Pedagogical Transformations in the UBC CS Science Education Initiative

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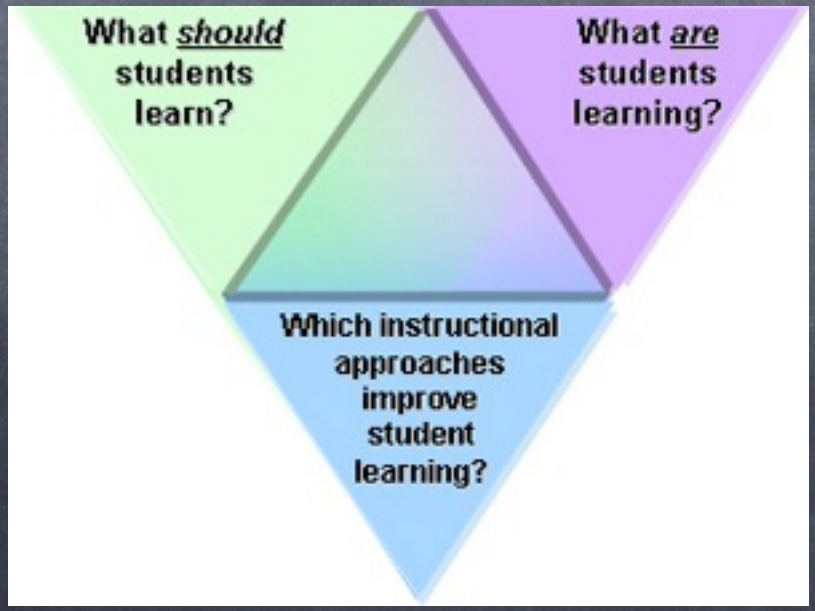
Outline

- Intro to CSSEI (very brief)
- Pedagogical Transformations
  - Attitudinal Surveys
  - CPSC 121-- Just in Time Teaching (JiTT)
  - BRACElet
  - CPSC 221-- Problem-based Peer Learning

Carl Wieman Science Education Initiative

- 5-year, $12M project aimed at dramatically improving undergraduate science education



Pedagogical Transformation 101:

1. Ask yourself what is and is not working in a course

Know Your Students

- Attitudinal Survey
- Abilities

Attitudinal Surveys

- Objective- know your students (what you want to find out about your students?)
  - What are their expectations?
  - How do they learn?
  - What occupies their time?
  - What are their attitudes wrt their efficacy in doing well in the course?

Student Interviews

- Objective – explore areas not covered in surveys (what students want to tell you about themselves?)
  - Use questions to provoke voluntary comments.
  - Use think-aloud to reveal how students solve problems.
  - Review exams to find out how students approached each question.

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CPSC 121: Models of Computation

- Problems with existing course:
  - Lectures often dominated by low-level learning goals
  - Circuit-based labs disconnected from in-class theory
  - Downstream courses spend extensive time on reviewing 121 concepts

CS121: Just-in-Time-Teaching

- Each lecture/unit ends with the preparatory assignment for next lecture:
  - A list of "pre-class learning goals"
  - A list of readings
  - Suggested exercises
- Students are additionally required to complete an online, low-credit quiz before the next lecture
- In-class activity using this material

Example Question: Can you be 1/3rd Scottish?

Conclusions:

- The experimental section performed substantially and significantly better than the traditional section
- However, past performance showed the experimental section contained stronger students, introducing a significant confounding factor

BRACElet Questions

- Unified questions asked across multiple courses to establish the progression of learning through the program
- Alternatively can be used to establish baselines and assess changes in a course

BRACElet Question

Explain in plain English: what does this piece of code do?

```
bool bValid = true;

for (int i = 0; i < iMAX - 1; i++) {

    if (iNumbers[i] > iNumbers[i+1])

        bValid = false;

}
```

Objectives

- Are BRACElet questions good predictors of student understanding of computer programming?
- What other assessment instruments are good predictors of the final course grade?
- Which specific questions in a particular assessment are good predictors for the final course grade? Why?
- How can this information be used to improve student performance?

