Interactive Textbooks (zyBooks)

Dr. Ryan Barlow

Lead Content Author – Engineering, zyBooks, A Wiley Brand

zyBooks Background

- Dr. Frank Vahid
  - UCR prof 1994, "embedded systems" research
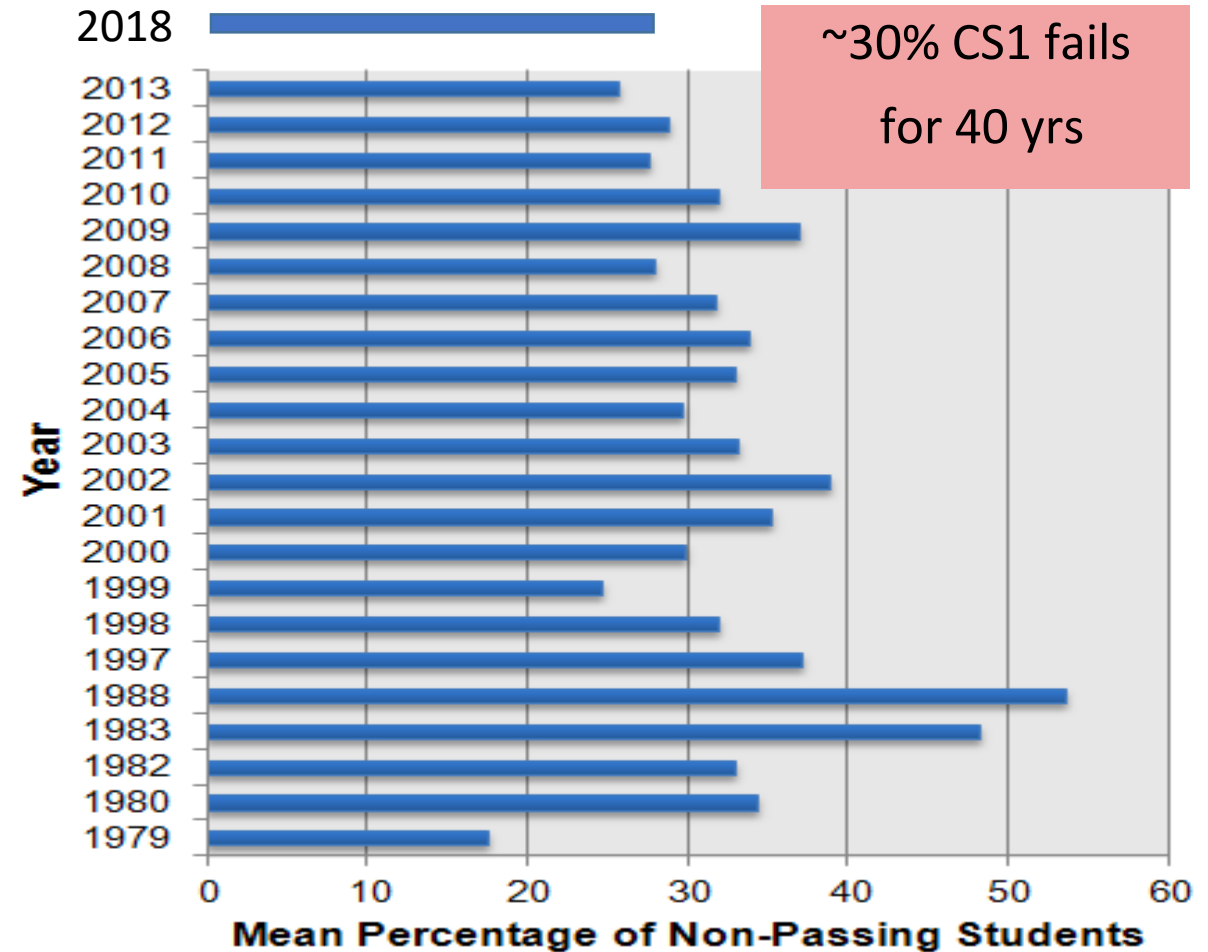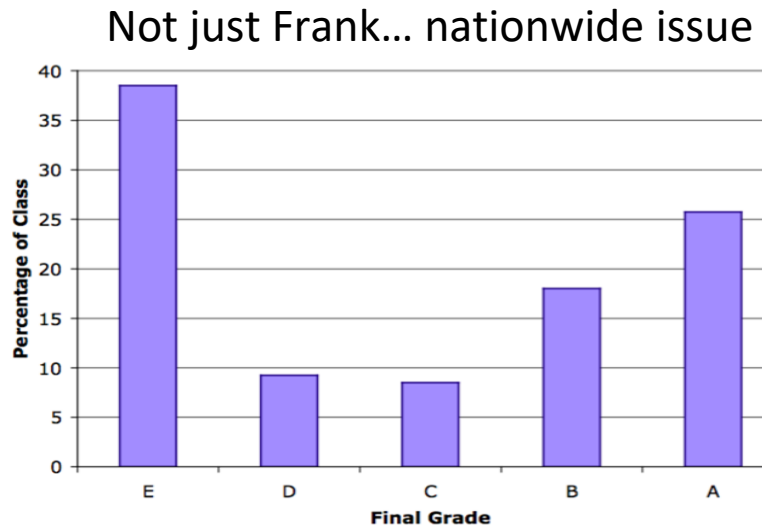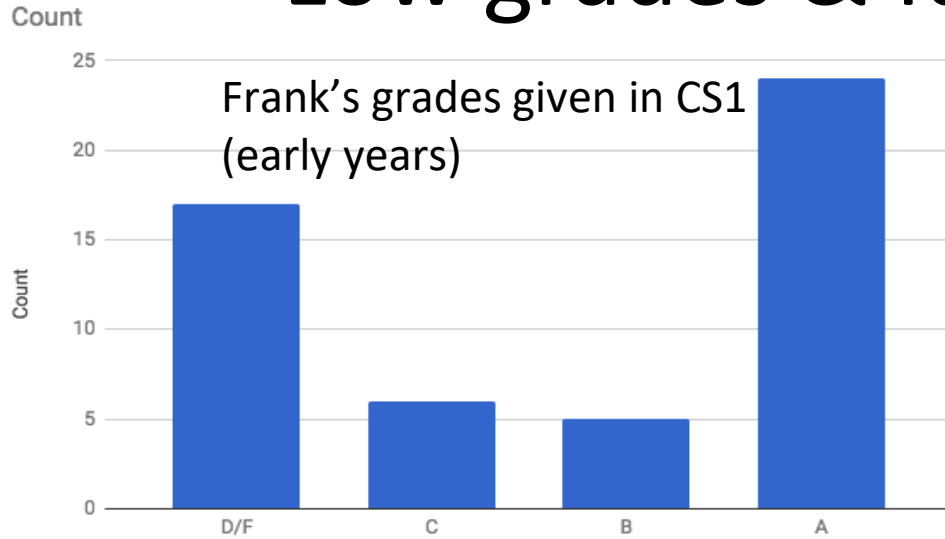 - CS undergrad advisor, saw attrition

Selection	Fall 2011 Cohort	Fall 2010 Cohort	Fall 2009 Cohort	Fall 2008 Cohort	Fall 2007 Cohort	Fall 2006 Cohort	Fall 2005 Cohort	Fall 2004 Cohort	Fall 2003 Cohort	Fall 2002 Cohort
Female										
Total	14	17	7	12	9	6	3	9	6	17
Year 1	57.1%	58.8%	85.7%	41.7%	77.8%	66.7%	66.7%	33.3%	50.0%	52.9%
Year 2	28.6%	41.2%	57.1%	33.3%	55.6%	50.0%	33.3%	22.2%	33.3%	17.6%
Male										
Total	63	85	65	73	59	61	42	48	76	109
Year 1	63.5%	80.0%	67.7%	56.2%	67.8%	62.3%	81.0%	68.8%	65.8%	72.5%
Year 2	44.4%	55.3%	44.6%	39.7%	49.2%	42.6%	42.9%	43.8%	39.5%	42.2%

https://ir.ucr.edu/stats/outcomes/retention

- *Read research on causes. One was harsh early grades.*

Low grades & fails: A nationwide problem

Count

Frank's grades given in CS1 (early years)

Not just Frank... nationwide issue

http://reflect.otago.ac.nz/staffpriv/anthony/publications/pdfs/RobinsLEM.pdf

2018

~30% CS1 fails

for 40 yrs

Avg 67 schools

Watson'14. , http://dro.dur.ac.uk/19223/1/19223.pdf%3FDDD10%2Bd74ks0%2Bdcs0lw

Bennedsen'19, https://cs.au.dk/~mec/publications/journal/60-inroads-failure-rates-12.pdf

Interactive content

	Programs	Hmwk	Reading
	zyLabs	Challenge	Participation
1. Wk1: Introduction	88%	96%	96%
2. Wk2: Variables/Assignments	79%	93%	94%
3. Wk3: Branches	70%	93%	95%
4. Wk4: Strings / Loops 1	69%	89%	95%
5. Wk5: Loops 2		88%	95%
6. Wk6: Midterm /		85%	95%
7. Wk7: Functions		86%	95%
8. Wk8: Vectors 1		84%	95%
9. Wk9: Vectors 2	64%	82%	94%
10. Wk10: The Internet and Web			89%

Company
- Investor funding
- NSF SBIR funding (>$2M)

Student does:
- ~1000 PAs
- ~100 CAs
- ~50 LAs
- All auto-graded, imm. feedback

Does it help students?

