

Measuring Engagement in an Inverted/Flipped Class Format

Jeffery S. Thomas, PhD, PE
Assistant Teaching Professor

Civil, Architectural & Environmental Engineering

Outline

1. Resource usage
2. Satisfaction & pass rates
3. Exam performance
4. Misc. measurements

Learning analytics

is the measurement, collection, analysis and reporting of data about learners, and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs.

- George Siemens

Resource Usage



Class	Students/ Semester	Web Pages	Images	Videos
<u>Mechanics of Materials</u>	300	1750	5000	230
<i>accessed 36,000 times for 9070 hours during 2011</i> <i>accessed 19,900 times for 5830 hours during 2010</i>				
<u>Materials Testing</u>	200	1300	5500	42
<i>accessed 21,800 times for 1210 hours during 2011</i> <i>accessed 6380 times for 600 hours during 2010</i>				
<u>Structural Analysis</u>	60	500	590	10
<i>accessed 6500 times for 1770 hours in 2011</i>				

Mechanics of Materials

Summer 2012

49 students

63 hours of measured
engagement per student

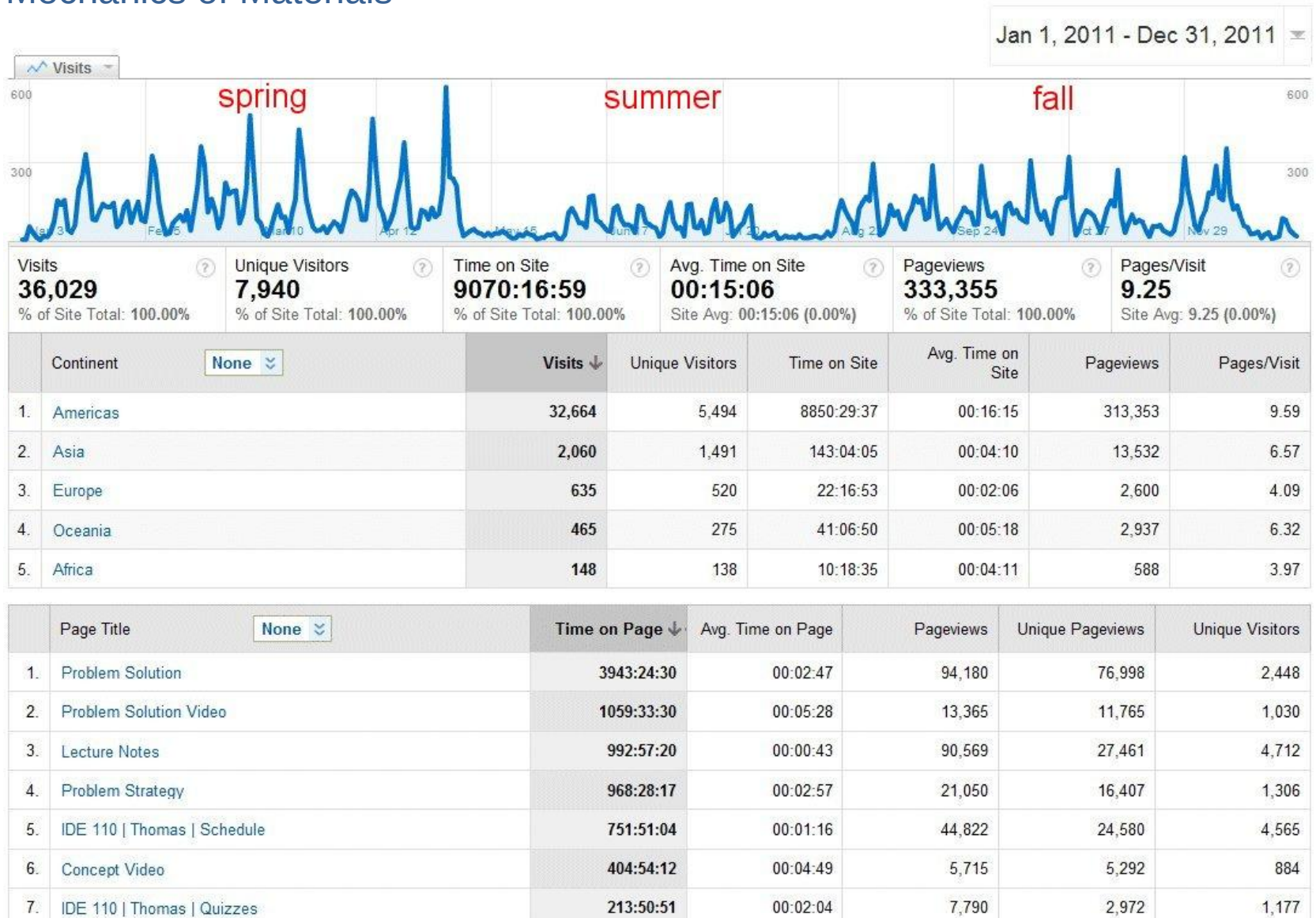
Does not include:

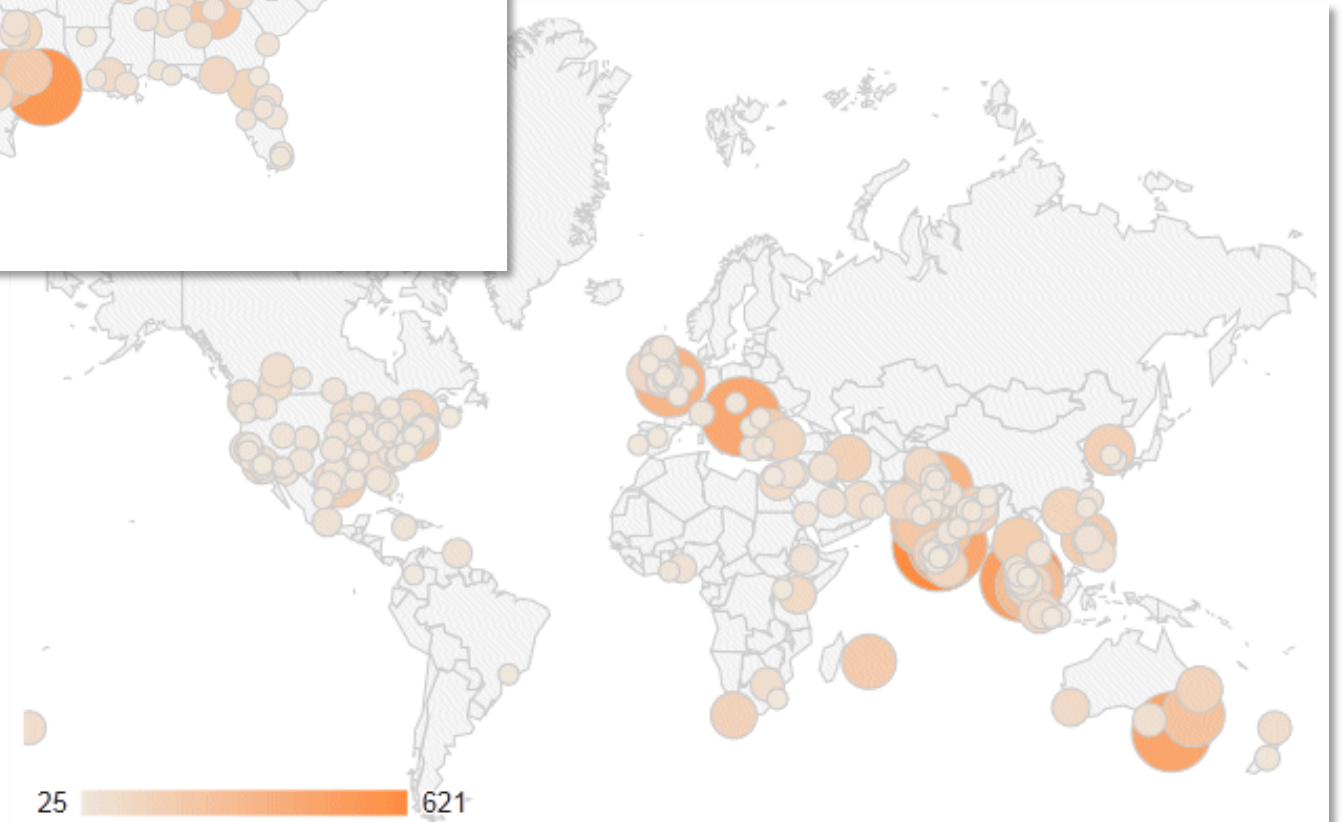
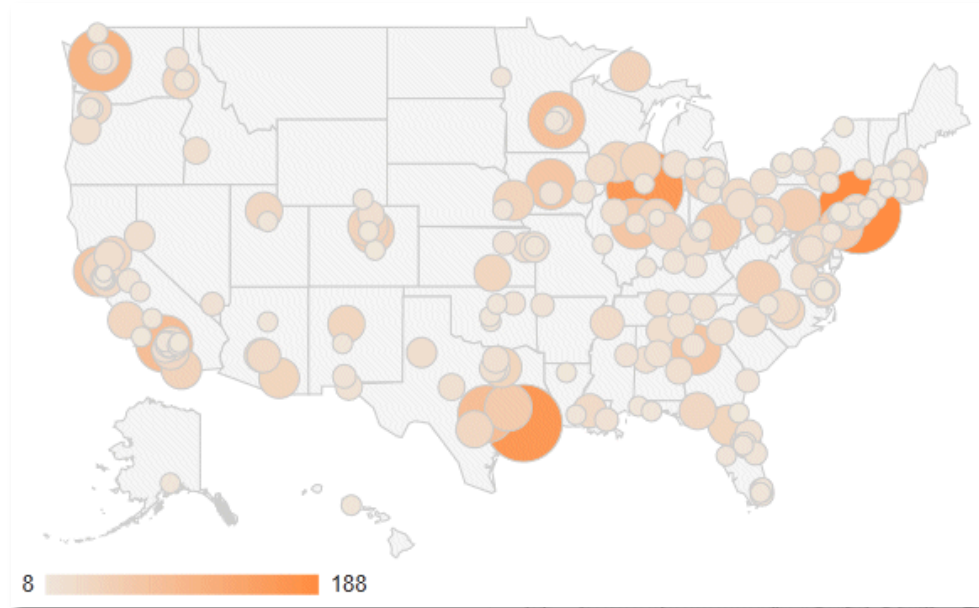
- LMS
- textbook
- MecMovies
- homework done
outside of class
- etc

Activity	Hours per Student	
Problem solutions	13.1	22.3
Problem solution videos	4.1	
Problem strategies	3.4	
Concept videos	1.0	
Lecture notes	0.6	
Demonstration videos	0.1	
Working HW in class	24.5	24.5
Taking exams	9.4	9.4
Site navigation	3.3	3.3
Semester schedule	2.1	3.4
Old exams	0.6	
Grades	0.5	
Policies	0.1	
FAQ	0.1	
Total	62.9	62.9