BRACElet Questions

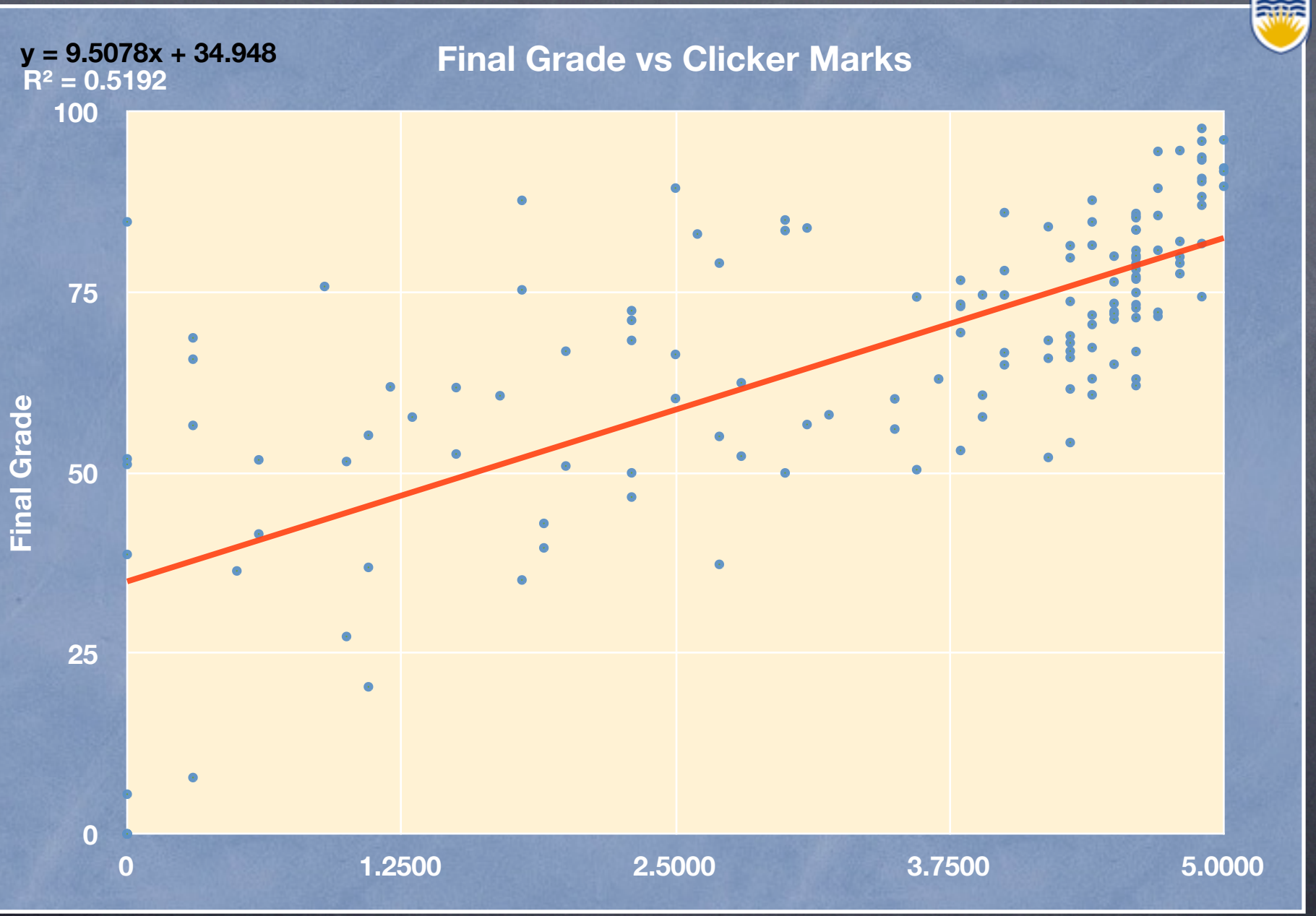
	Final Exam Grade	Final Course Grade
B1	0.47	0.45
B2	0.44	0.35
B3	0.52	0.47