PAs only

Randomized controlled trial

Cross-semester analysis

Survey (UCI CS1)
"The textbook contributed to my success in the course"

16% more improvement — 5.5 / 6.4 (All Students)
64% more improvement — 4.5 / 7.4 (Initially Lowest Quartile)
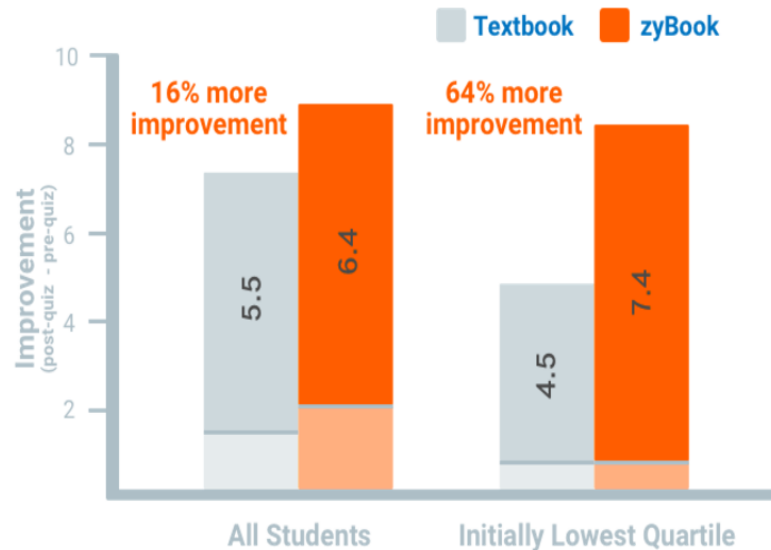
And spent 2x time

ASEE 2014 (best paper award)

+0.3 GPA

Before / After
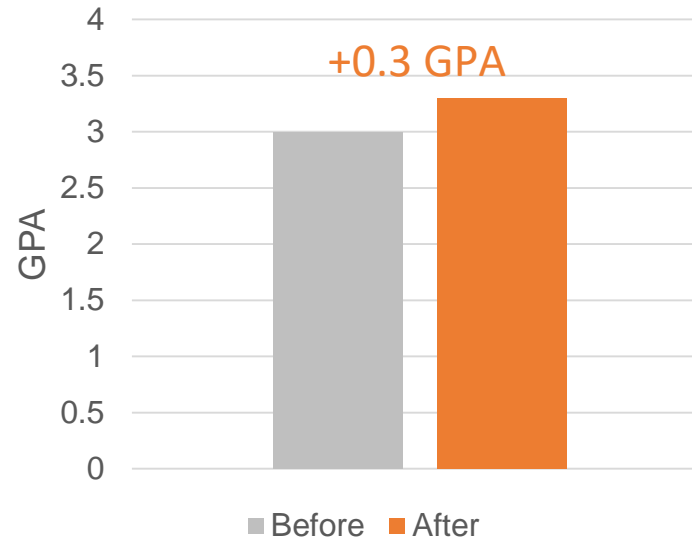
- Only change ▯ zyBook
  - U Mich, U Ariz, UC Davis
    - N = 1,945
    - 14% exams, 7% projects
  - "Students prepared for class"

ASEE 2015 (best paper award)

Textbook Spr18

zyBook Fal18
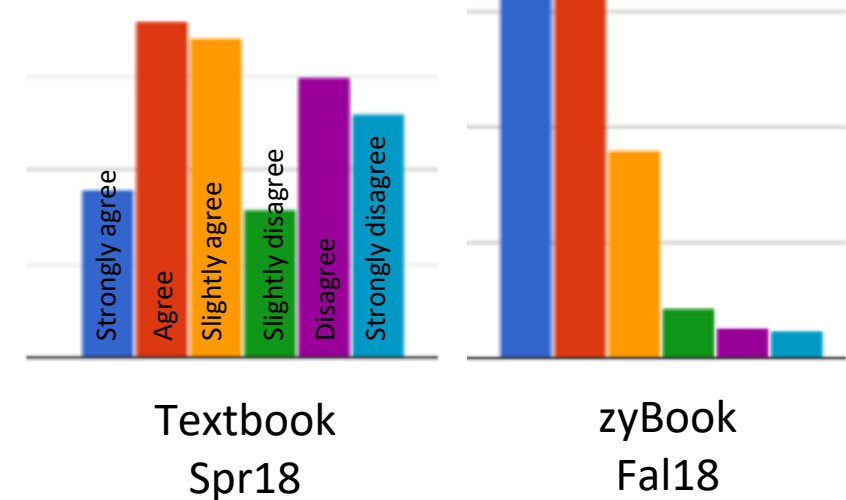
The rise of program auto-graders (zyLabs)

Courses
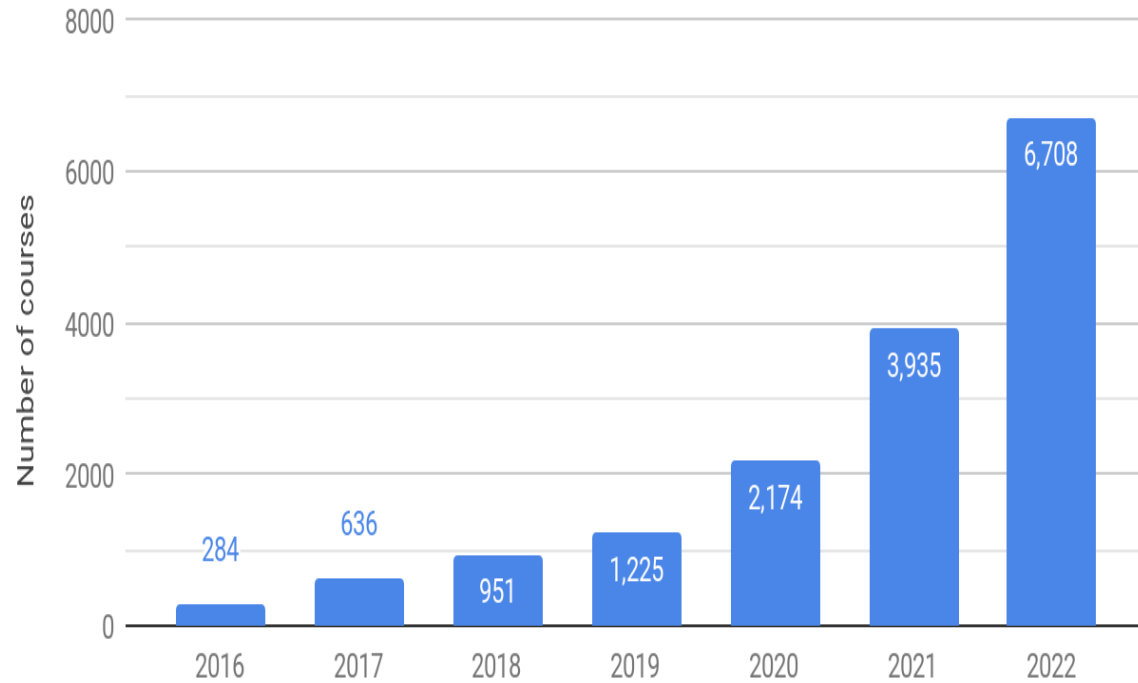
312,000 students
in 2022

Submissions
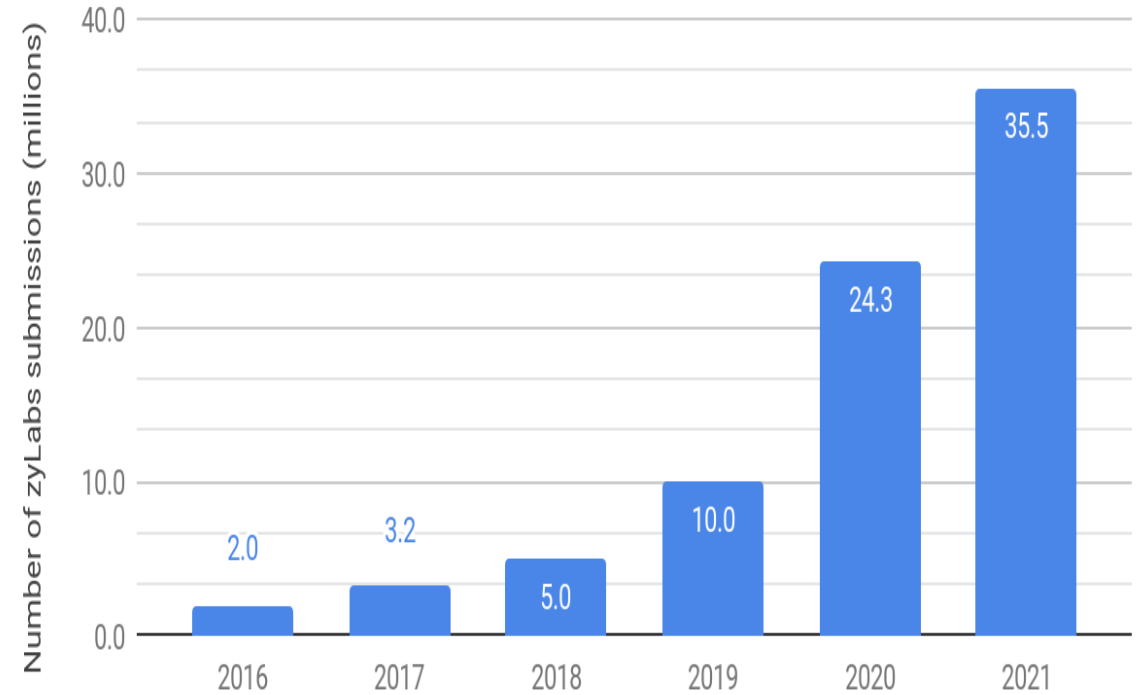
Immediate feedback for students