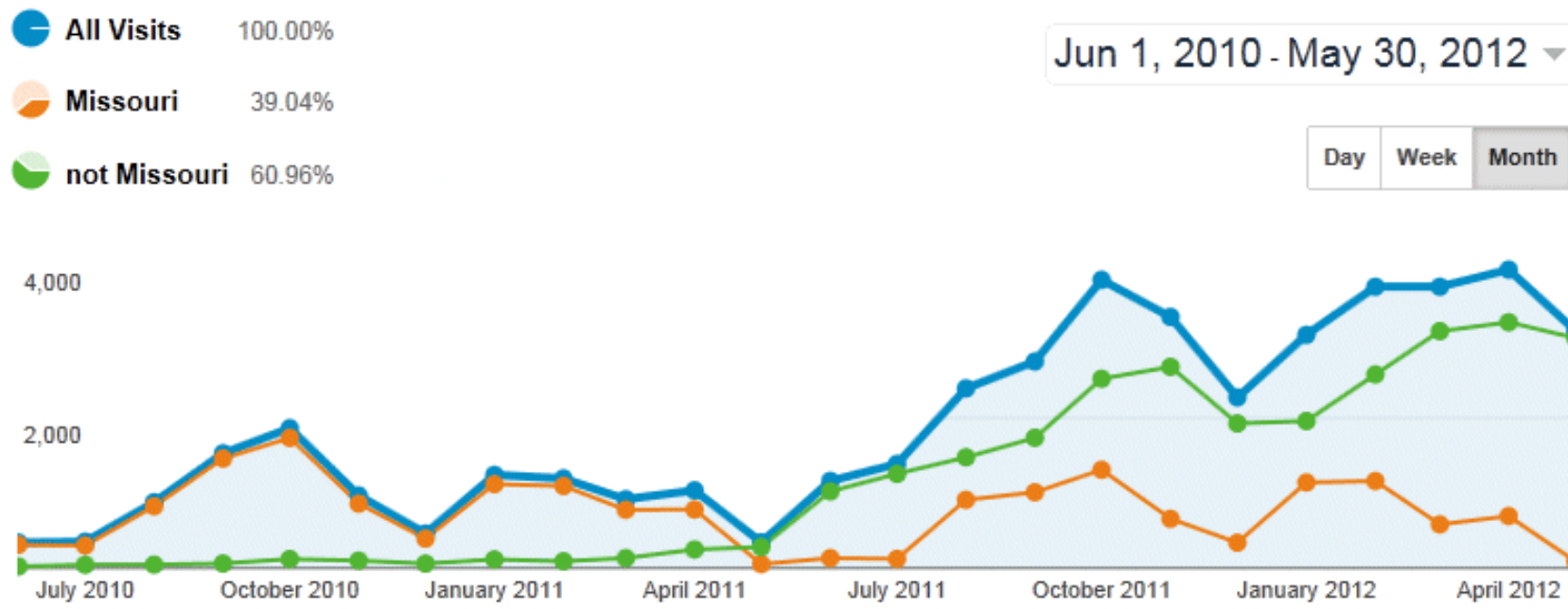
Activity	Fall 2011 (89 students)	Spring 2012 (114 students)	Summer 2012 (49 students)
Problem solutions Problem solution videos Problem strategies Concept videos Lecture notes Demonstration videos	25	25	22
Working HW in class	7	16	25
Taking exams	9	11	9
Site navigation	5	4	3
Semester schedule Old exams Grades Policies FAQ	4	4	3
Total	50	61	63

Mechanics of Materials



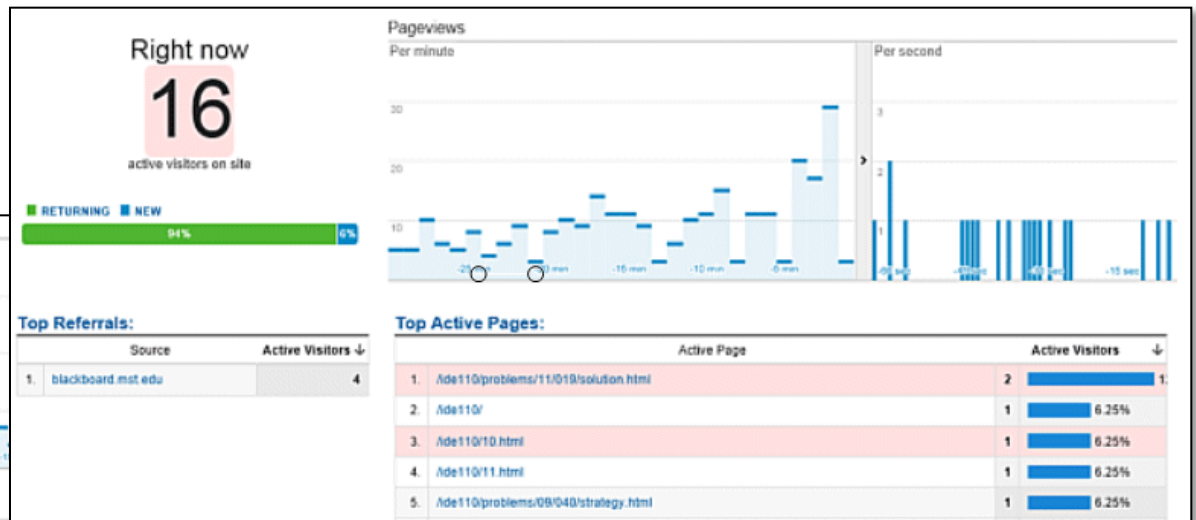
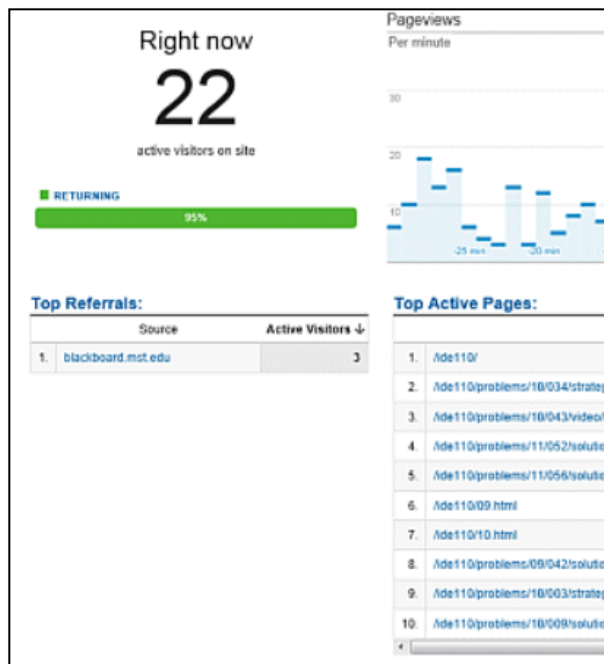


Materials Testing



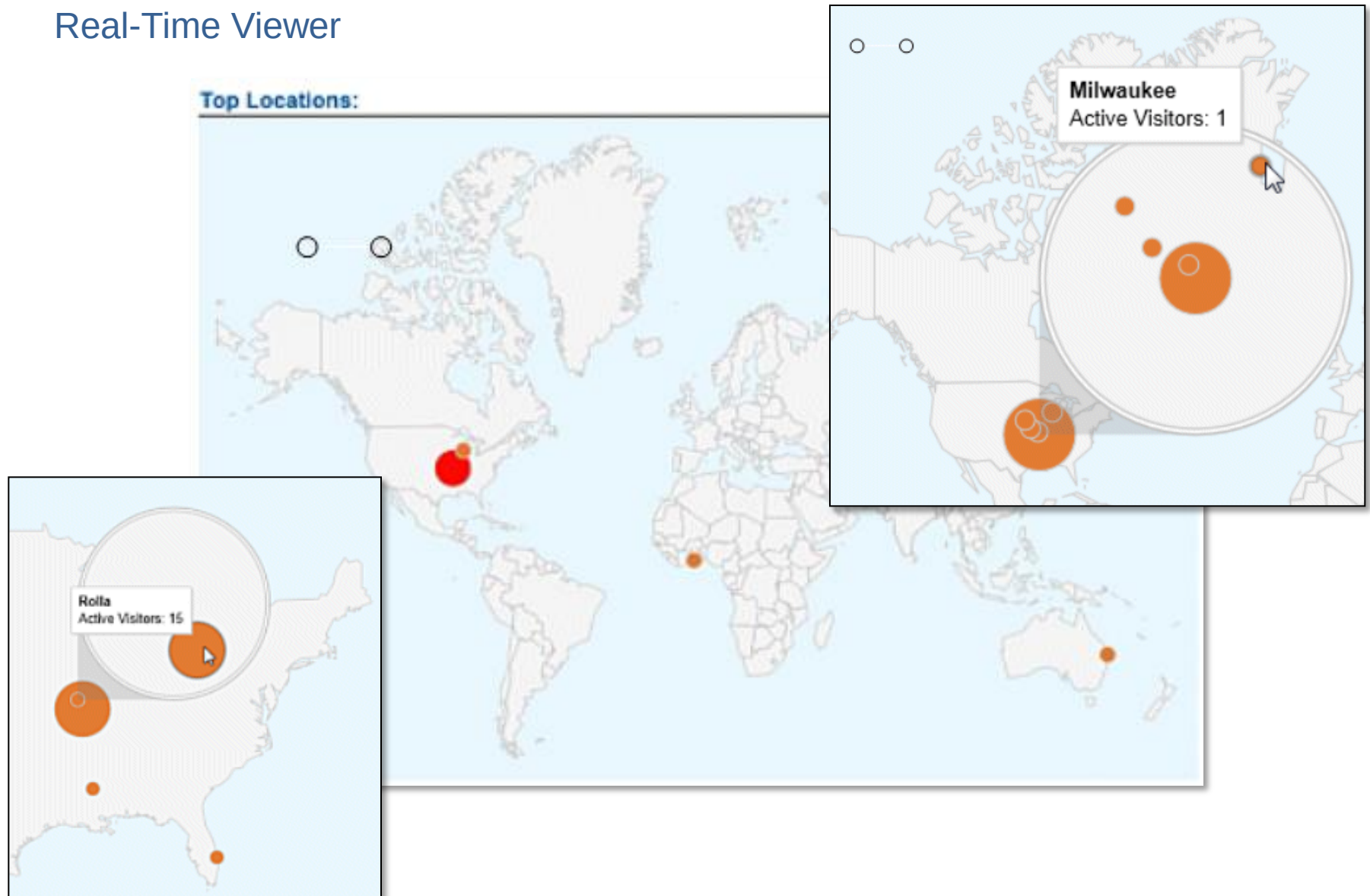
	Visits	Unique Visitors	Visit Duration	Avg. Visit Duration	Pageviews	Pages / Visit
All Visits	45,775	28,805	2476:43:44	00:03:15	155,860	3.40
Missouri	17,871	4,147	2027:40:02	00:06:48	107,536	6.02
not Missouri	27,904	24,729	449:03:42	00:00:58	48,324	1.73

Real-Time Viewer



Active Page	Active Visitors
/ide110/problems/11/019/solution.html	2
/ide110/	1 6.25%
/ide110/10.html	1 6.25%
/ide110/11.html	1 6.25%
/ide110/problems/09/040/strategy.html	1 6.25%
/ide110/problems/09/049/video/index.htm	1 6.25%
/ide110/problems/10/003/solution.html	1 6.25%
/ide110/problems/10/030d/solution.html	1 6.25%

