The flipped classroom: the good, the bad, and the ~~ugly~~ surprising?

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A Tale of Three Courses

This paper explores three distinct implementations of the flipped classroom paradigm, used to teach Chemical Engineering students at Imperial College London (ICL) in the 2023-24 academic year:

The "Good" - 3rd year elective course: *Introduction to Numerical Methods, INM*. Entirely taught in a **flipped class** approach.

The "Bad" - 2nd year core course: *Process Dynamics and Control, PDC*
The first half of the course in traditional format, **the second half flipped**.

The "Surprising" - Workshop in 3rd year core course: *Process Design, PD*
One-week workshop on heat integration **using the flipped classroom**.

2-step **Flipped Class** implementation at IC in each week:

1. **Preparation** – set of pre-rerecorded video segments/training quiz to be completed as homework before class
2. **Class Meeting** – Focusing on open-ended problem solving by students

A Tale of Three Courses

Focus:

- Gauging student satisfaction and mastery:

  Analysis based on student surveys on satisfaction and perception of mastery confidence.

- Learning outcomes:

  Comparison of exam results for the first two courses, and design project performance for the last course.

- Drawing conclusions and recommendations for implementing the flipped class method based on classroom situations.

Three Research Questions

RQ1. What was the level of students' approval for the usage of flipping? Was this perception different for those students who engaged more with the course resources and activities, compared to those who engaged less?

RQ2. Did the students who engaged most with the course resources and activities achieve better learning outcomes than those who engaged less?

RQ3. Which of the three versions of flipping achieved the best results, and why?

Student Perceptions

Survey Questions – Categorize

Table 1: Categorization as "active" students according to response.

	INM, the "good"	*PDC*, the "bad"	*PD*, the "surprising"
No. of registered students	29	140	138
No. of responders	25 (86%)	105 (75%)	108 (78%)
What was your degree of participation in the following activities?			
Q1. Online lessons (OL) completed	Completed all OLs	Completed all OLs	Completed all OLs
Q2. Class meetings (CMs) attended	Attended at least 5 out of 10 CMs	Attended at least half of 5 CMs	Attended at least 1 out of 3 CMs
What was your degree of active participation in the following activities?			
Q3. Engagement while watching online lessons	Watched some clips repeatedly	Not asked	Watched all clips at least once
Q4. Degree of active participation in CMs	Tried to solve some or all the class problems	Tried to solve problems in at least half of the CMs	Tried to solve most or all of the class problems
No. of "Active" students	14 (56%)	41(39%)	52 (48%)

Survey Questions – Assess

Q5.	Flipped classroom (FC) is more appropriate than traditional teaching	❶
Q6.	FC improved my ability to learn	
Q7.	FC motivated me to take an active role in my learning	
Q8.	FC encouraged me to learn more effectively	
Q9.	FC was a valuable learning experience	
Q10.	I want to expand my learning opportunities with more courses using FC	
Q11.	The online lessons (OLs) were helpful in clarifying the course material	❷
Q12.	The OLs prepared me adequately for class meetings	
Q13.	The in-class activities in the class meetings (CMs) were engaging and interactive	
Q14.	The CMs helped me to apply concepts I learned from OLs	
Q16.	What was the level of confidence in your mastery after CMs?	❸