Auto-grading: Fewer teaching resources, happier teachers/TAs

Blue: Total TA time
Red: TA grading time

Before program
auto-grading

After program
auto-grading
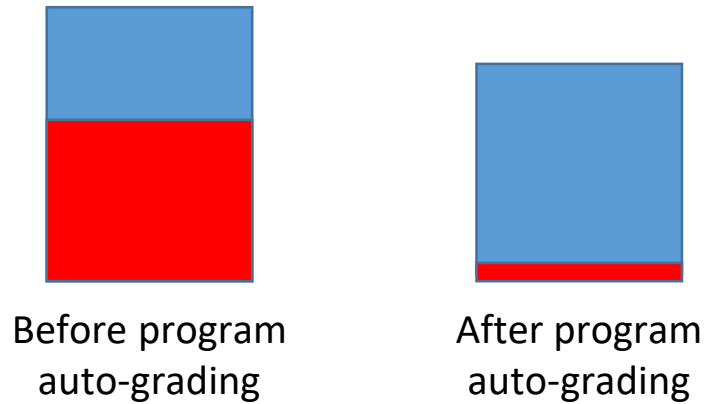
Prof: 5-6 hrs/wk

Hours	Task
3	Lecture time (online synch / in-person)
1	Lecture prep (2 x 30 min)
½ - 1	Office hour (1 hr, but usually just 30 min)
½ - 1	Misc

Professors: Self-reported time savings from program auto-grader (82 respondents)

Number of instructors

Hours saved grading per week
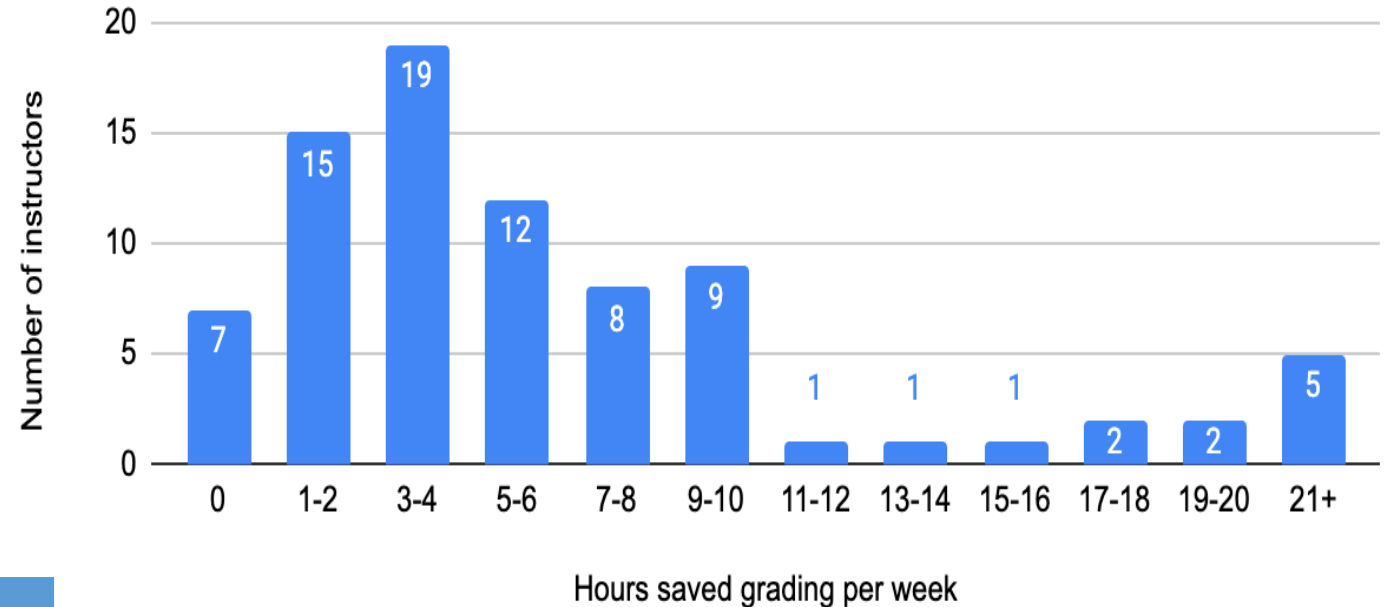
Average: 9 hours / week *saved*

"The auto-grader has freed up a lot of my time so I can spend more time working with students."

Analytics enables insights / research

Average Time per week (If final taken) vs. User
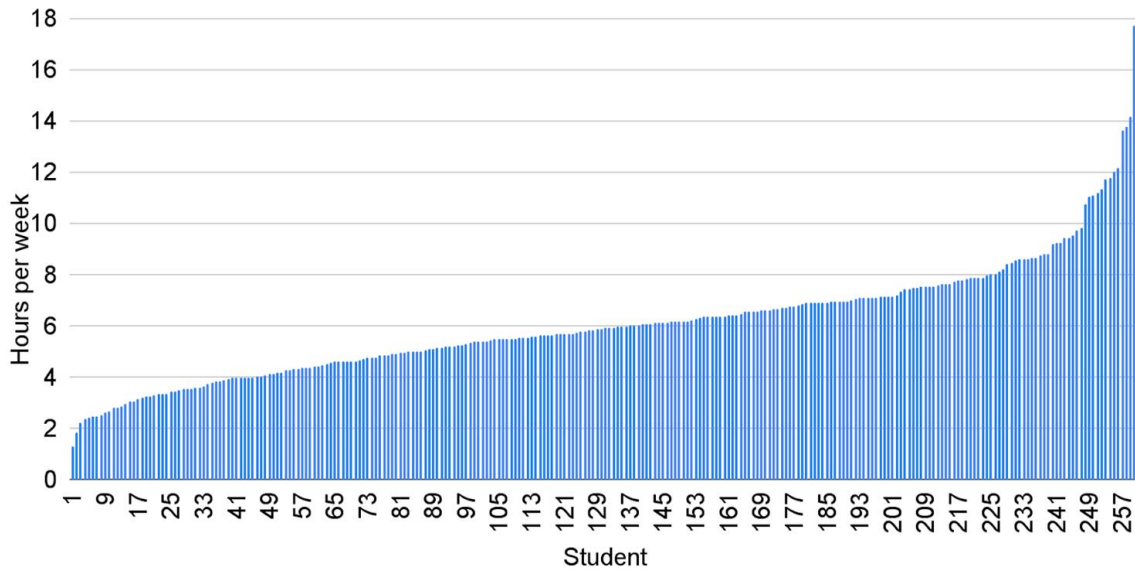
Midterm Grades for Hours Spent (No Prior Experience)

NET RESULTS: CS1 grades

2008-2012 (3,020 students)

UCR

2013-2019 (5,220 students)

CS2 too

CS12
2007-2012 (1,160 students)