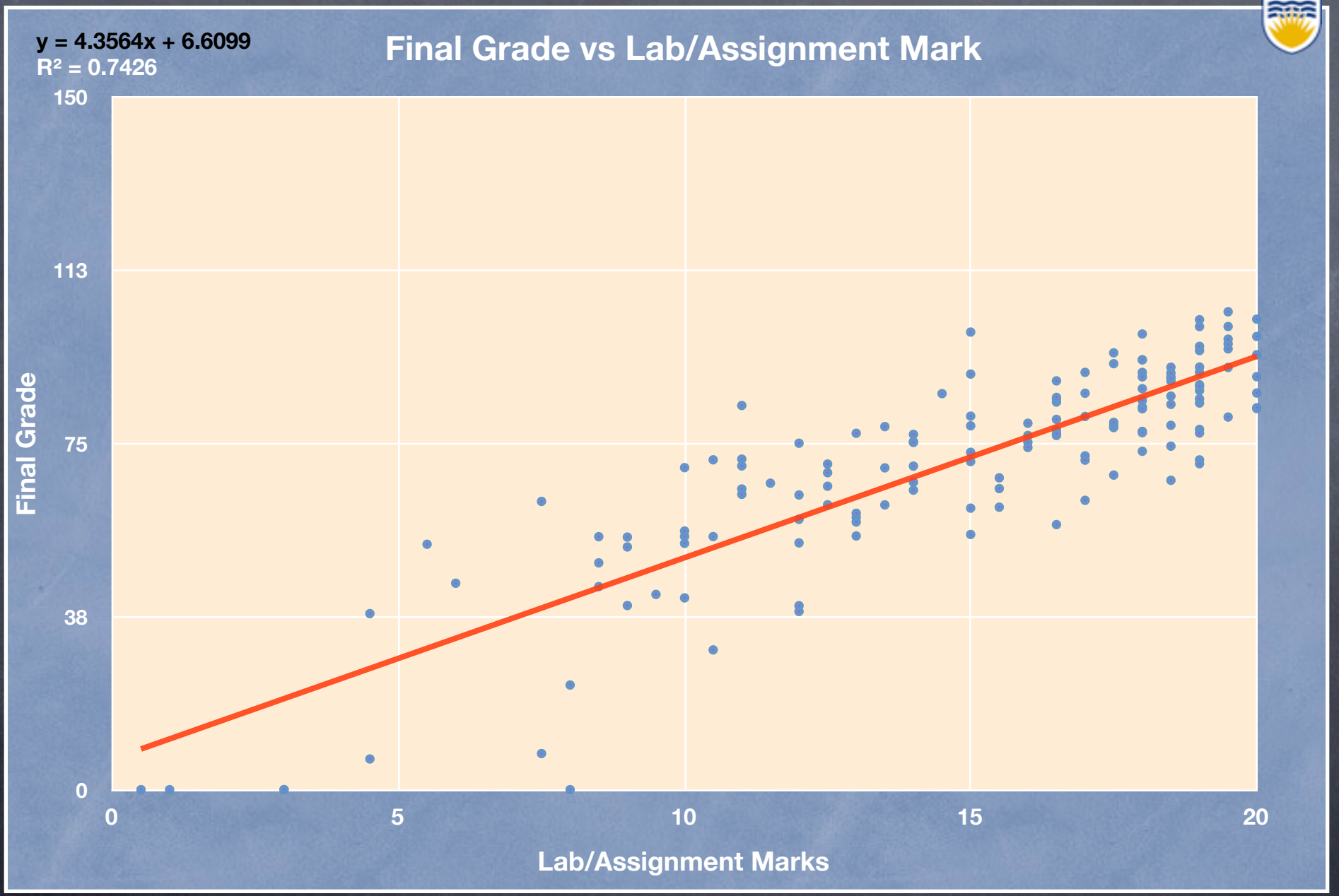
Final Exam

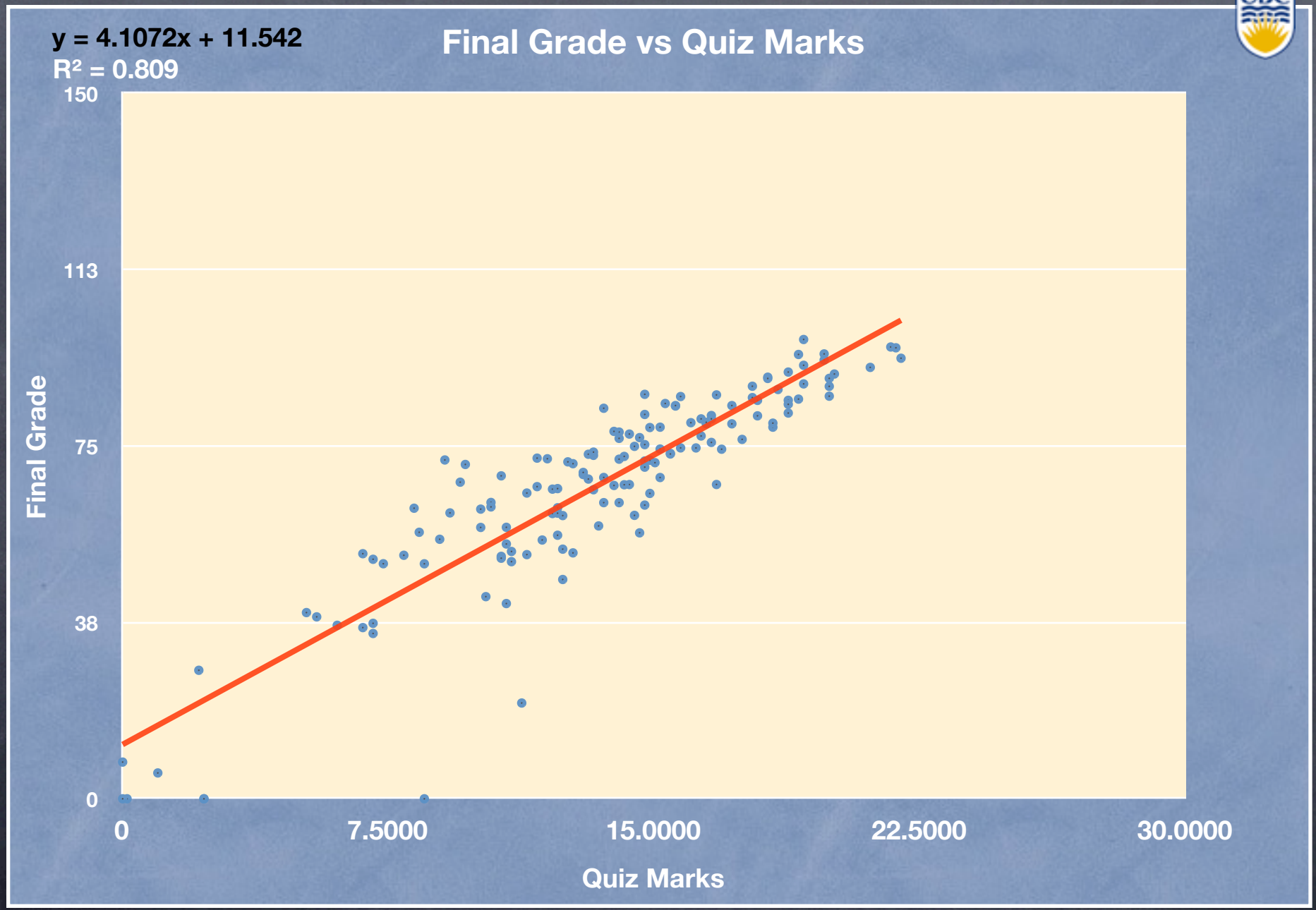
	2	3a	3b	3c	4	5	6	7	8	9	10	11	12	13	Final	Grade
1	**0.69**	0.53	0.55	0.43	0.61	0.56	0.48	0.57	0.38	0.45	**0.69**	0.66	0.58	0.6	0.67	**0.73**
2		0.54	0.56	0.49	0.61	0.51	0.53	0.59	0.4	0.46	0.63	0.62	0.62	**0.68**	**0.76**	**0.76**
3a			0.54	0.4	0.49	0.36	0.43	0.44	**0.29**	**0.28**	0.47	0.51	0.37	0.44	0.47	0.53
3b				0.65	0.5	0.46	0.42	0.4	**0.24**	0.36	0.5	0.55	0.4	0.46	0.44	0.48
3c					0.43	**0.34**	0.43	0.42	**0.25**	**0.3**	0.49	0.44	0.52	0.49	0.52	0.52
4						0.44	0.52	0.59	0.42	0.45	0.65	0.54	0.54	0.61	0.68	**0.71**
5							0.42	0.4	**0.29**	0.4	0.6	0.54	0.44	0.44	0.46	0.48
6								0.48	0.39	0.39	0.62	0.56	0.42	0.47	0.61	0.63
7									0.42	0.41	0.6	0.45	0.53	0.63	0.72	0.68
8										**0.28**	0.48	0.4	0.37	0.42	0.52	0.5
9											0.53	0.47	0.44	0.43	0.45	0.4
10												**0.67**	0.63	0.65	**0.76**	**0.77**
11													0.6	0.54	0.59	0.64
12														0.63	0.68	0.67
13															**0.83**	**0.79**

