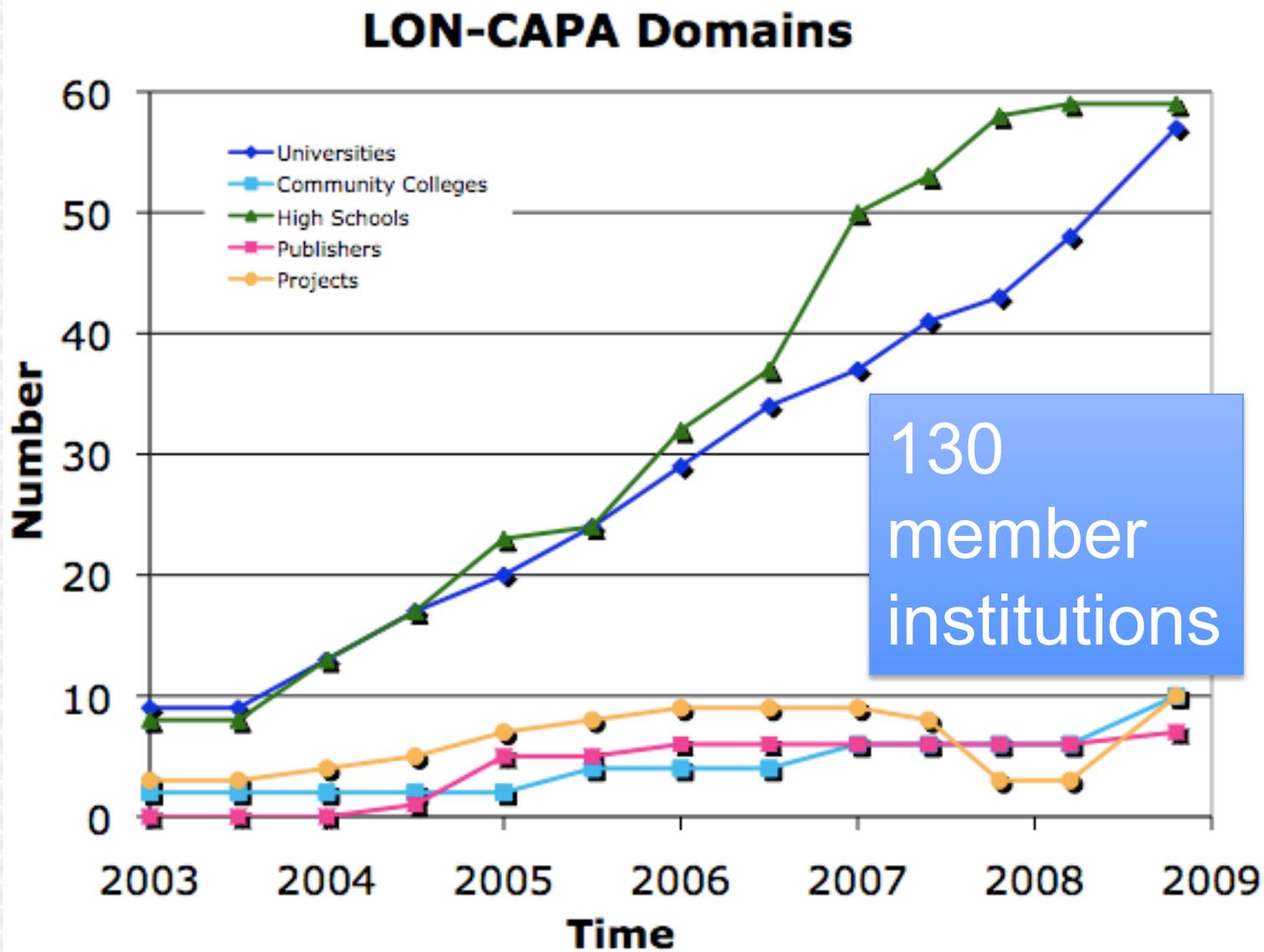
## LON-CAPA Shared Resource Pool



Shared content repository with almost 350,000 resources

Almost 150,000 online homework problems

# The LON-CAPA Community



# The LON-CAPA Community

High Schools, Colleges, and Universities



... plus grant projects and publishing companies.

# The Consortium

- Out of the 130 member institutions, five form the LON-CAPA Academic Consortium

- Three institutions that made long-term financial commitments:

- Simon Fraser University
- University of Illinois at Urbana-Champaign
- Michigan State University



SIMON  
FRASER  
UNIVERSITY



MICHIGAN STATE  
UNIVERSITY

- Two institutions continually contributing to the code base and development:

- Ohio University
- University of Applied Science, Wolfenbüttel



OHIO  
UNIVERSITY



Fachhochschule  
Braunschweig/Wolfenbüttel  
University of Applied Sciences

- Governing board and long-term sustainability

# Running LON-CAPA

- Running LON-CAPA
  - Locally
    - Dedicated Linux server or virtual machine
  - Hosted
    - <http://www.educog.com/>



# Thank You!

- More information about LON-CAPA can be found at

<http://www.lon-capa.org/>

# Mahalo!