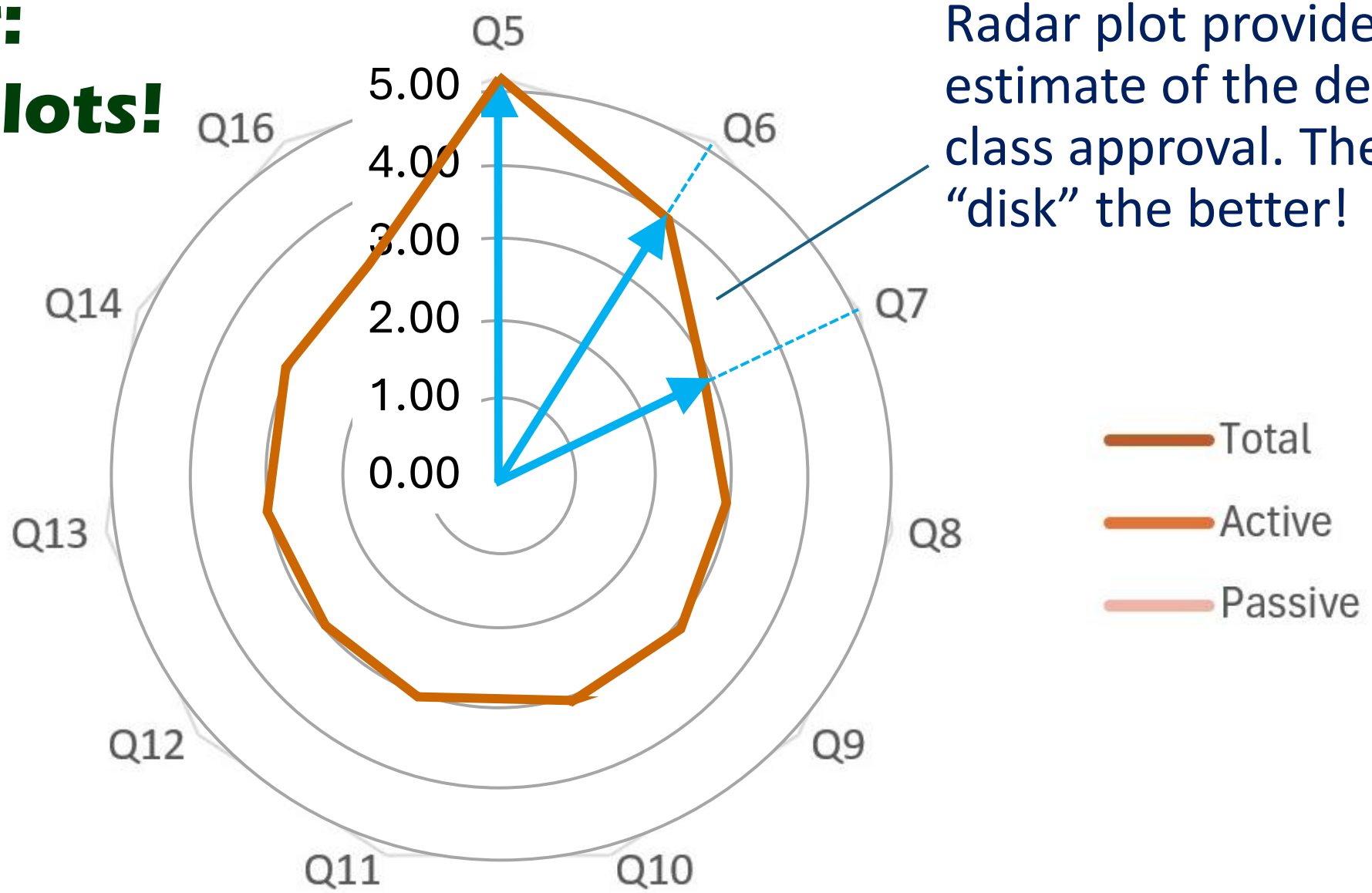
Scale	
1	Strongly disagree
2	Disagree
3	Neither agree nor disagree
4	Agree
5	Strongly agree

Scale	
1	Not at all confident
2	Somewhat confident
3	Confident
4	Very confident
5	Extremely confident

How to compactly pre-sent data for these 11 survey questions for the three courses?