CS12
2013-2019 (2,460 students)
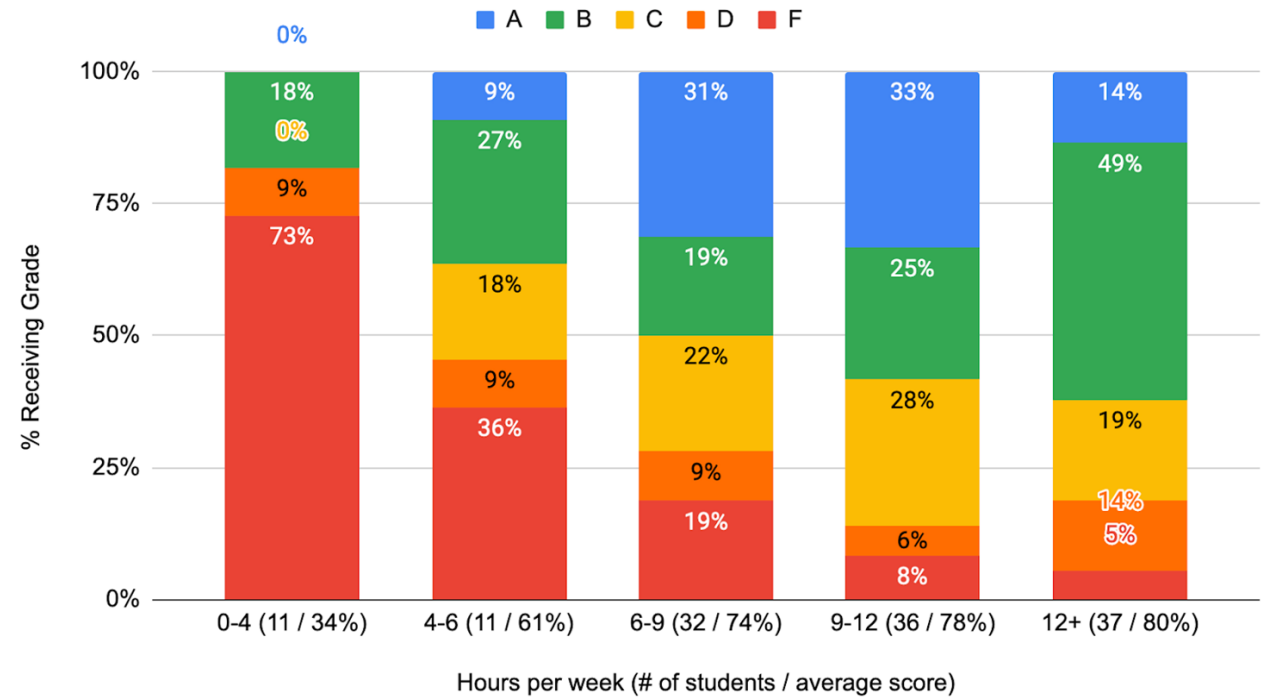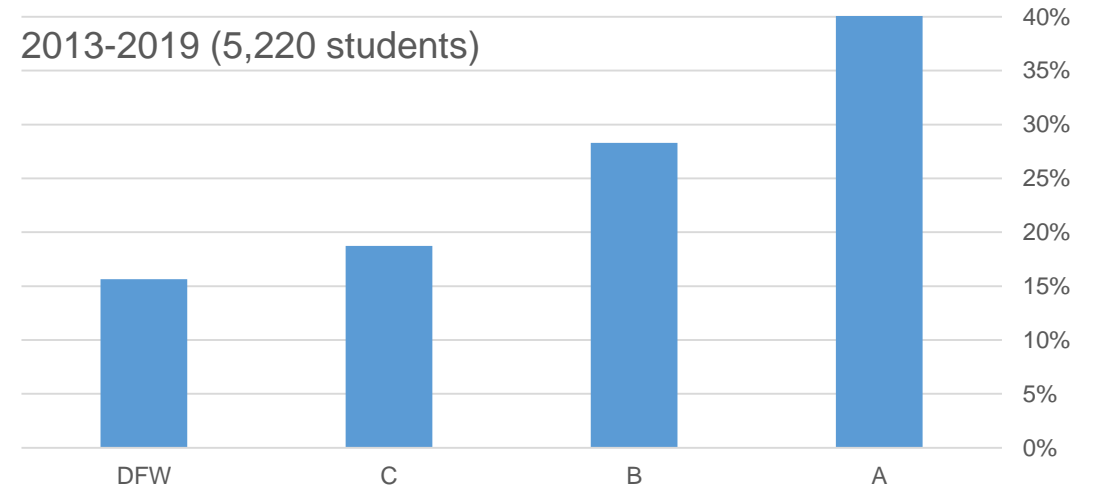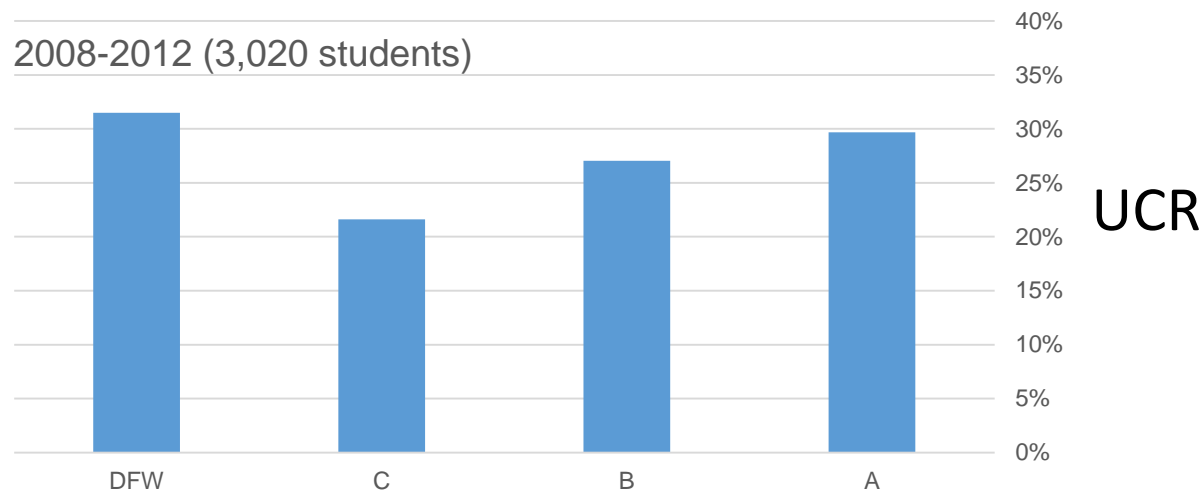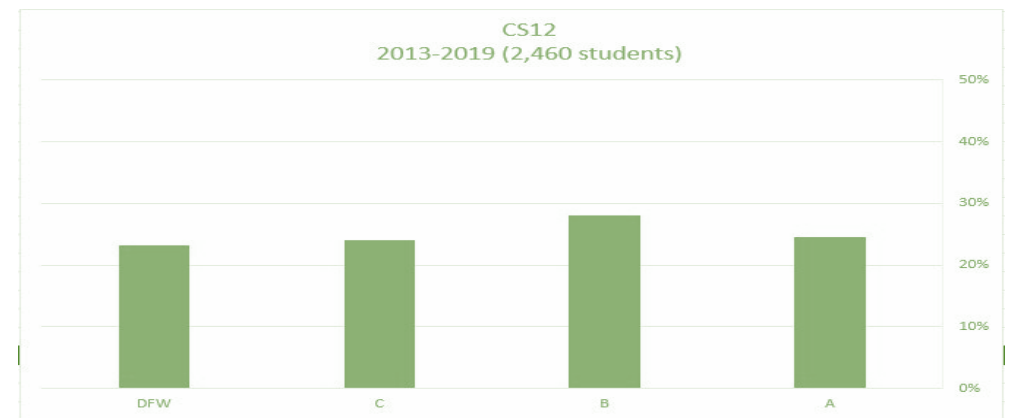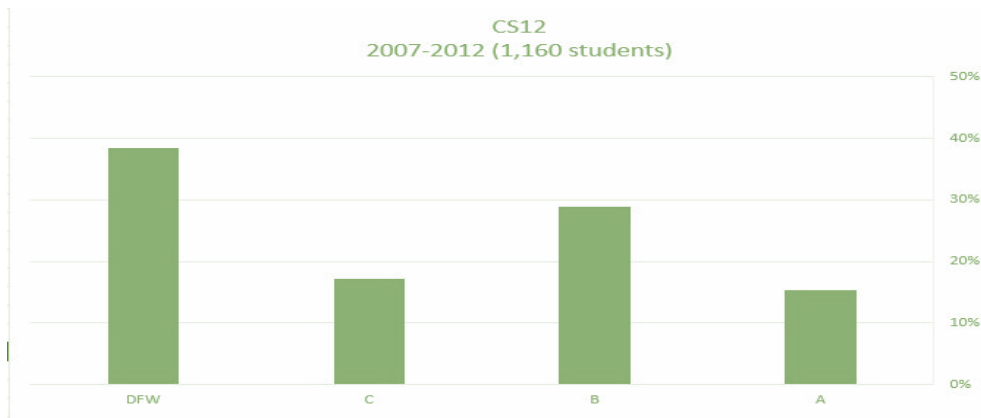
CS1 positive evaluations

Fall 2010

19 The course overall as a learning experience was excellent   14 11 13 1 5 - 3.6 4.0 1.3   19   4.0   4.0 1.0   53   4.1   4.0 1.0

Fall 2013

19 The course overall as a learning experience was excellent   10 12 6 5 1 - 3.7 4.0 1.1   21   4.2   4.0 0.9   50   4.2   4.0 0.9

Fall 2014

19 The course overall as a learning experience was excellent   15 19 9 4 - - 4.0 4.0 0.9   56   4.0   4.0 1.0   64   4.2   4.0 0.9

Textbook → Interactive content

Spring 2015

19 The course overall as a learning experience was excellent   19 17 7 - 2 - 4.1 4.0 1.0   53   4.1   4.0 1.0   69   4.2   4.0 0.9

Fall 2015

19 The course overall as a learning experience was excellent   22 19 11 - - - 4.2 4.0 0.8   65   4.1   4.0 1.0   70   4.2   4.0 0.9

OLPs → Many small programs

Spring 2017

19 The course overall as a learning experience was excellent   31 11 - - 1 - 4.65 5.0 0.7   86.90 4.19 4.0 0.9   86.62 4.23 4.0 0.9

Spring 2018

19 The course overall as a learning experience was excellent   34 10 1 1 - - 4.67 5.0 0.6   92.39 4.16 4.0 0.9   86.30 4.23 4.0 1.0

Winter 2019

19 The course overall as a learning experience was excellent   16 4 2 - - - 4.64 5.0 0.7   85.00 4.21 4.0 1.0   82.29 4.24 5.0 1.0

CS1 evaluations robust across instructors

Other schools publishing similar results

Figure 1: CS 1 (Java) student outcomes of the last 4 semesters with passive learning textbook (156 students total) and first two semesters with active learning textbook (81 students).