Big Picture: Course Level Components

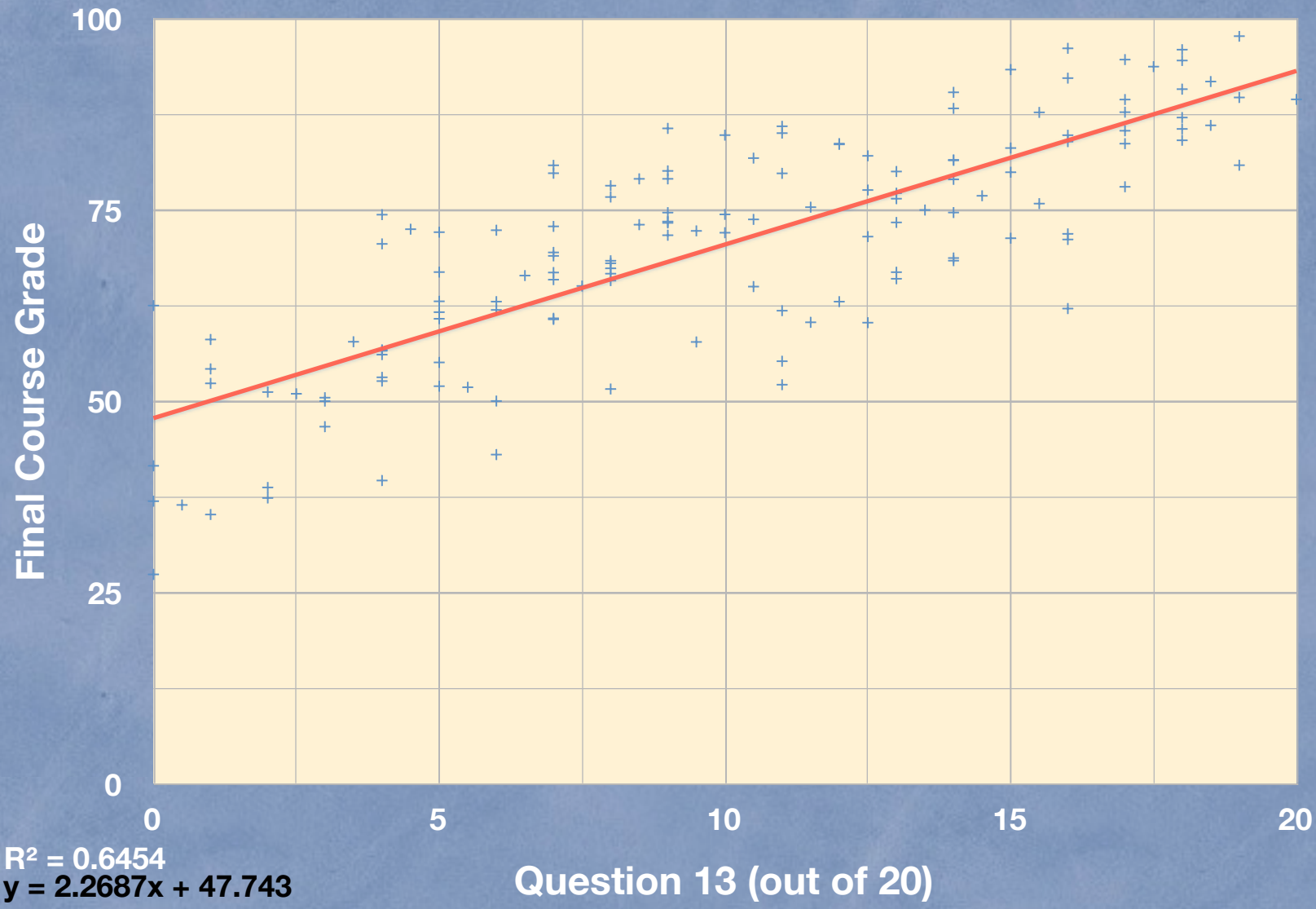
	Assignment	Quiz	Clickers	Final Exam	Course Grade
Lab	0.52	0.67	0.59	0.69	0.76
Assignment		0.61	0.54	0.64	0.75
Quiz			0.63	**0.84**	**0.89**
Clickers				0.64	0.72
Final Exam					**0.97**