Real-Time Viewer

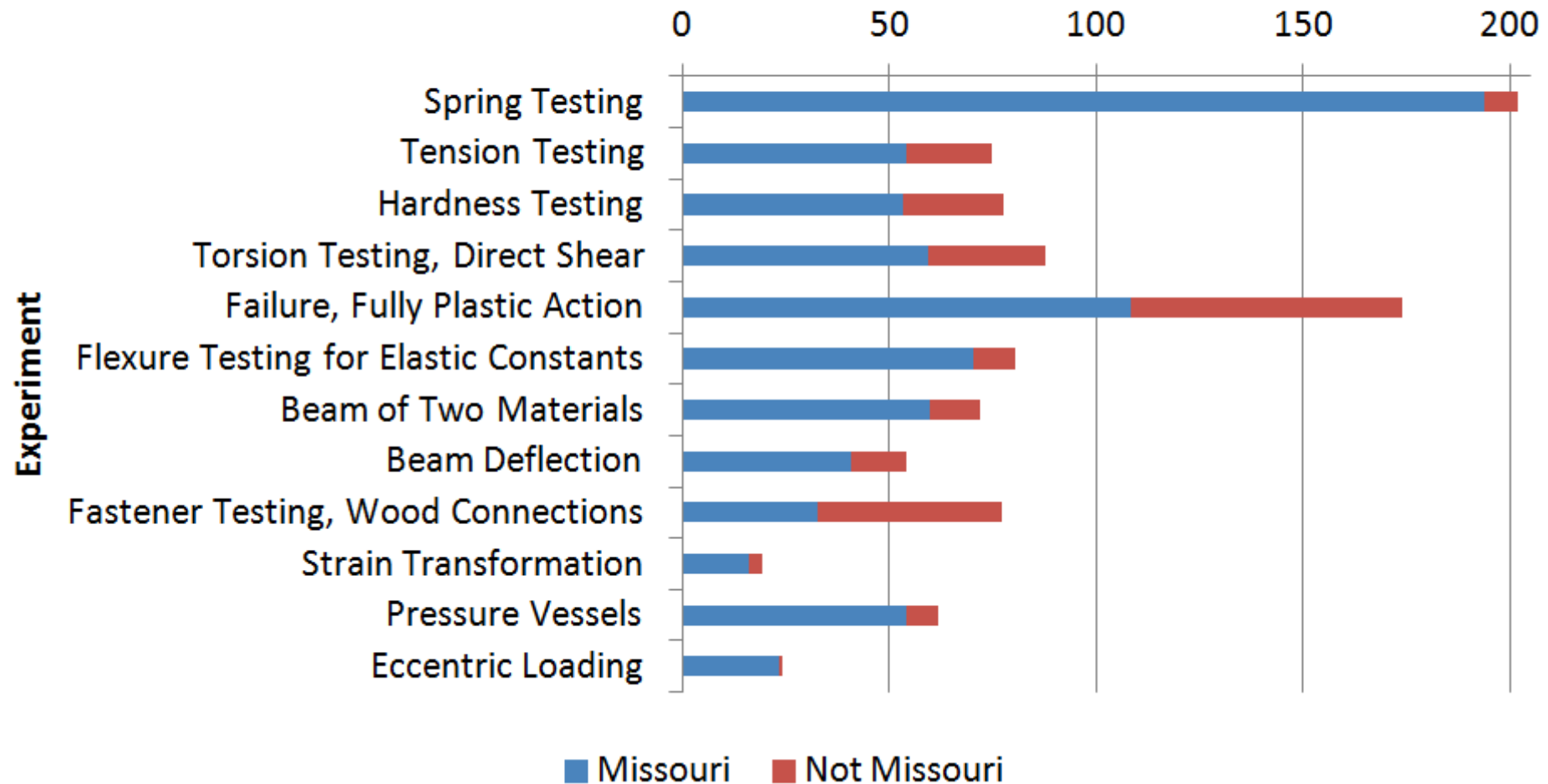


Materials Testing

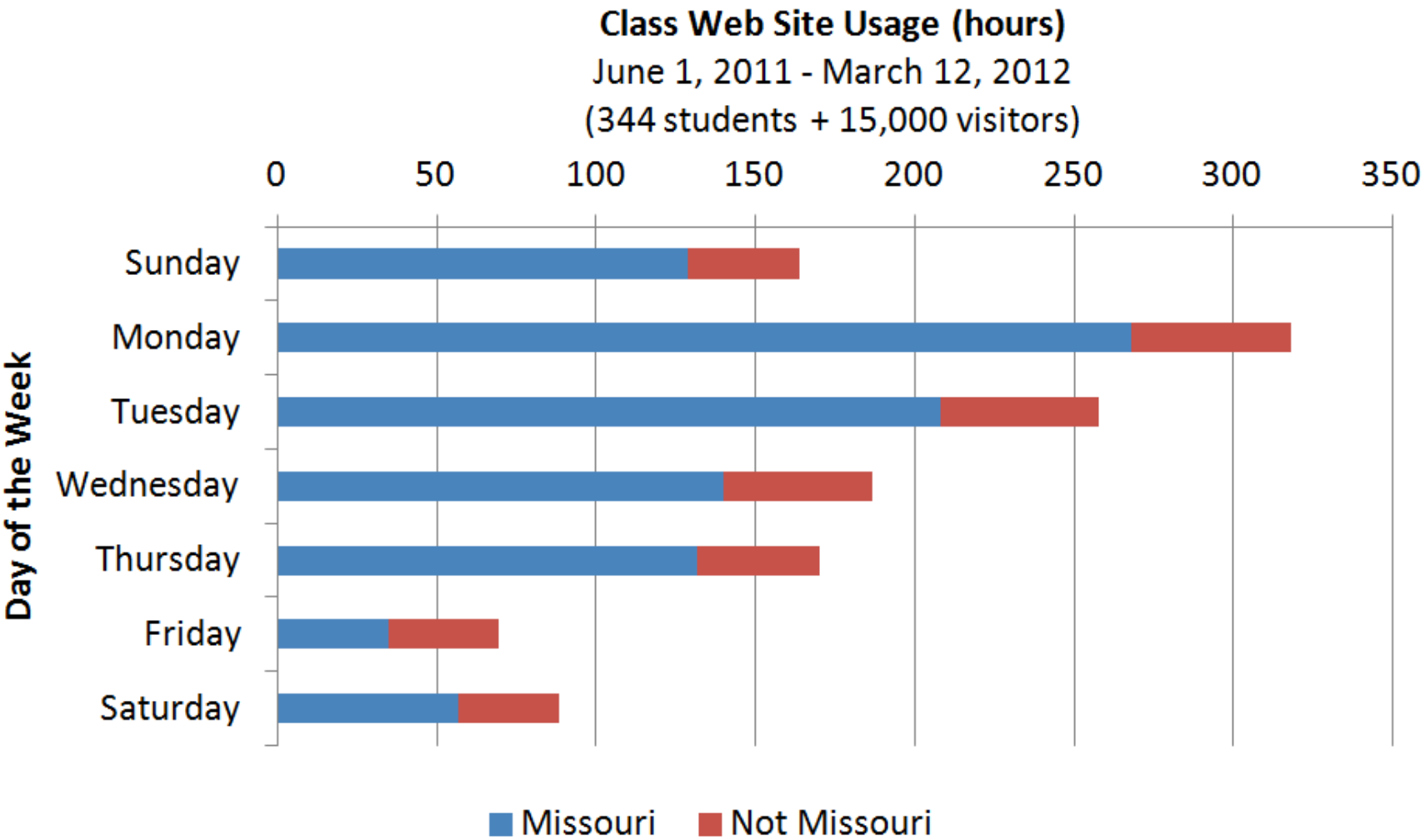
Lesson and Video Usage (hours)

June 1, 2011 - March 12, 2012

(344 students + 15,000 visitors)



Materials Testing



Outline

1. Resource usage
2. Satisfaction & pass rates
3. Exam performance
4. Misc. measurements

Satisfaction & Pass Rates

Format	Semesters	Students
lectures	F98 – W08	305
videos	S08 – F08	209
lectures + videos	W09 – W10	721
inverted	S10 – S12	578

Inverted Classes

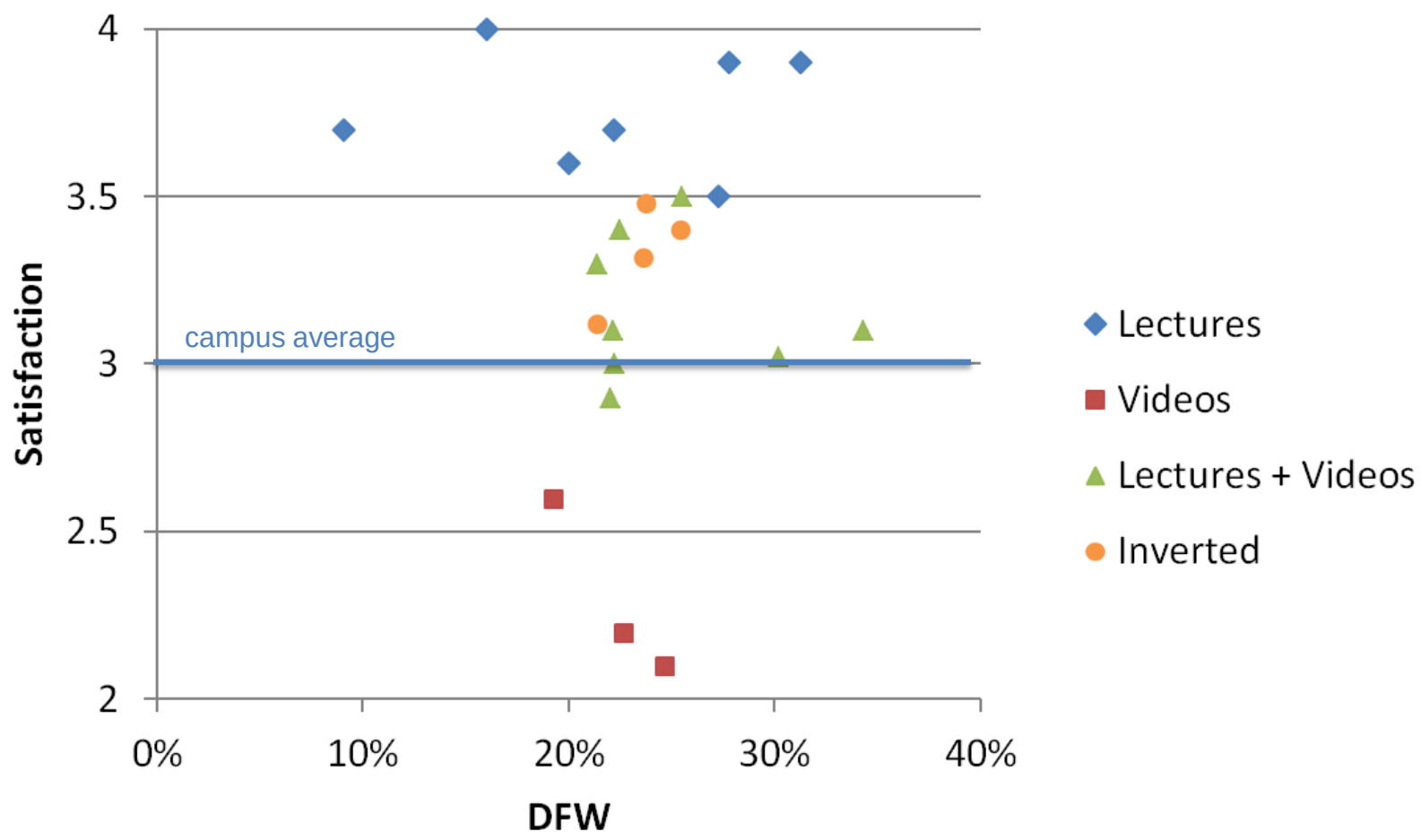
- watch videos outside of class
- do homework during class
- do experiments during class