Survey Questions – Display

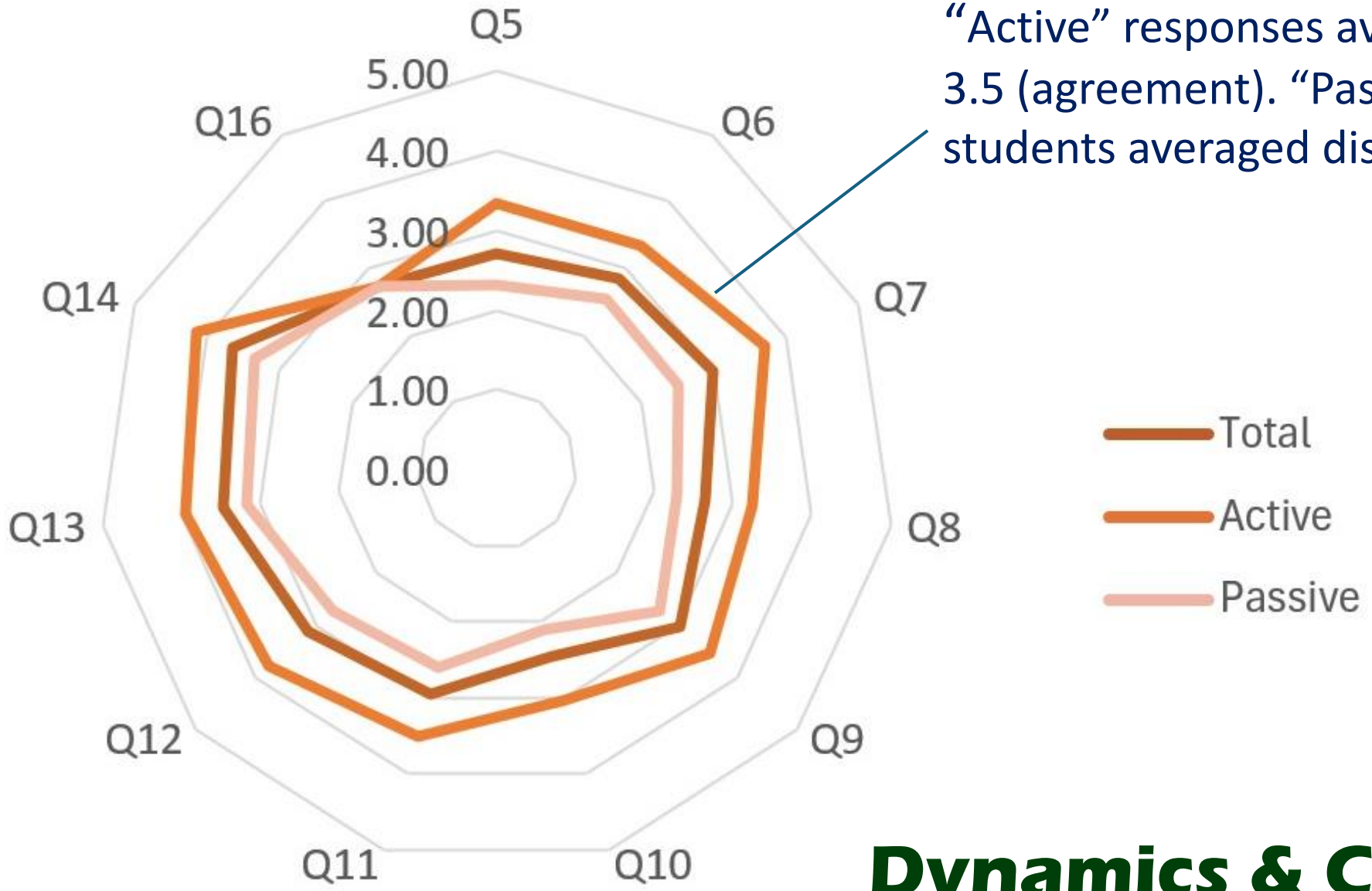
Answer: Radar Plots!



Radar plot provides a visual estimate of the degree of class approval. The bigger the "disk" the better!