McKinney (U South Alab.), ASEE'20

Irani (UCI) SIGCSE'20

Discrete Math D/F rate dropped from 23% to 11%

Rosen

zyBook
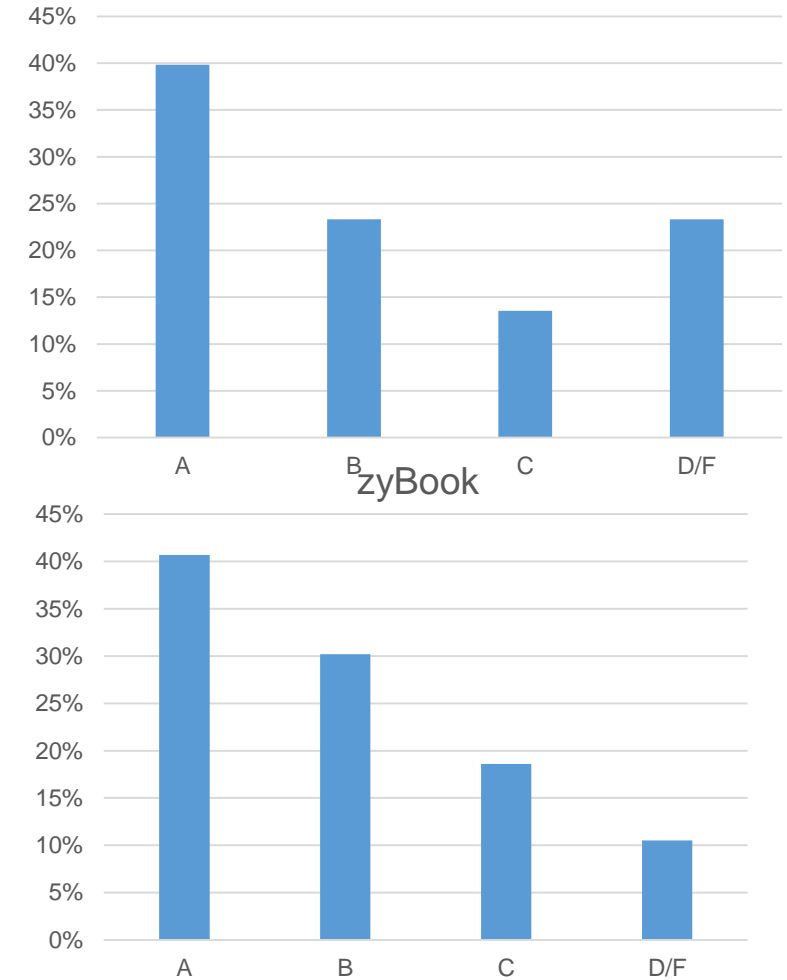
And back to why it all started: Retention
Now 90%, no matter how sliced

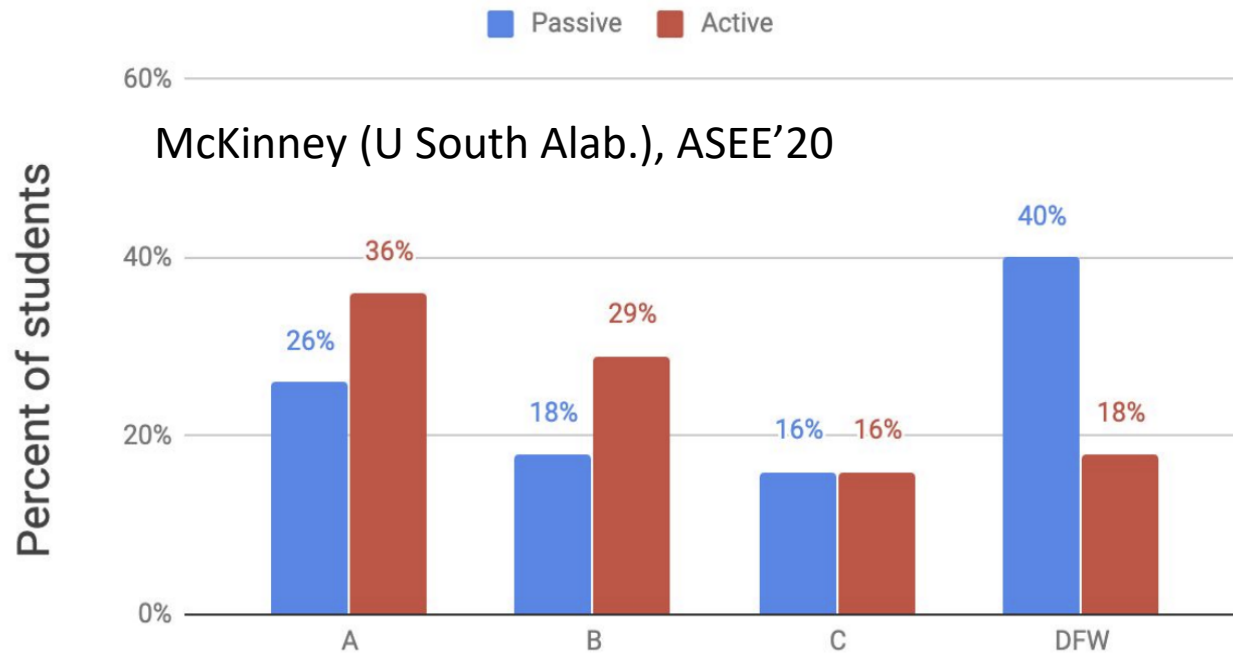| Selection	Fall 2011 Cohort	Fall 2010 Cohort	Fall 2009 Cohort	Fall 2008 Cohort	Fall 2007 Cohort	Fall 2006 Cohort	Fall 2005 Cohort	Fall 2004 Cohort	Fall 2003 Cohort	Fall 2002 Cohort
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Total	14	17	7	12	9	6	3	9	6	17
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Year 2	28.6%	41.2%	57.1%	33.3%	55.6%	50.0%	33.3%	22.2%	33.3%	17.6%
Male										
Total	63	85	65	73	59	61	42	48	76	109
Year 1	63.5%	80.0%	67.7%	56.2%	67.8%	62.3%	81.0%	68.8%	65.8%	72.5%
Year 2	44.4%	55.3%	44.6%	39.7%	49.2%	42.6%	42.9%	43.8%	39.5%	42.2%

2012: CS1/2 zyBooks

Selection	Fall 2021 Cohort	Fall 2020 Cohort	Fall 2019 Cohort	Fall 2018 Cohort	Fall 2017 Cohort	Fall 2016 Cohort	Fall 2015 Cohort	Fall 2014 Cohort	Fall 2013 Cohort	Fall 2012 Cohort
Female										
Total	28	22	46	26	13	18	9	12	16	9
Year 1	89.3%	86.4%	84.8%	92.3%	84.6%	88.9%	100.0%	91.7%	87.5%	88.9%
Year 2		81.8%	63.0%	69.2%	53.8%	72.2%	100.0%	58.3%	25.0%	88.9%
Male										
Total	122	119	141	81	77	65	50	71	67	70
Year 1	95.9%	91.6%	89.4%	86.4%	89.6%	90.8%	86.0%	87.3%	77.6%	77.1%
Year 2		76.5%	80.9%	67.9%	72.7%	72.3%	70.0%	63.4%	58.2%	64.3%