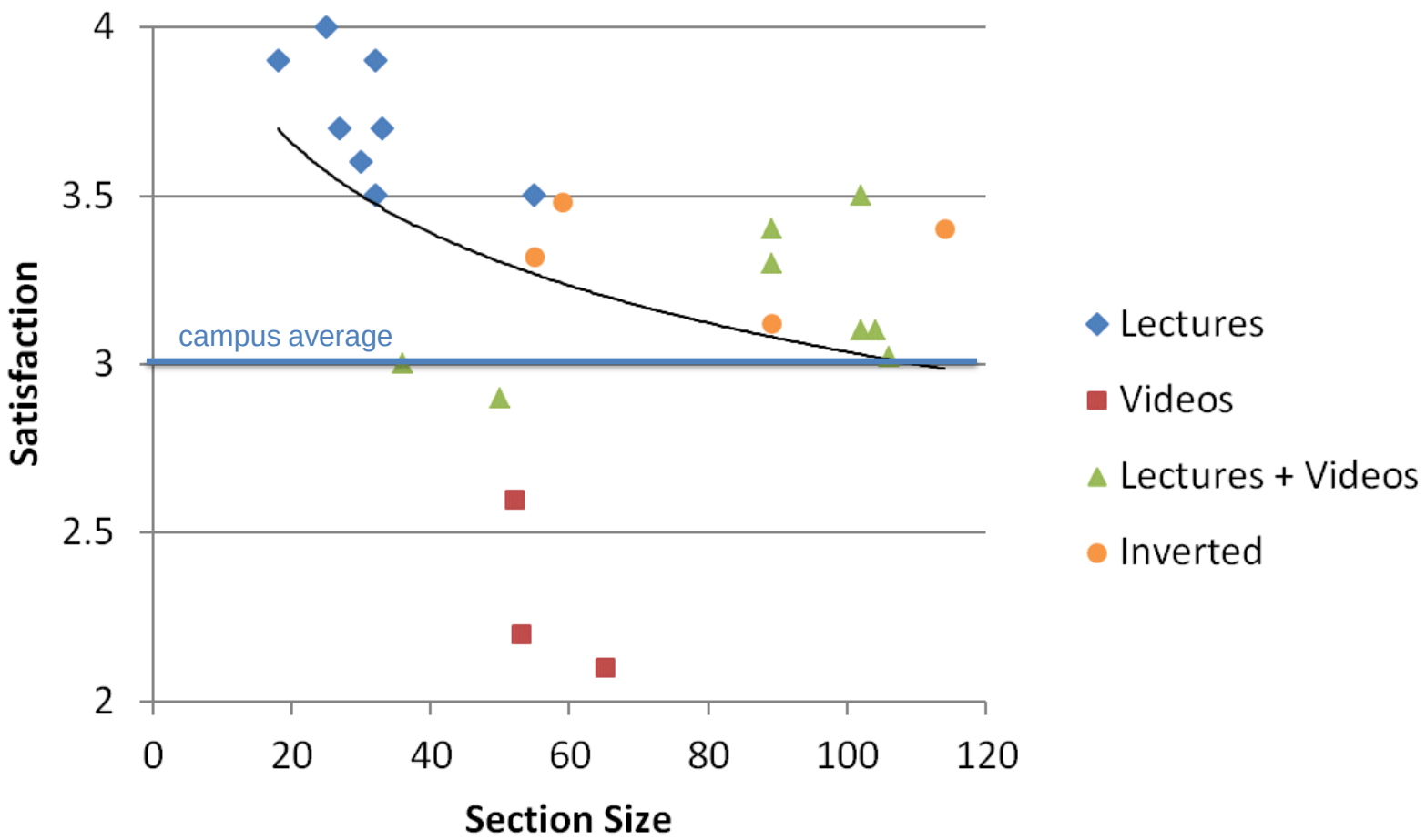


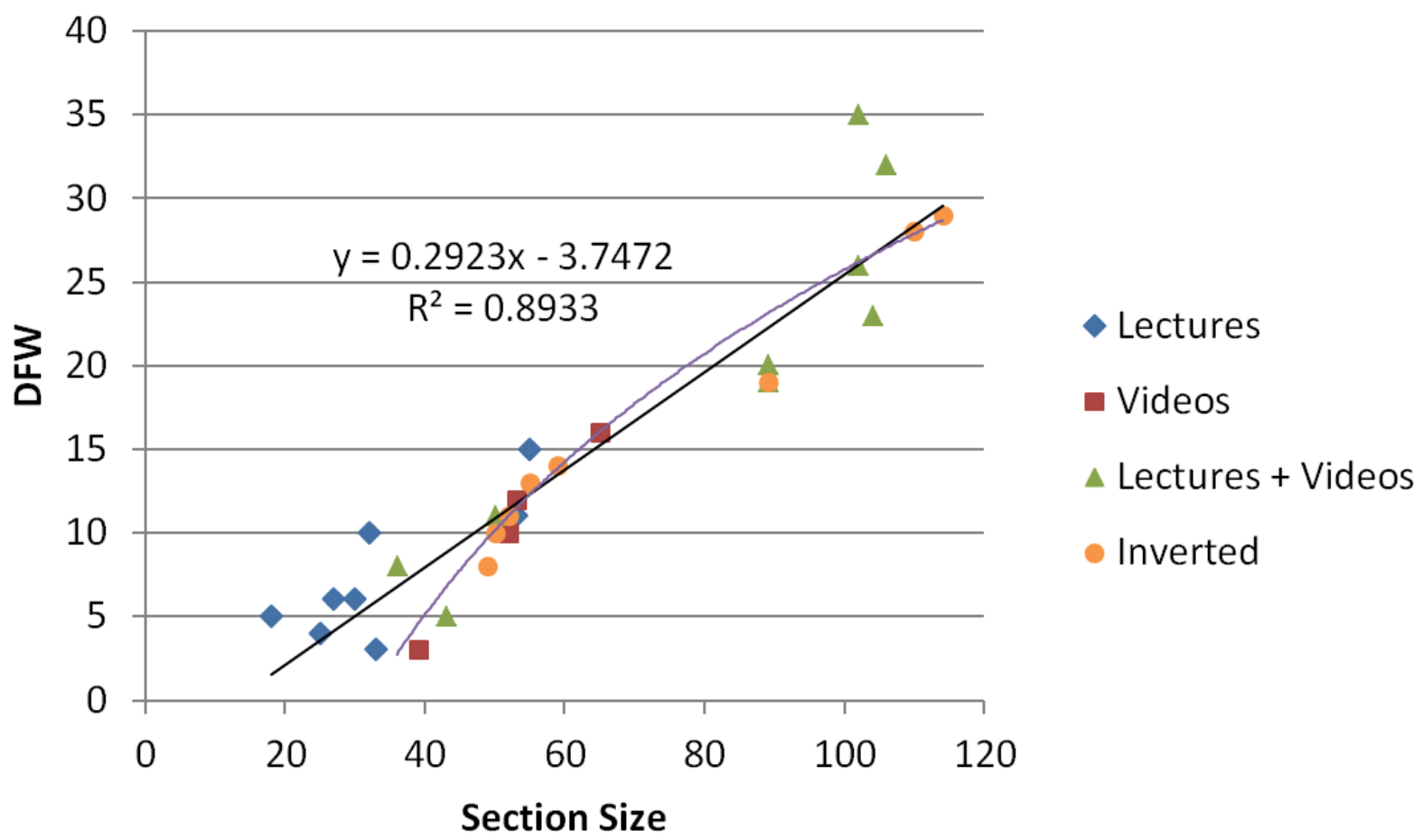
- flexibility
- classroom space
- learning analytics

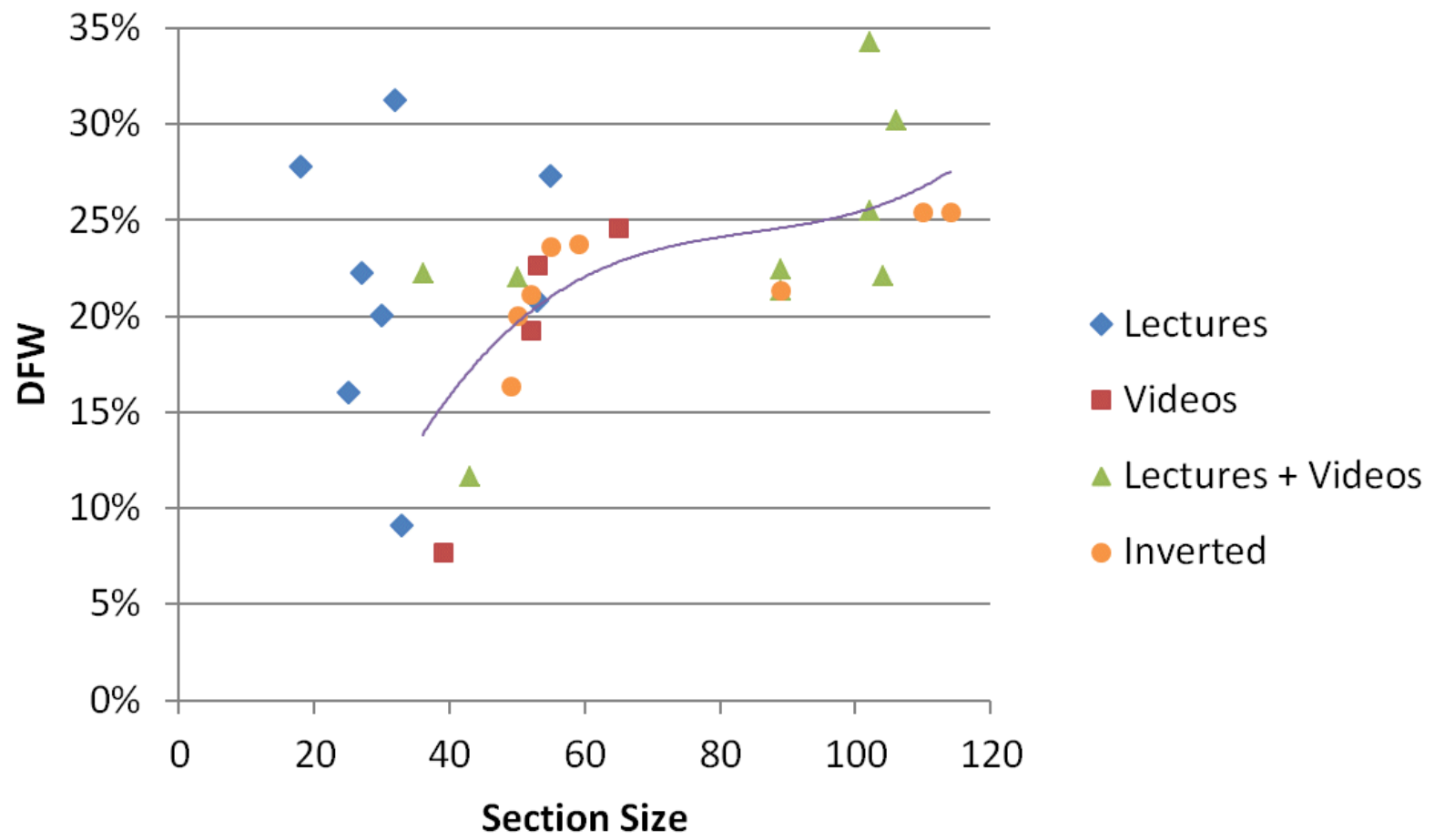
	Lectures	Videos	Lectures + Videos	Inverted
Section Size	34	52	80	72
Students/Semester	34	105	180	83
Satisfaction	3.7	2.3	3.2	3.3
DFW	22%	20%	25%	23%
<i>Section Success</i>	0.20	0.22	0.44	0.44