Student Polls

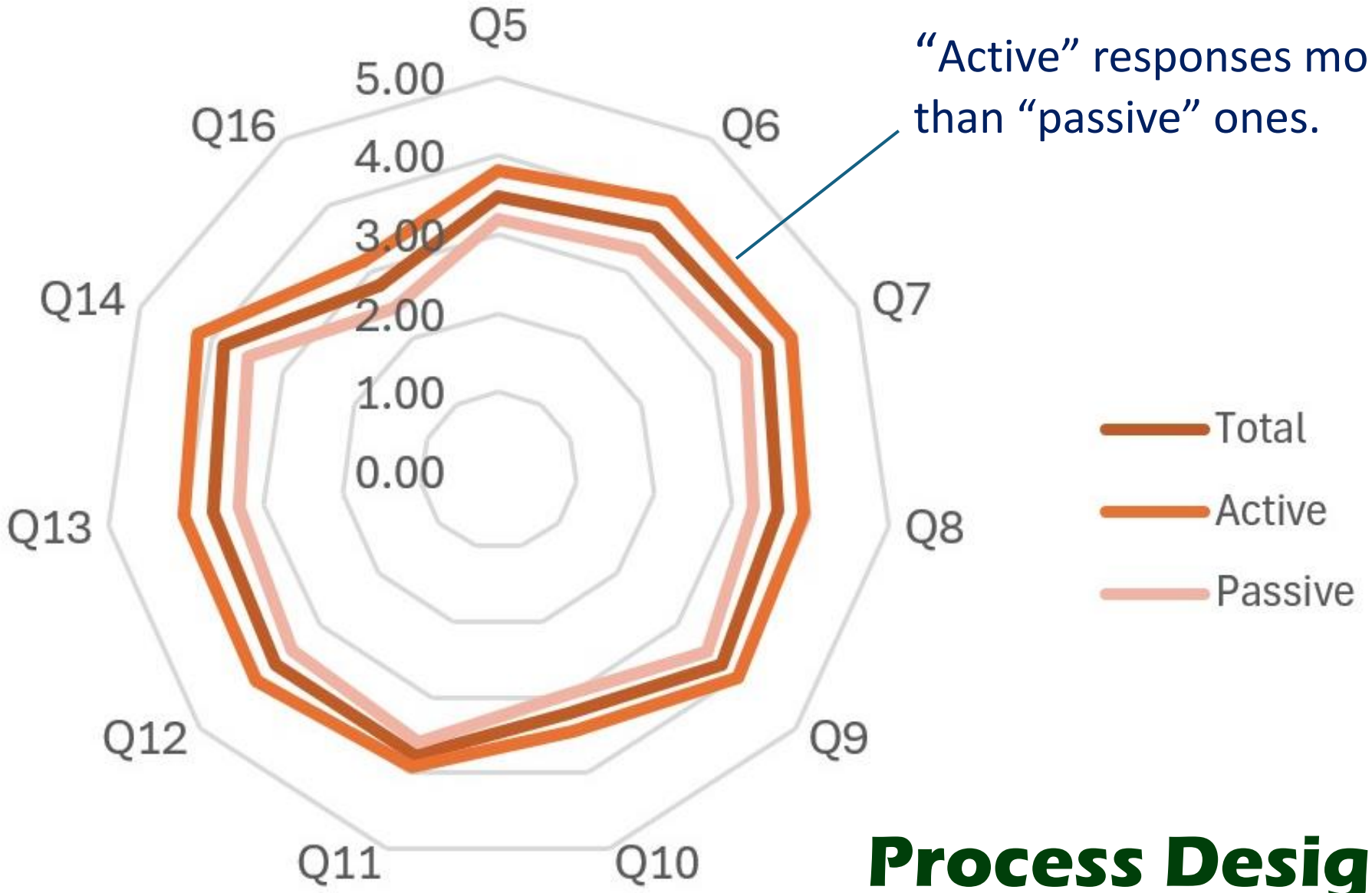
PDC



"Active" responses averaged at 3.5 (agreement). "Passive" students averaged disagreement