ir.ucr.edu
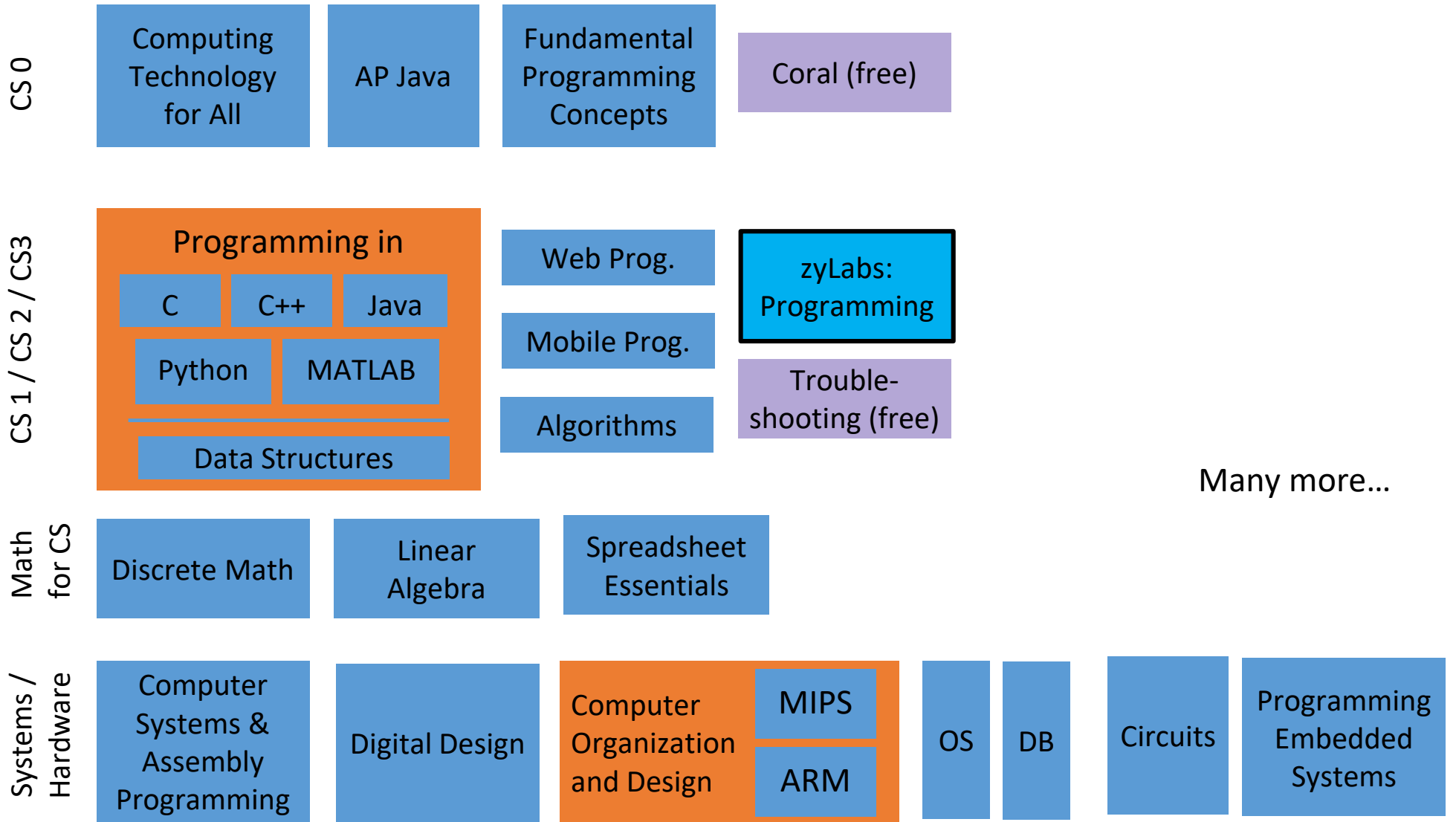
Additional Books

- Engineering
  - Circuits
  - Digital design
  - Signals/Systems
  - Control Systems (Nise)
  - Matlab
- Math
  - Calculus
  - Linear Algebra
  - Discrete Math
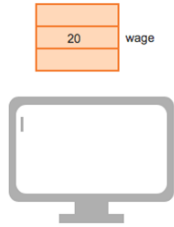
Summary

zyBooks

Helped by: NSF SBIRs (>$2M),
Dept. of Ed SBIR, NSF, Google

Now ~170 employees
Acquired by Wiley July 2019, still a unit

Demonstration

- Kirchoff's Current Law
  - Link: https://learn.zybooks.com/zybook/BarlowCircuitsNIJul2020/chapter/2/section/6
- Resistors
  - Link: https://learn.zybooks.com/zybook/BarlowCircuitsNIJul2020/chapter/2/section/2
- Signal Transformation
  - Link: https://learn.zybooks.com/zybook/BarlowSig&SysMay2021/chapter/2/section/3
- Laplace Transforms
  - Link: https://learn.zybooks.com/zybook/BarlowSig&SysMar2023/chapter/3/section/12
- Stability
  - Link:
  - https://learn.zybooks.com/zybook/BarlowCtrlSysMar2023/chapter/6/section/11

Questions

Tried building OER

- Online book + coding window
- 2010, NSF CCLI grant, ~10 schools
- Online content+platform is _hard_

Initial → Revisions 1-3 yrs
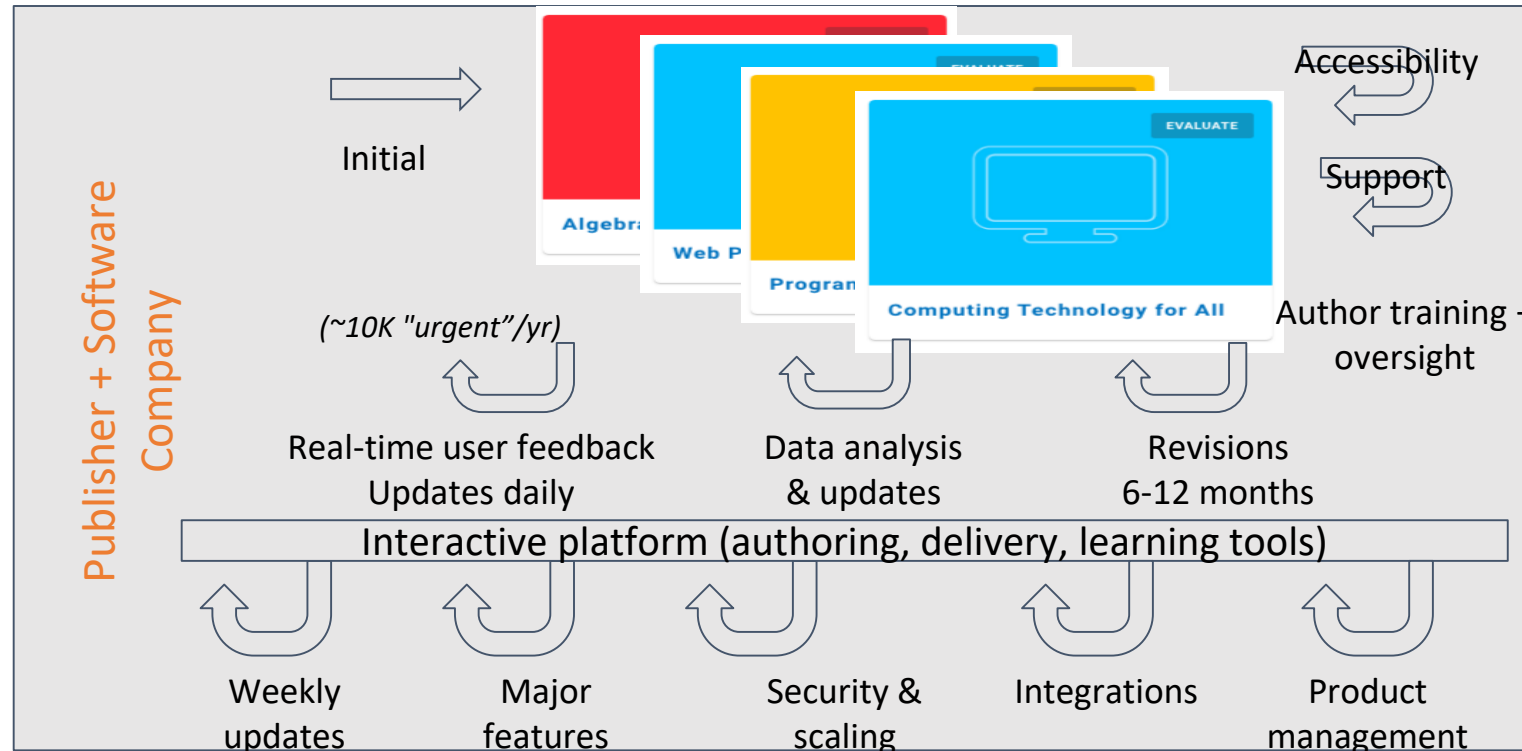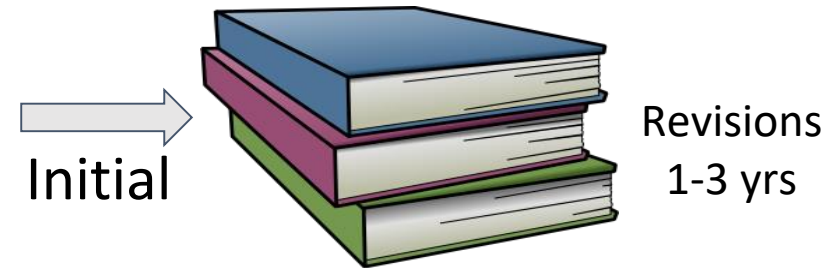
Previously authored traditional textbooks (Digital Design, Embedded Systems)

https://www.cs.ucr.edu/~vahid/dd/

Publisher + Software Company

Initial

Accessibility

Support

(~10K "urgent"/yr)

Author training + oversight

Real-time user feedback
Updates daily

Data analysis
& updates

Revisions
6-12 months

Interactive platform (authoring, delivery, learning tools)

Weekly updates | Major features | Security & scaling | Integrations | Product management

Now the best-selling college-level C++, Java, and Python intro textbooks in the U.S.