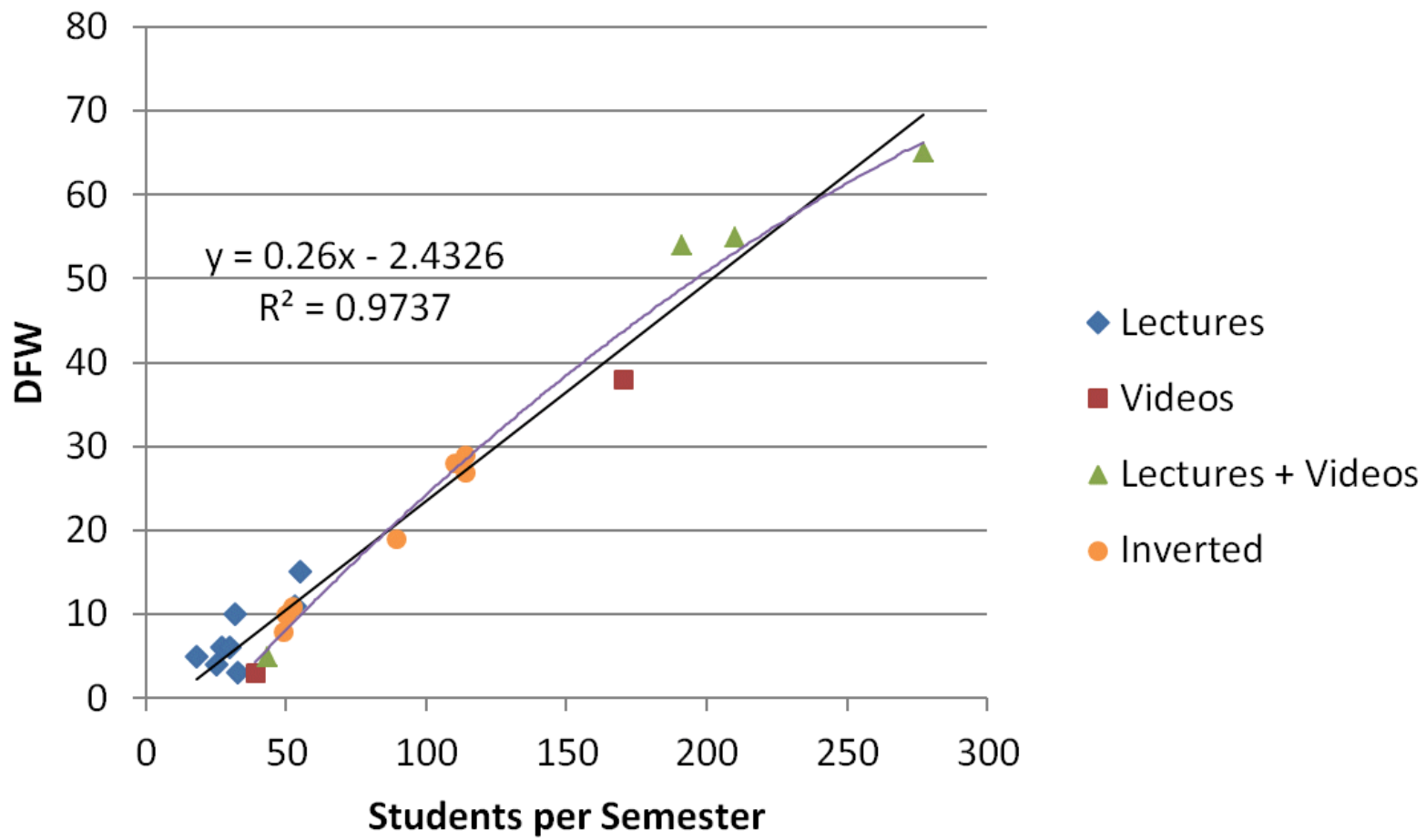
$$Section\ Success = \left(\frac{students}{114} \right) \left(\frac{satisfaction}{4} \right) (1 - DFW)$$

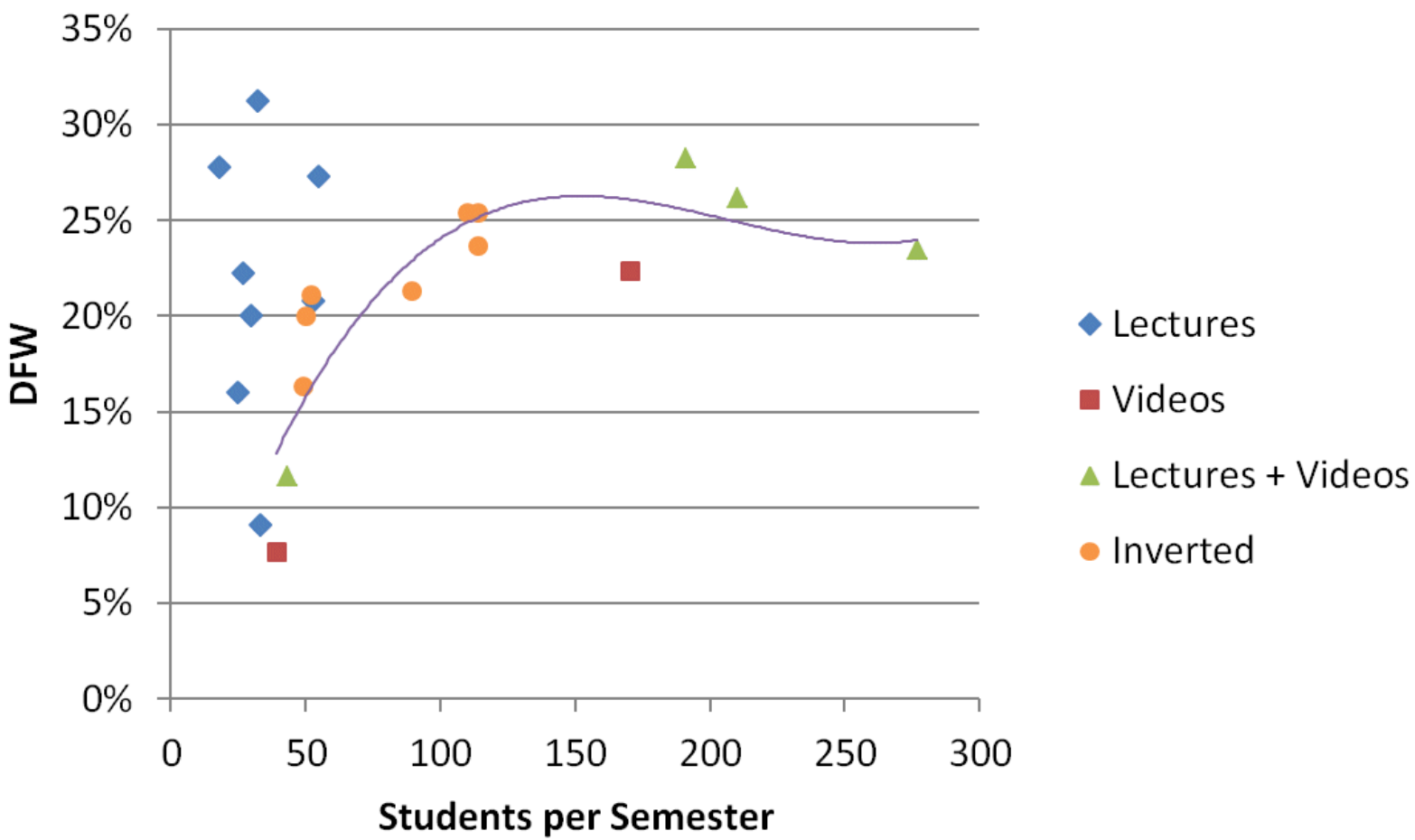












Outline

1. Resource usage
2. Satisfaction & pass rates
3. Exam performance
4. Misc. measurements

Exam Performance



Effect of Format

	Students	Lectures (n = 50)	Videos (n = 195)	Lectures + Videos (n = 668)	Inverted (n = 150)
Mean Final Exam Score	high GPA	76.7			81.6
	all	71.7	73.9	75.9	73.1
	low GPA	66.1			63.9

- same instructor, author and problem solutions
- no significant difference between mean final exam scores
- high GPA students do 5 pts better in inverted format
- low GPA students do 2 pts worse in inverted format

Effect of Instructor & Format

	Instructors that use Lecture format in Mechanics of Materials	Instructor that uses Inverted format in Mechanics of Materials
Mean score on common final exam in Mechanics of Materials	67.5 (n = 513)	66.9 (n = 556)
Mean class grade in Structural Analysis	86.1 (n = 40)	86.5 (n = 44)

- three Mechanics of Materials instructors
- one Structural Analysis instructor
- same author and problem solutions
- no significant difference

Question Bank

- 622 calculation questions (algorithmic)
- 421 conceptual questions
- 220 categories
- 132 enabling objectives
- 12 terminal objectives

	In-Class Exams	Final Exams
Students	813	1394
Sections	9	20
Semesters	7	7
Question categories	145	71
Root questions	429	147
Graded questions	84,651	38,139

Performance Index for Each Question

Question Category			Performance Index	Root Questions	Graded Questions	Exams
Hooke's law			1.08	3	1036	7
Poisson's ratio			1.08	3	1290	7
Hooke's law & Poisson's ratio			0.93	1	260	2
shear modulus			0.71	2	415	3
stress-strain curve	0.93	Young's modulus	0.85	4	347	3
		proportional limit	1.06	4	275	3
		yield strength	1.00	4	347	3
		ultimate strength	0.95	4	347	3
		fracture strength	1.00	4	275	3
		true fracture strength	0.66	4	224	2

$$\text{Performance Index} = \frac{\text{Root Question Mean}}{\text{Exam Mean}}$$

$$\text{Combined Performance Index} = \frac{\sum \left(\frac{\text{Root Question Mean}}{\text{Exam Mean}} \times \text{Graded Questions} \right)_i}{\sum (\text{Graded Questions})_i}$$

Performance Index for Each Chapter

Chapter	Online Content Usage per Student (minutes)	Performance Index (1 = average)	Question Categories	Root Questions	Graded Questions
1. Stress	128	1.14	15	25	8,656
2. Strain	86	1.02	6	16	5,412
3. Mechanical properties	63	0.98	10	33	4,816
4. Design concepts	87	1.00	6	9	2,594
5. Axial deformation	150	0.98	13	17	6,330
6. Torsion	201	0.94	13	32	10,857
7. Equilibrium of beams	37	1.13	11	28	5,934
8. Bending	165	1.07	10	30	10,998
9. Shear stress in beams	134	0.90	7	25	10,007
10. Beam deflections	131	0.98	12	54	14,293
11. Statically indeterminate beams	103	0.81	6	19	4,514
12. Stress transformations	107	1.13	13	42	12,346
13. Strain transformations	129	1.05	10	37	9,833
14. Thin-walled pressure vessels	49	0.89	6	24	8,520
15. Combined loads	183	0.85	7	38	7,680

Performance Index for Each Objective

Chapter 3 - Mechanical Properties of Materials

Course objectives:

- To interpret a stress-strain diagram and understand elastic constants.
- To understand the stress-strain relationship for axial force members.