Student Polls

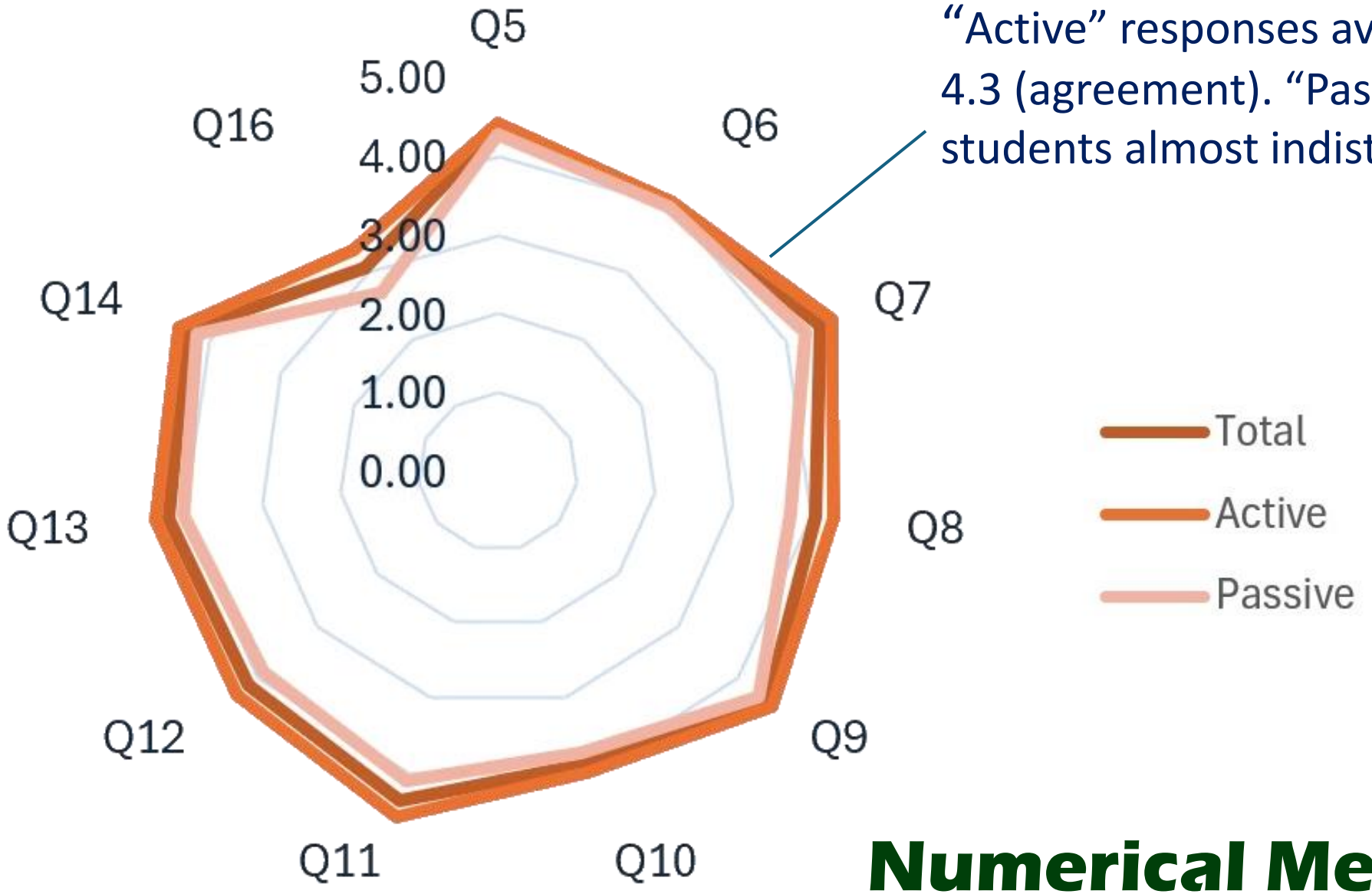
PD



"Active" responses more positive than "passive" ones.