Source: Navstem.com, 2021
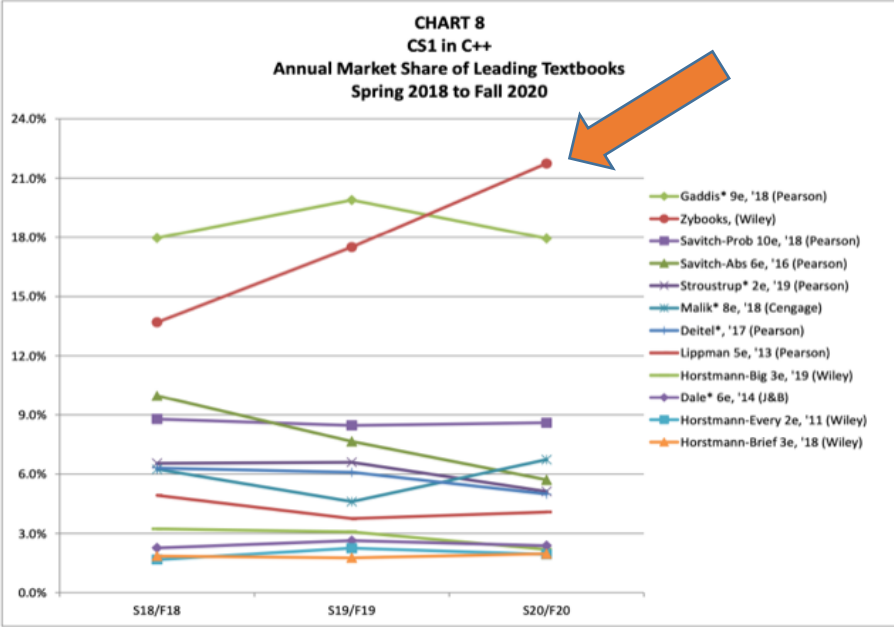
C++
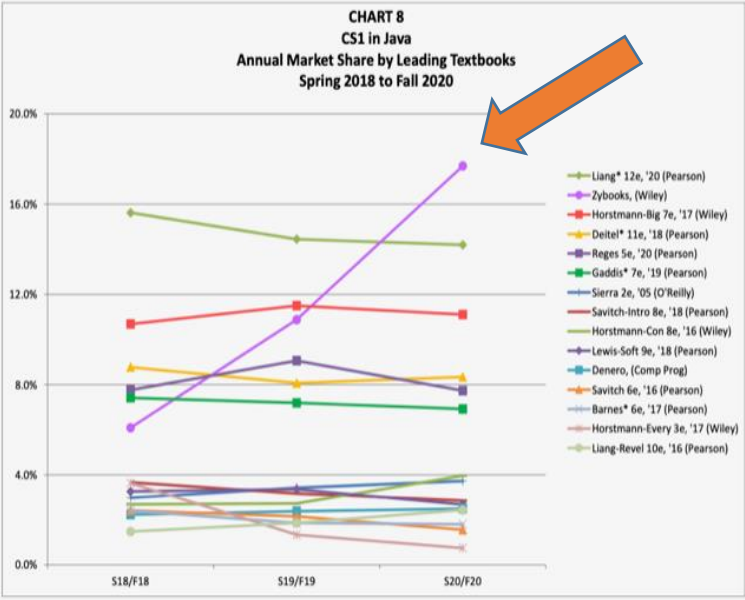
Java
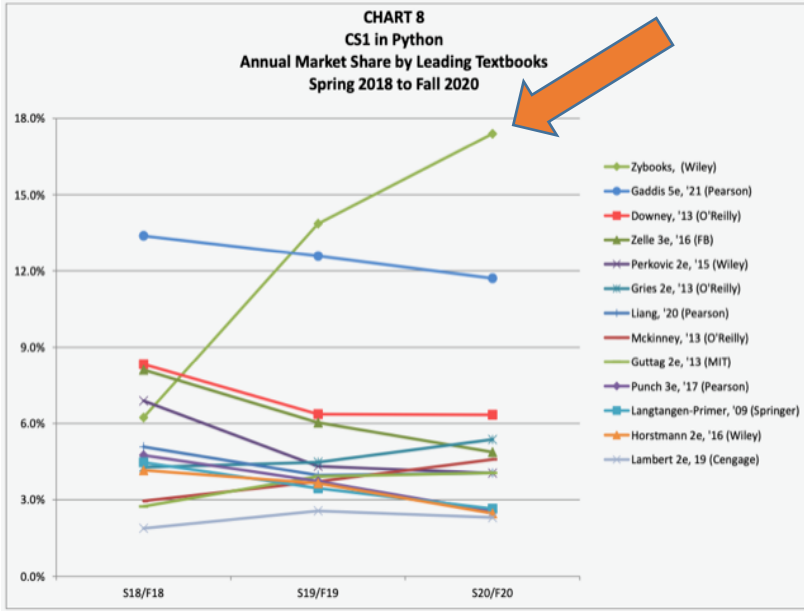
Python

Active lecture: Examples, Activities

"Freed"

| Q&A / Motivation / Mentoring |
| Examples, Activities |
| Basic concepts |

Instructor — Book

Typical

Instructor — Interactive content

Better

In-person or online

Provides baseline
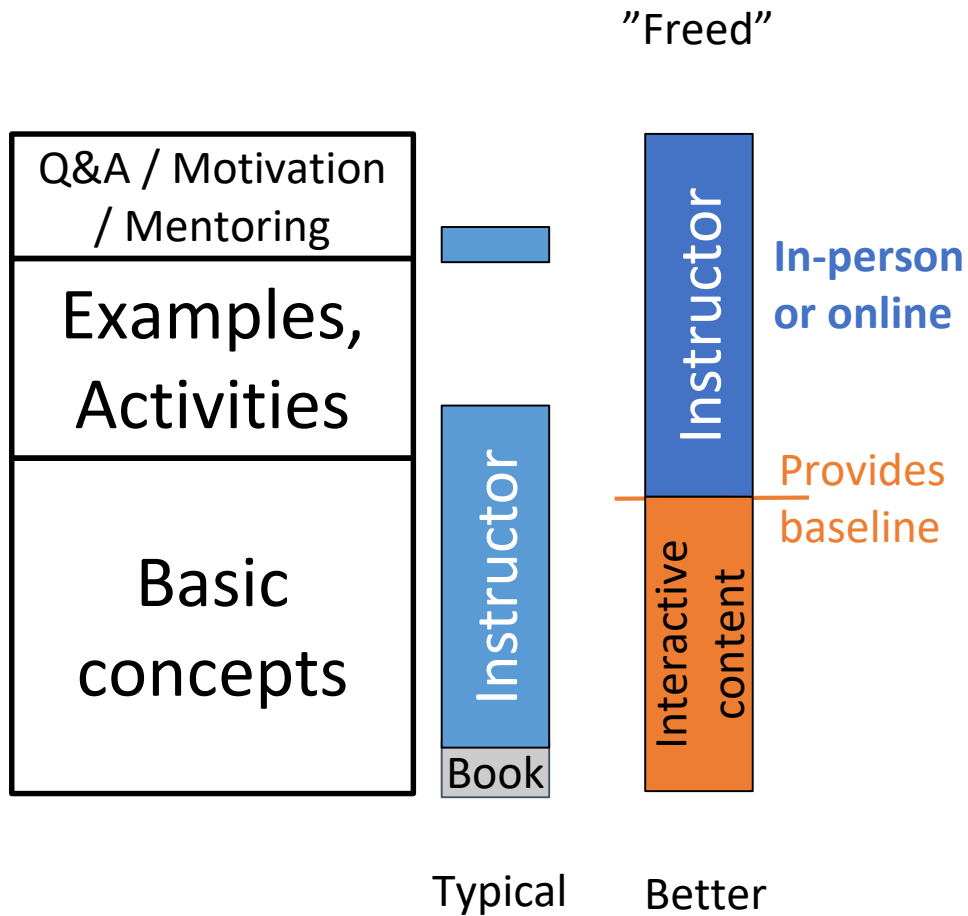
```cpp
using namespace std;

int CountCharacters(char userChar, string userString) {
    unsigned int i;
    int numChars;

    i = 0;
    numChars = 0;

    while (i < userString.length()) {
        if (userString.at(i) == userChar) {
            ++numChars;
        }
        ++i;
    }

    return numChars;
}
```

main.cpp

- Students pre-read, know basics
- Turn lecture into active sessions
  - Students solve problems (together)
  - Prof does examples, poses problems, gives feedback

Actually *easier* on teacher

Retention 90% no matter how sliced

ir.ucr.edu

First generation

	Fall 2018 Cohort	Fall 2017 Cohort	Fall 2016 Cohort	Fall 2015 Cohort	Fall 2014 Cohort	Fall 2013 Cohort	Fall 2012 Cohort	Fall 2011 Cohort	Fall 2010 Cohort	Fall 2009 Cohort
Total	40	19	26	13	35	30	30	38	48	31
Year 1	90.0%	100.0%	84.6%	92.3%	82.9%	76.7%	83.3%	57.9%	77.1%	58.1%
Year 2		84.2%	57.7%	69.2%	62.9%	53.3%	70.0%	36.8%	52.1%	41.9%

Low income

	Fall 2018 Cohort	Fall 2017 Cohort	Fall 2016 Cohort	Fall 2015 Cohort	Fall 2014 Cohort	Fall 2013 Cohort	Fall 2012 Cohort	Fall 2011 Cohort	Fall 2010 Cohort	Fall 2009 Cohort
Total	36	23	21	13	23	21	20	38	50	23
Year 1	88.9%	95.7%	90.5%	84.6%	87.0%	71.4%	65.0%	60.5%	78.0%	60.9%
Year 2		87.0%	71.4%	53.8%	52.2%	47.6%	60.0%	34.2%	52.0%	52.2%