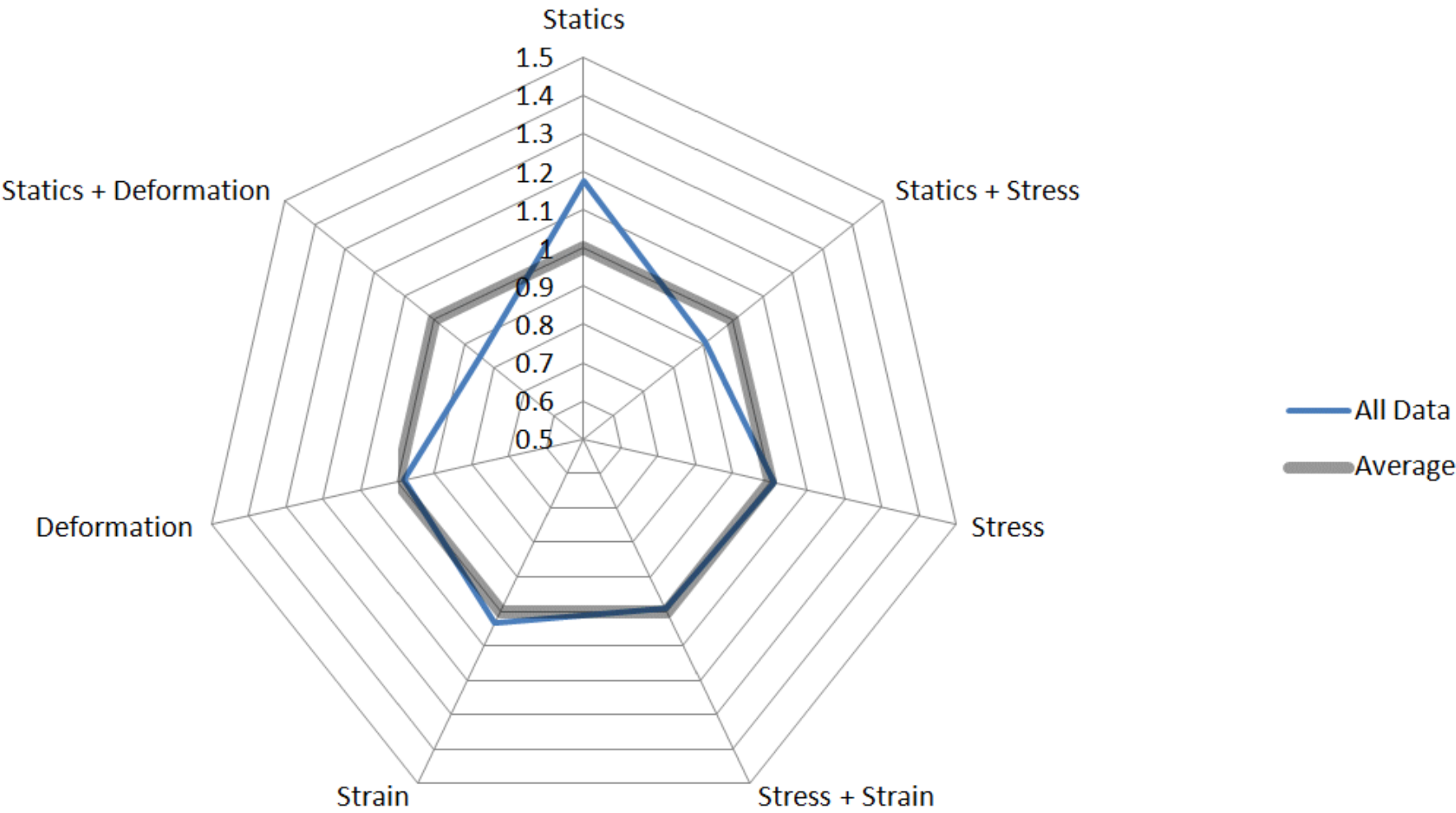
Learning objectives:

- Identify the terminology and symbols associated with tension tests.
- Identify elastic, yield, strain-hardening, ultimate and necking regions of basic stress-strain diagrams.
- Read/calculate commonly used values from basic stress-strain diagrams: Young's modulus (0.85), proportional limit (1.06), yield strength (1.00), ultimate strength (0.95), fracture strength (1.00), true fracture strength (0.66).
- Convert between normal stress and normal strain using Hooke's Law relationship (1.08).
- Calculate Poisson's ratio from changes in axial and transverse strains and deformations (1.08).
- Calculate shear modulus from shear stress and shear strain (0.71).

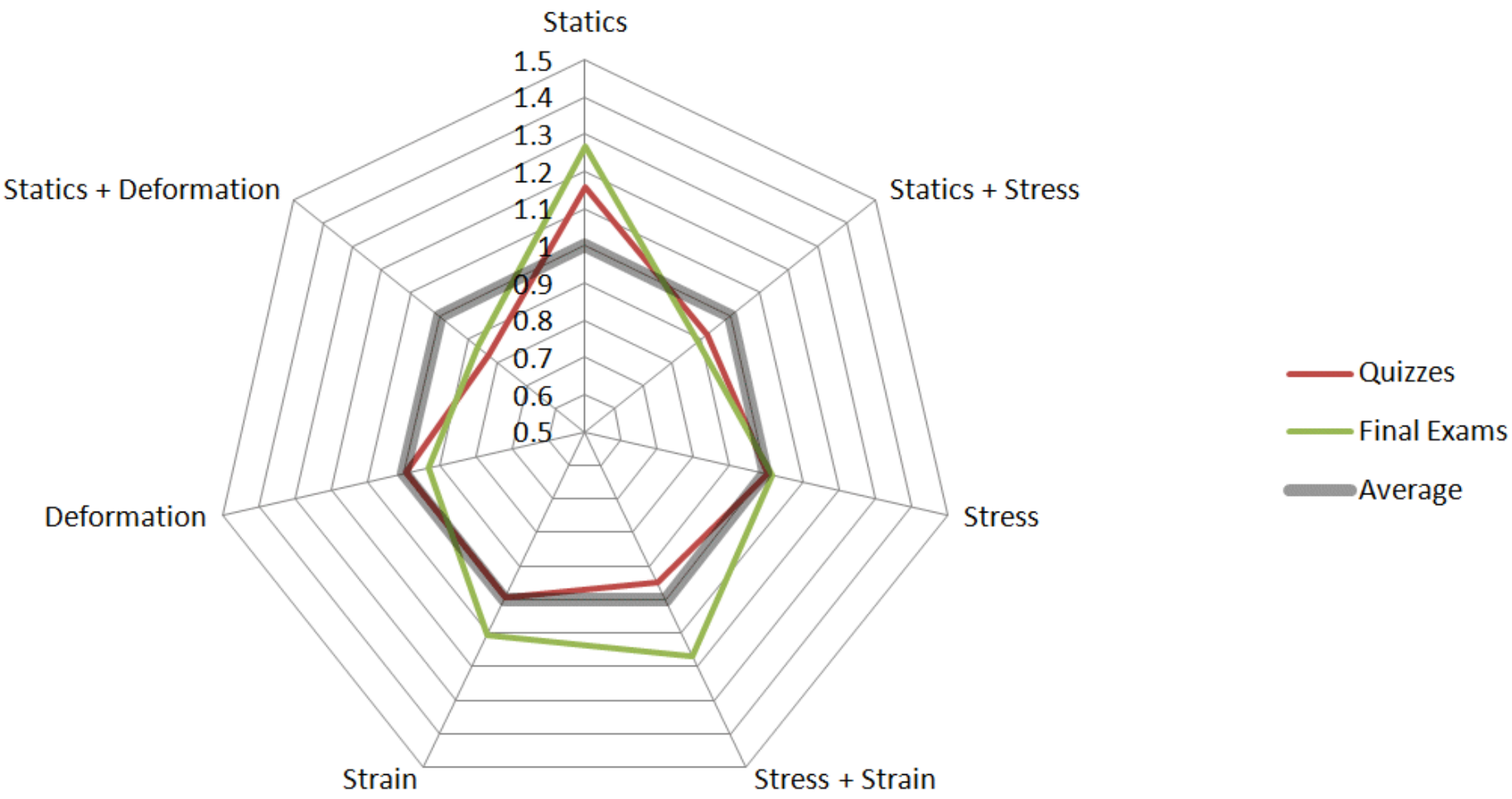
Ranked Categories

Chpt	Problem Category	Statics Only?	Performance Index	Root Questions	Graded Questions	Exams
15	shaft with N & T		1.47	1	180	1
15	shaft with N and multiple T		1.43	3	257	3
8	centroid	yes	1.43	3	1249	9
10	integration, find slope at spot		1.41	1	85	1
5	deformation		1.37	2	1704	12
10	integration, boundary conditions, cantilever		1.36	6	1530	4
12	draw Mohr's circle, principals and max shear		1.28	3	1573	11
			1.26			
5	indeterminate, rotating bar		0.63	1	88	1
11	movable support, simply supported		0.63	5	1192	6
8	combined loading, rectangular cross section		0.61	6	1338	7
5	indeterminate, rotating bar with gap		0.54	1	190	1
15	pressurized pipe		0.51	5	1048	7
5	indeterminate thermal, end-to-end (two materials)		0.51	2	639	4
5	indeterminate thermal, coaxial		0.47	1	617	5