Process Design

Student Polls

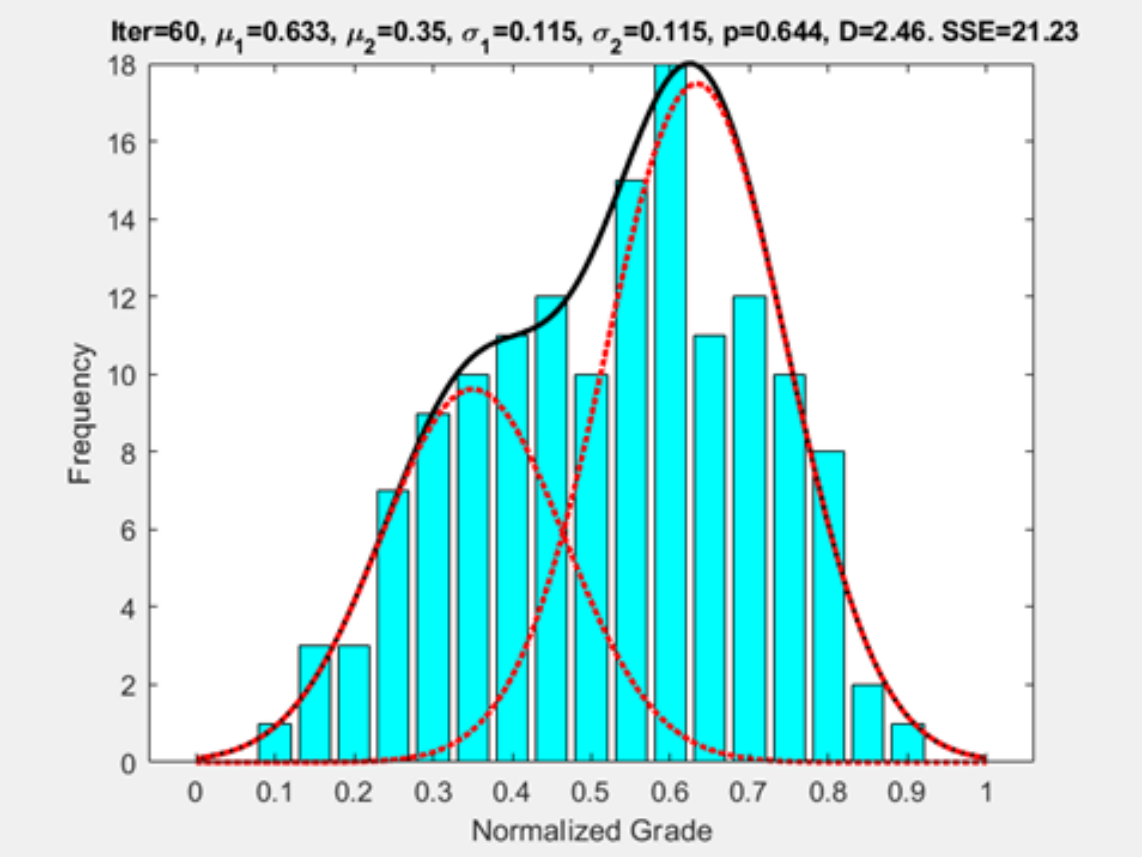


"Active" responses averaged at 4.3 (agreement). "Passive" students almost indistinguishable.