Mar 2023

Cheating reduction
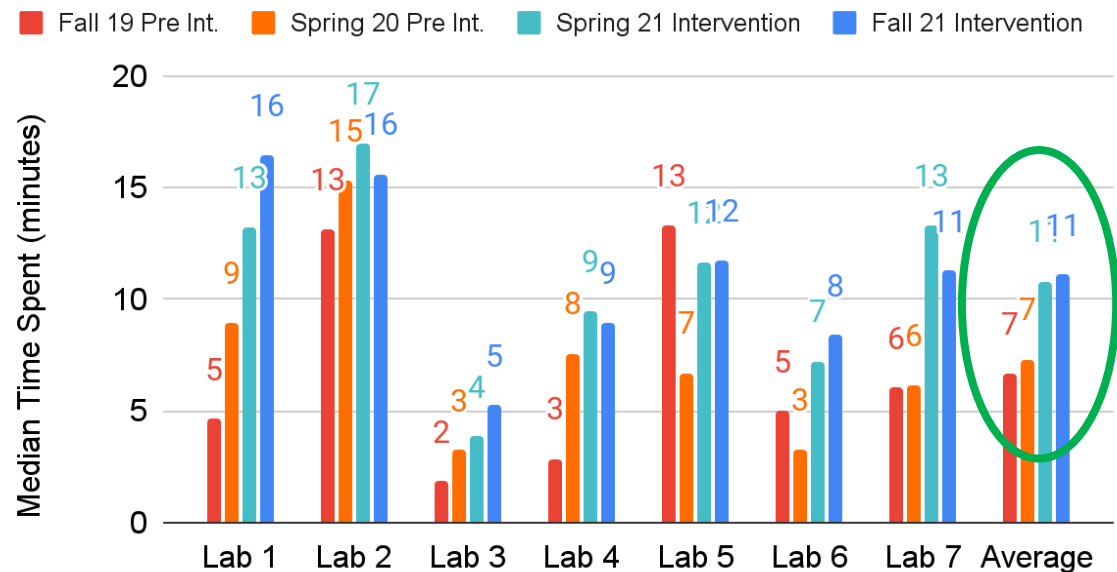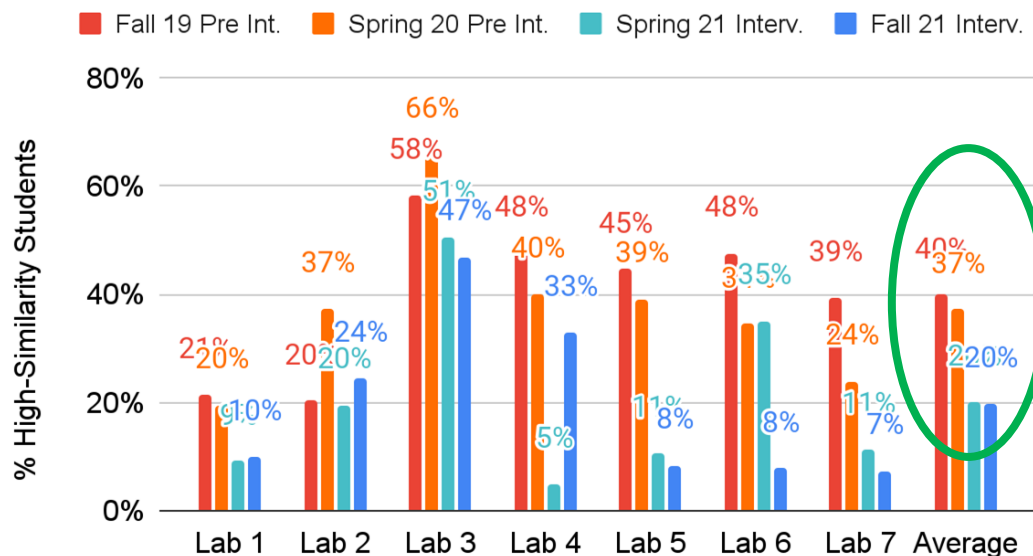
2nd instructor
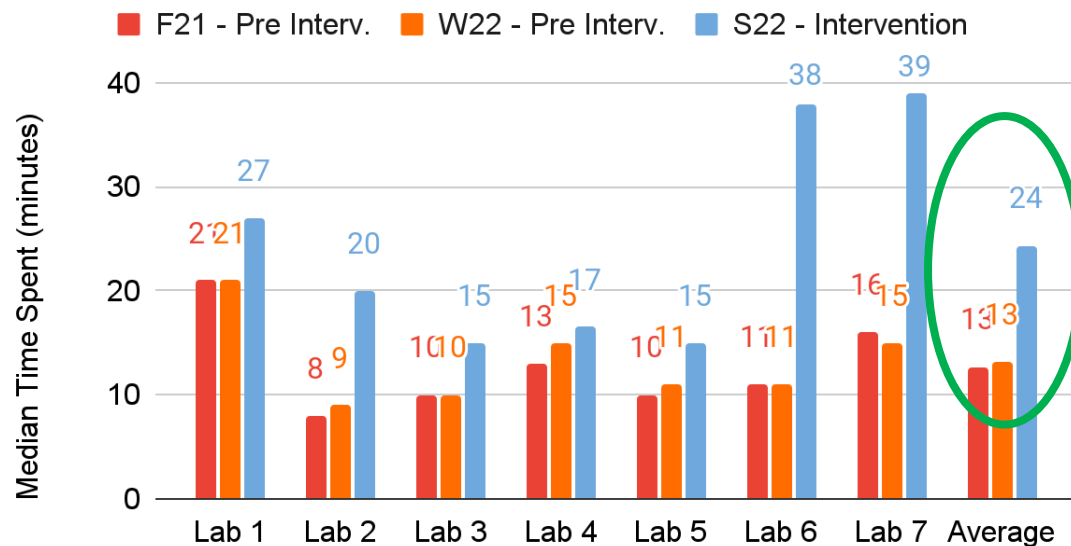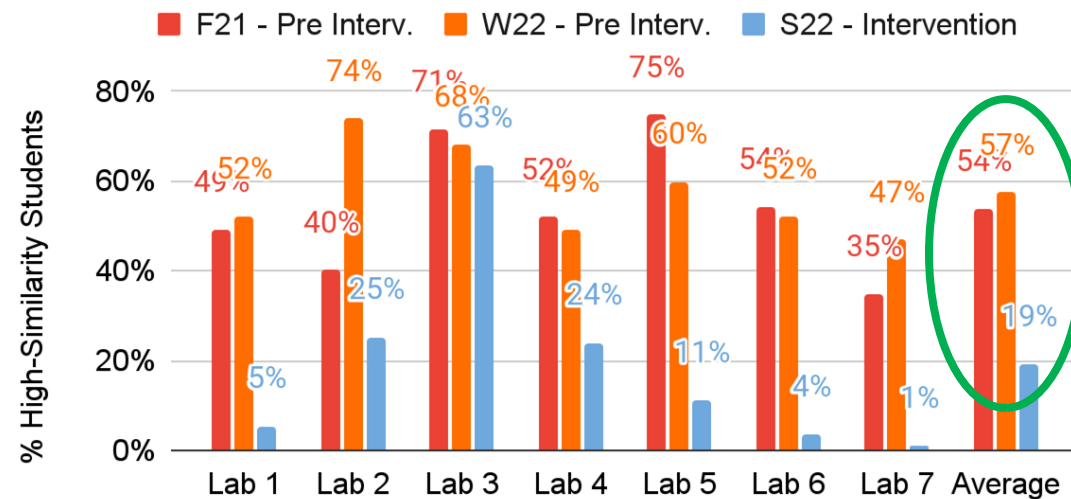
Cheat detection – Sorted list of students of concern, across multiple labs

UCRCS10AOnlineFall2021
Chapters 7

Apex tool

Roster — 107 students — Search roster... — Anonymous 👁 — Expand — 💾

lass Section	ID	Labs Attempted	Total Time	Total Runs	Avg. Score	Total Score	Possible Score	Points-Rate Concern	Similarity Concern	Frequently Similar Students	Style Anomaly Concern	Style Anomaly Score
ot Found	577583	7	00:08:13	11	6	42	70	0.93	0 0/4	None	1	94
ot Found	1138206	7	00:35:46	71	7.29	51	70	0.25	0 0/4	None	1	28
ot Found	1141954	6	07:40:23	342	9.33	56	60	0	0 0/4	None	1	27
ot Found	1138285	6	01:34:51	93	9.67	58	60	0.06	0.3 1/4	None	1	27
ot Found	1137170	7	04:08:34	216	9.57	67	70	0	0 0/4	None	1	19
ot Found	1346409	2	00:16:56	15	9	18	20	0.06	0 0/4	None	1	17
ot Found	1139583	6	03:24:06	172	10	60	60	0	0 0/4	None	1	17
ot Found	1137126	7	01:09:30	43	3.86	27	70	0	0 0/4	None	1	16
ot Found	1136926	5	01:28:54	60	8.2	41	50	0.01	0 0/4	None	0.98	14
ot Found	1013473	7	00:52:04	25	10	70	70	0.31	0 0/4	None	0.98	14

Used ChatGPT

ChatGPT "student" – high on style anomaly and points rate lists

UCRCS10AOnlineFall2021
Chapters 7

| Roster | 107 students | | | | | | | Q Search roster... | | Anonymous ⊙ | Expand ⤢ | 💾 |

lass Section	ID	Labs Attempted	Total Time	Total Runs	Avg. Score	Total Score	Possible Score	Points-Rate Concern	?	Similarity Concern	?	Frequently Similar Students ?	Style Anomaly Concern	?	Style Anomaly Score
ot Found	577583	7	00:08:13	11	6	42	70	0.93		0	0/4	None	1		94
ot Found	1138206	7	00:35:46	71	7.29	51	70	0.25		0	0/4	None	1		28
ot Found	1141954	6	07:40:23	342	9.33	56	60	0		0	0/4	None	1		27
ot Found	1138285	6	01:34:51	93	9.67	58	60	0.06		0.3	1/4	None	1		27
ot Found	1137170	7	04:08:34	216	9.57	67	70	0		0	0/4	None	1		19
ot Found	1346409	2	00:16:56	15	9	18	20	0.06		0	0/4	None	1		17
ot Found	1139583	6	03:24:06	172	10	60	60	0		0	0/4	None	1		17
ot Found	1137126	7	01:09:30	43	3.86	27	70	0		0	0/4	None	1		16
ot Found	1136926	5	01:28:54	60	8.2	41	50	0.01		0	0/4	None	0.98		14
ot Found	1013473	7	00:52:04	25	10	70	70	0.31		0	0/4	None	0.98		14