y = 9.5078x + 34.948
R² = 0.5192
Final Grade vs Clicker Marks
Final Grade
100
75
50
25
0
0
1.2500
2.5000
3.7500
5.0000


y = 4.3564x + 6.6099
R² = 0.7426
Final Grade vs Lab/Assignment Mark
150
113
75
38
0
Final Grade
0
5
10
15
20
Lab/Assignment Marks


y = 4.1072x + 11.542
R² = 0.809
Final Grade vs Quiz Marks
150
113
75
38
0
Final Grade
0
7.5000
15.0000
22.5000
30.0000
Quiz Marks

Final Course Grade vs Question 13



Next Steps

- Explore other BRACElet questions and better evaluation schemes. (Item response theory?)
- Validate hypotheses from this study in the next course.
- Map learning goals to each question of the assessment and track student learning within the course.
- Track predictors and retention of learning
- Make changes and check outcomes

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   b. Multiple-sections approach: Choose an aspect to vary, control everything else

Two Sections of CPSC 221:

The Theory: Well designed exercises will help guide the students to their learning destination.

201: **MWF 10am - 11am (64 students)** CONTROL

Traditional lecture: Powerpoint slides w/ learning goals delivered by instructor, mild classroom interaction via questions, clicker questions, short discussions.

202: **TTh 3:30pm - 5pm (47 students)** EXPERIMENTAL

Lecture: Brief introduction delivered by instructor, remainder of lecture delivered as workshop (instructor as facilitator only)

Results

Final Grades:

Control (Sec 201): 74%

Experimental (Sec 202): 70%

CPSC 221 historical 5-year average:

Section 201: 71.58% (STDEV 2.9)

Section 202: 70.7% (STDEV 2.5)

Baseline Comparison:

The control section did better on both control questions, suggesting perhaps a stronger section overall.

In general the **control** performed better on programming assignments and programming questions.

In all other areas the two groups performed equally...

Student enjoyment seemed **higher** in **experimental** group:

- Evidenced by extremely high attendance and mid-term anonymous reviews.

Workshop delivery needs to be refined with clearer introductory lecture component and wrap up:

- Performance on questions in later units improved and **surpassed** that of the **control** group.

This method of teaching is **effective:**

- Even as an inaugural, experimental offering, student performance was on par with standard 221 offerings and close to the control.

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