Student Performance Maps



Student Performance Maps

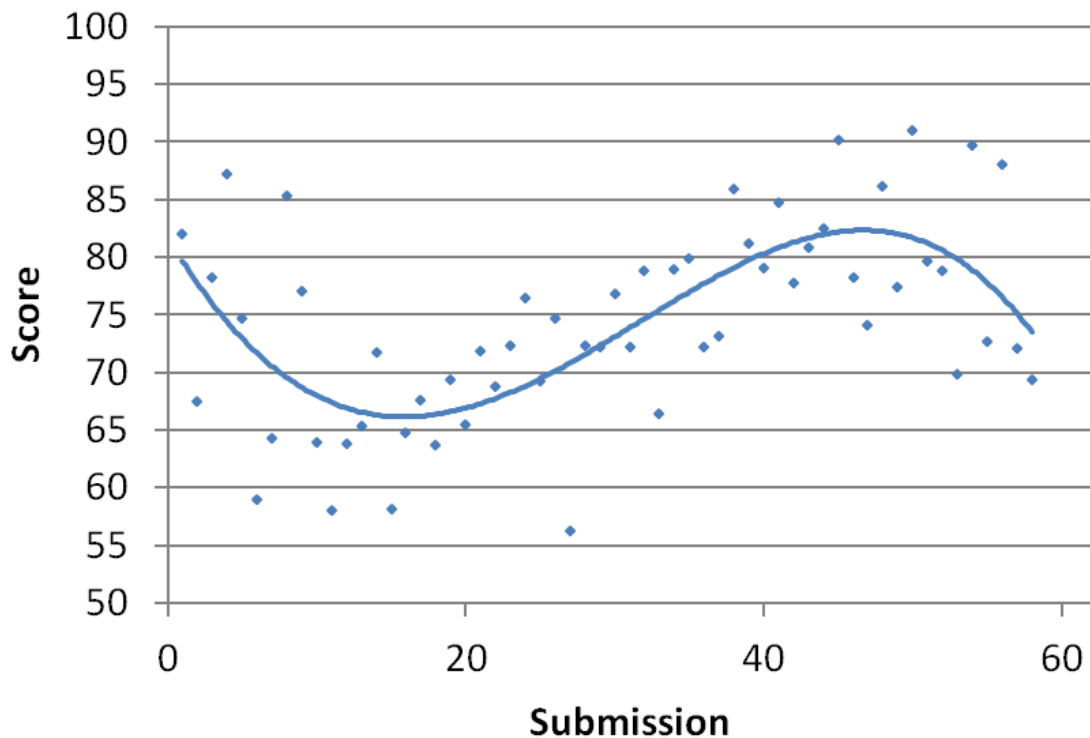




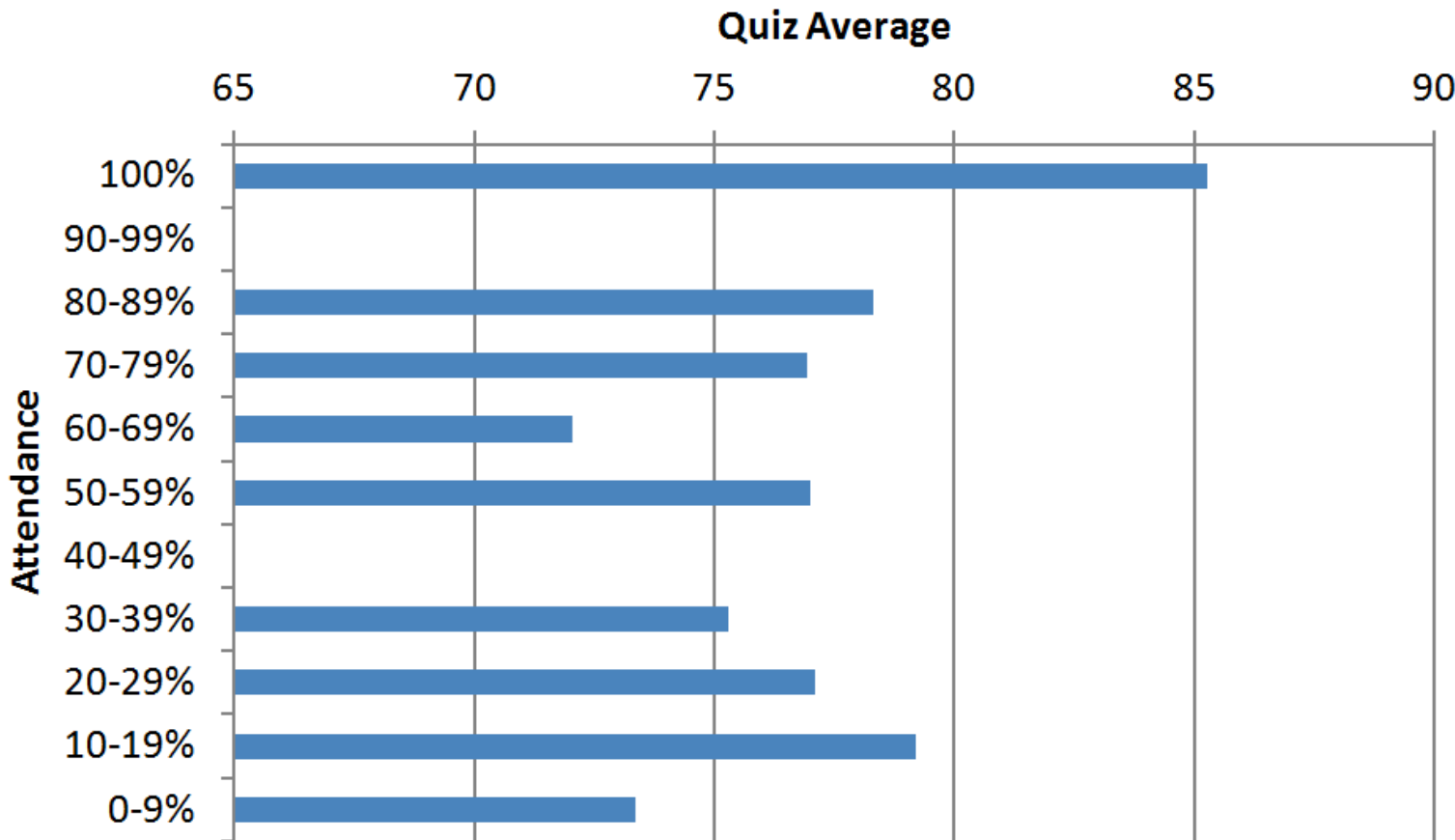
Outline

1. Resource usage
2. Satisfaction & pass rates
3. Exam performance
4. Misc. measurements

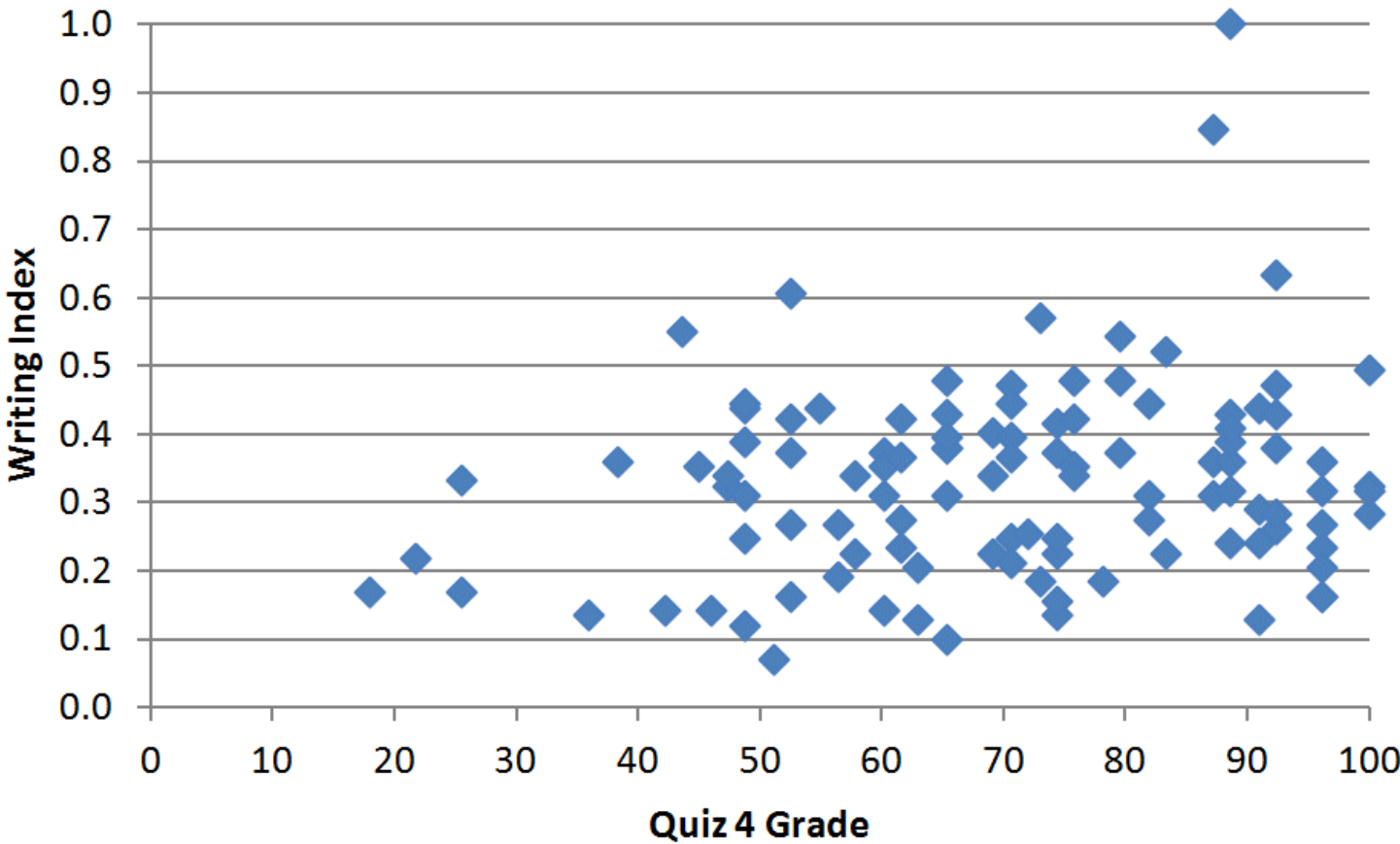
Miscellaneous Measurements



Does (optional) attendance matter?



How much do students need to write down?



What about gender and major?

Major	Students	A	B	C	D	F	WD	GPA	ABC	DFW
Ceramic Engineering	9	6	2	1	0	0	0	3.6	9 100%	0 0%
Petroleum Engineering	8	3	5	0	0	0	0	3.4	8 100%	0 0%
Mining Engineering	1	0	1	0	0	0	0	3.0	1 100%	0 0%
Aerospace Engineering	15	6	6	0	2	1	0	2.9	12 80%	3 20%
Metallurgical Engineering	15	5	6	1	1	0	2	2.7	12 80%	3 20%
Mechanical Engineering	89	24	23	25	9	4	4	2.5	72 81%	17 19%
Civil Engineering	37	6	13	12	4	1	1	2.5	31 84%	6 16%
Architectural & Civil Engineering	17	4	4	6	1	0	2	2.4	14 82%	3 18%
Architectural Engineering	17	6	2	4	2	1	2	2.4	12 71%	5 29%
Geological Engineering	9	2	2	2	0	2	1	2.0	6 67%	3 33%
Engineering Management	17	1	3	6	4	2	1	1.7	10 59%	7 41%
Nuclear Engineering	3	0	1	1	0	0	1	1.7	2 67%	1 33%
Environmental Engineering	3	0	0	2	0	1	0	1.3	2 67%	1 33%
Undeclared	12	0	2	2	2	3	3	1.0	4 33%	8 67%
Total	254	64	70	62	26	15	17	2.4	196 77%	58 23%

Gender	Students	A	B	C	D	F	WD	GPA	ABC	DFW
Female	55	16	17	11	6	3	2	2.6	44 80%	11 20%
Male	204	51	53	52	21	12	15	2.4	156 76%	48 24%
Total	259	67	70	63	27	15	17	2.4	200 77%	59 23%

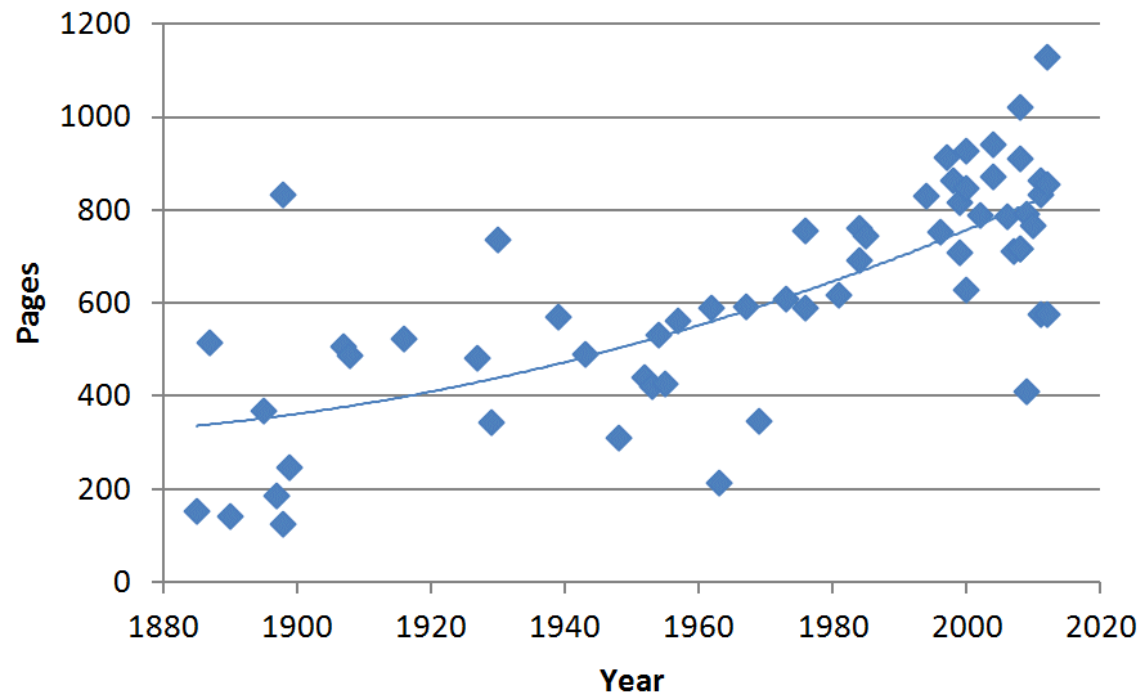
Class rank?

	N	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	FE
Sophomore	14	86	82	85	72	69	76	65	85	71
Junior	131	79	82	81	71	70	80	75	77	70
Senior	89	78	73	74	69	66	70	75	72	67
Graduate	3	83	72	84	108	92	92	90		86
Aerospace Engineering	15	86	77	87	73	81	83	80	75	75
Architectural & Civil Engineering	15	78	83	84	64	68	81	83	61	71
Architectural Engineering	15	79	77	85	77	73	73	80	84	74
Ceramic Engineering	9	82	88	85	86	86	85	87	95	83
Civil Engineering	34	77	81	77	72	66	75	78	75	73
Engineering Management	16	65	62	68	63	58	71	76	59	60
Environmental Engineering	3	69	65	73	44	54	73	69		66
Geological Engineering	8	79	84	73	71	66	80	70	79	66
Mechanical Engineering	85	79	80	79	70	70	76	81	77	70
Metallurgical Engineering	13	88	83	89	75	68	83	86	92	75
Mining Engineering	1	86	53	92	75	58	84	89		79
Nuclear Engineering	2	90	68	86	81	71	84	92		66
Petroleum Engineering	8	85	85	73	85	81	75	86	91	79
Undeclared	9	81	69	67	59	52	65	67	85	52

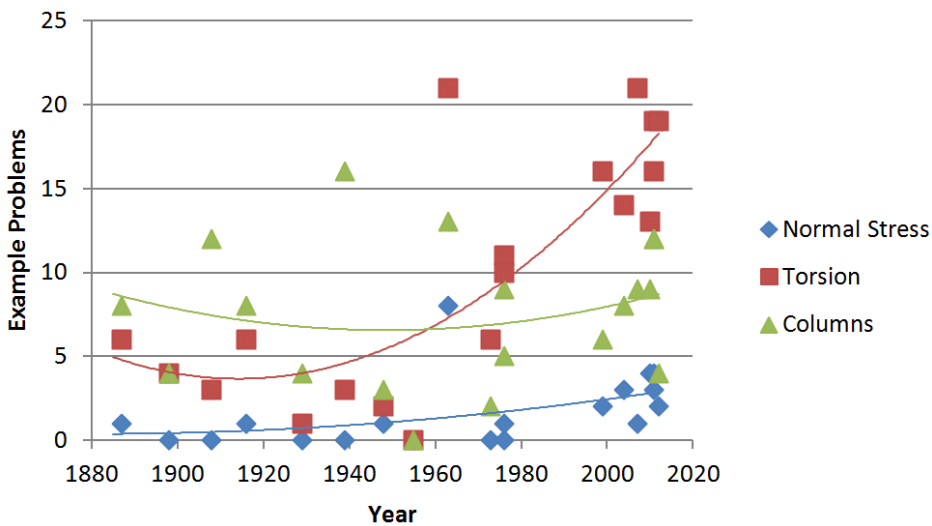
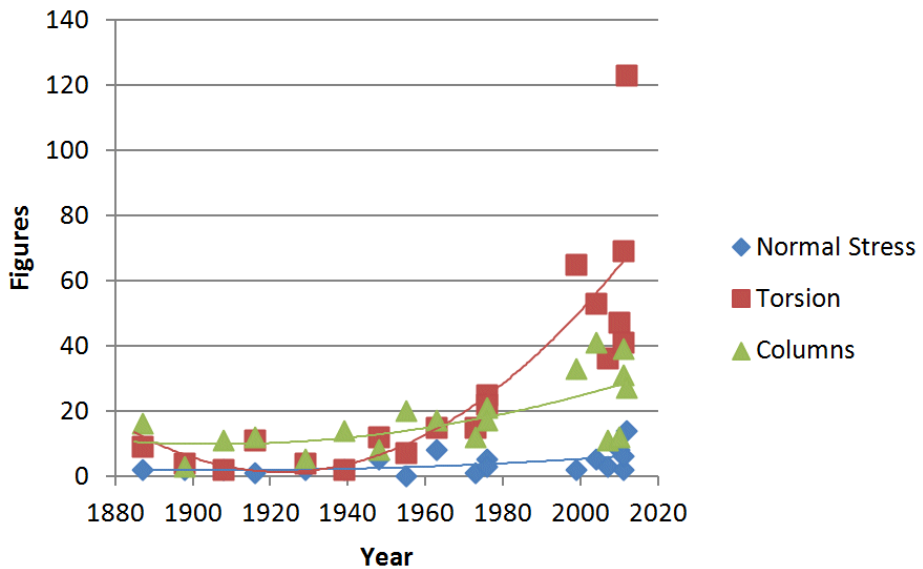
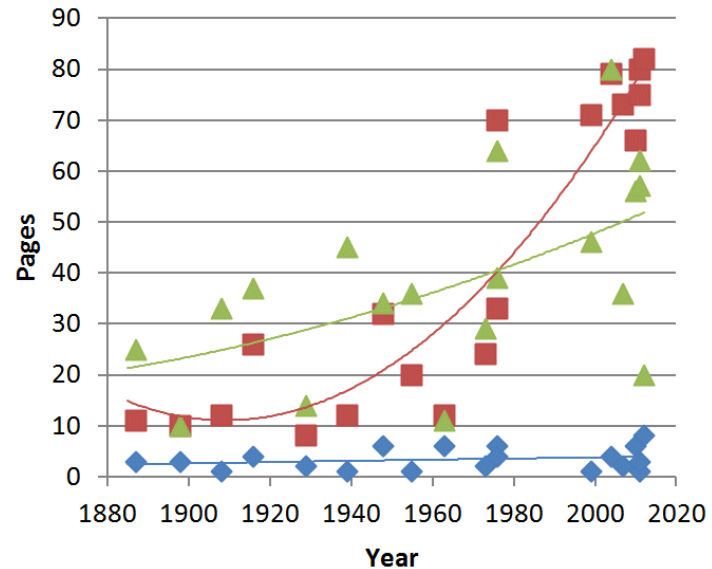
How have textbooks changed?

Year	Author(s)	Pages
1885	Merriman	152
1887	Church	514
1890	Kent	142
1895	Merriman	368
1897	Mather	186
1898	Church	834
1898	Merriman	124
1899	Ewing	246

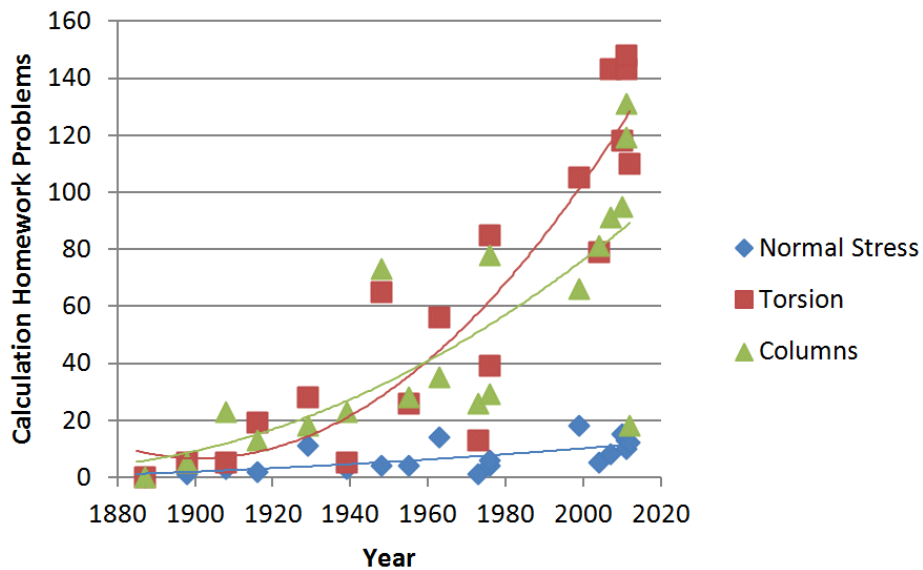
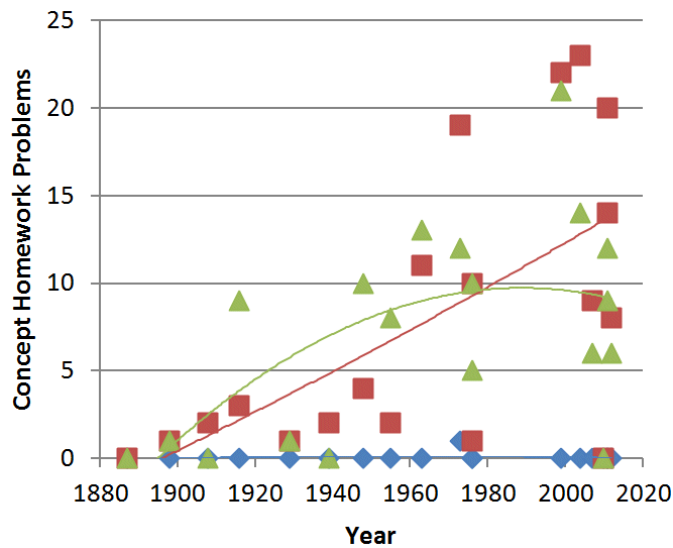
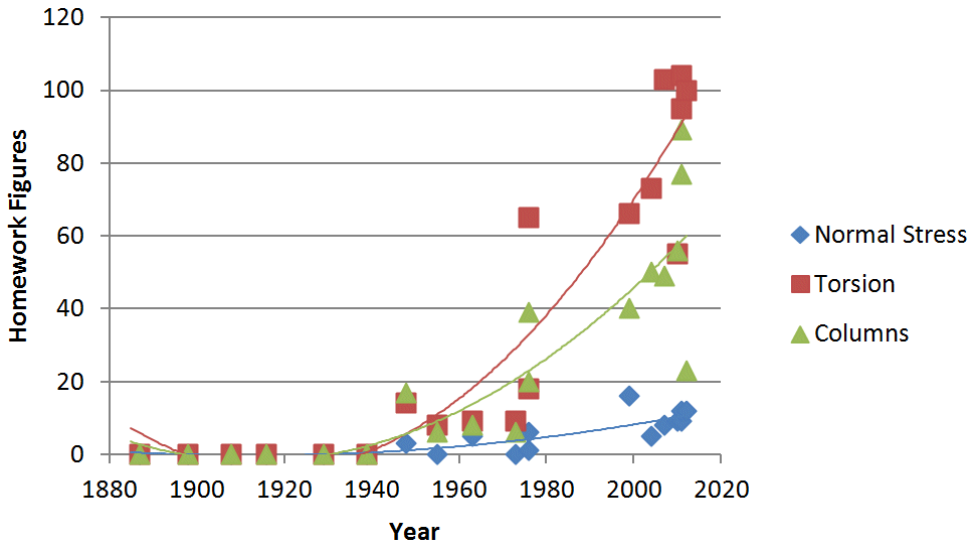
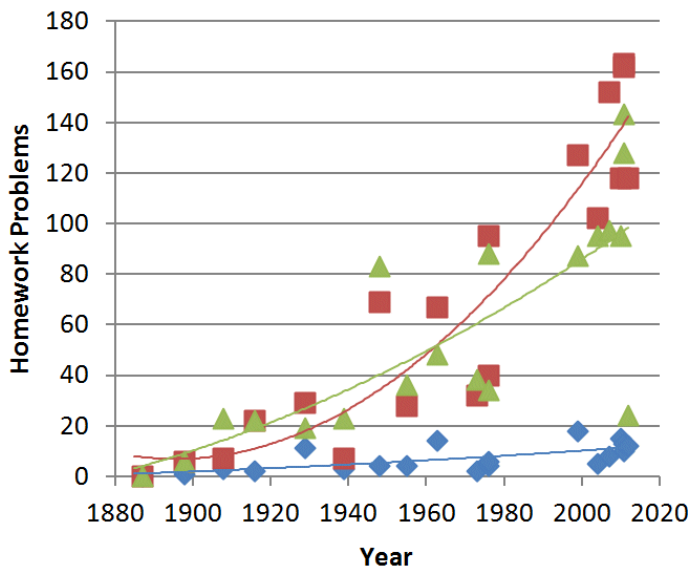
2009	Beer, Johnston, DeWolf, Mazurek	790
2009	Thiagarajan, Deshmukh	410
2010	Philpot	767
2011	Hibbeler	862
2011	Beer, Johnston, DeWolf, Mazurek	832
2011	Pytel, Kiusalaas	576
2012	Gere, Goodno	1130
2012	Craig	856
2012	Steif	576



How have textbooks changed?



How have textbooks changed?



Outline

1. Resource usage
2. Satisfaction & pass rates
3. Exam performance
4. Misc. measurements

Conclusions

1. ability to evaluate study habits & learning aids
2. student/instructor flexibility and satisfaction
3. detailed learning estimates

Questions?

Acknowledgements

- Timothy Philpot, Douglas Carroll, Richard Hall, Malcolm Hays
- Missouri S&T Educational Technology
- Missouri S&T Educational Research Mini-Grants
- Missouri S&T eFellows Program
- Missouri S&T Office of the Vice Provost for Academic Affairs
- NSF Grant 0837339
- many student assistants