Learning Outcomes

Learning Outcomes

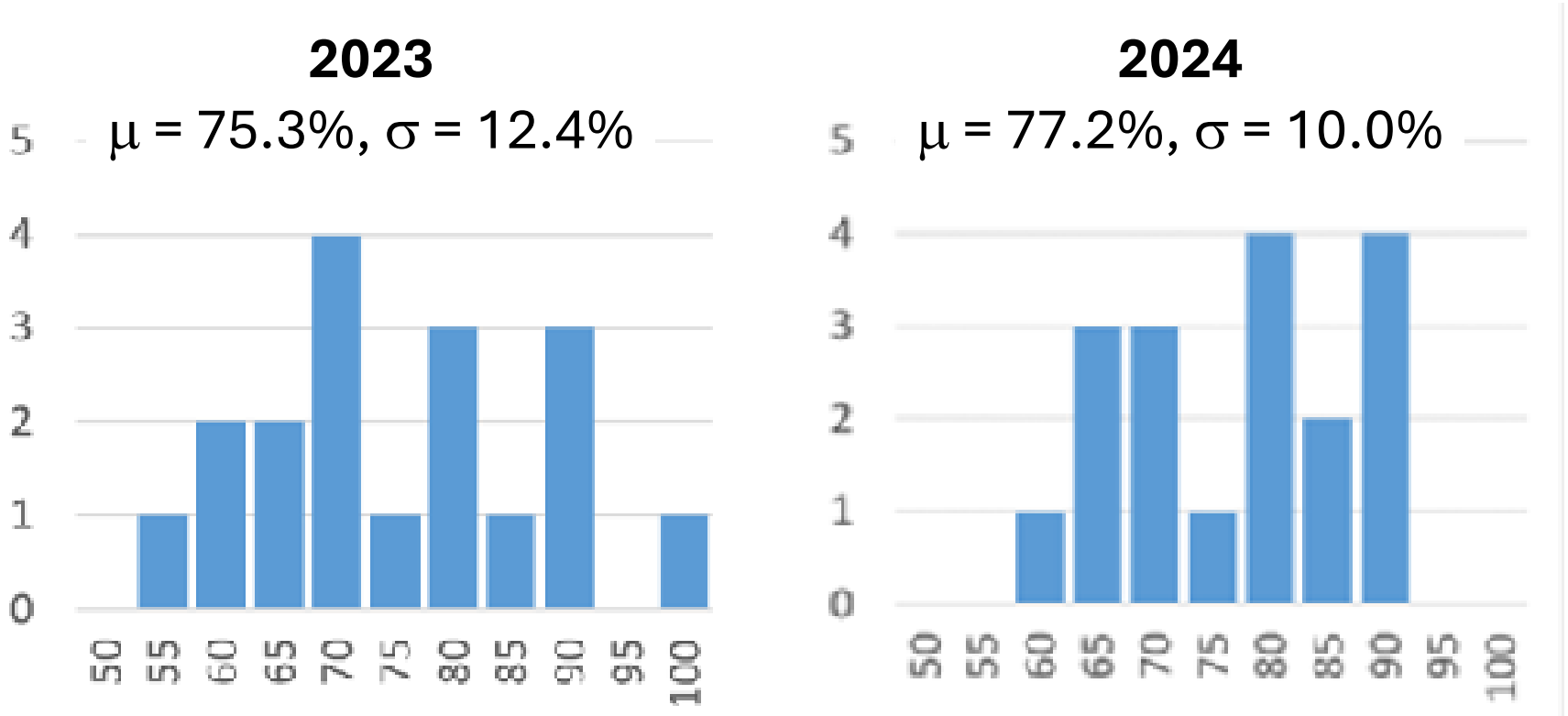
Dynamics & Control



The exam bimodal grade distribution indicates 36% underperformers, with a class average of 50% and 28% failures. Students cannot expect mastery without engagement, regardless of the teaching method.

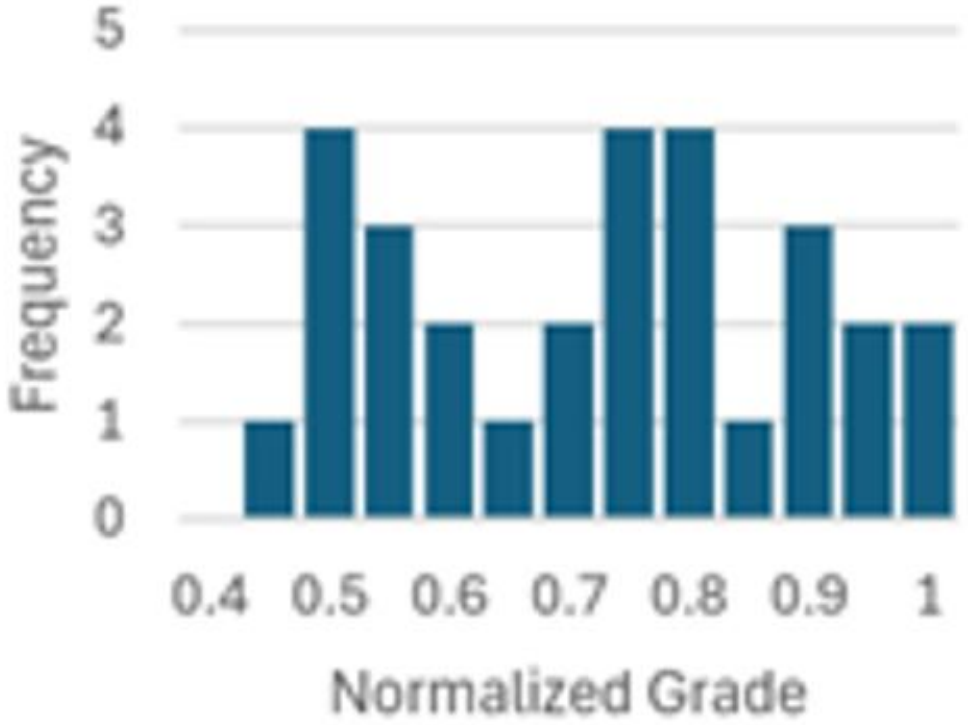
PD

Process Design: Grades for HEX part of project



This small improvement in performance is not statistically significant.

Numerical Methods



The exam grade distribution has an average grade of 71%, with no failures. Given this high level of motivation in the class, this result is not surprising

Conclusions and Recommendations

Addressing RQs

RQ1. *What was the level of students' approval for the usage of flipping? Was this perception different for those students who engaged more with the course resources and activities, compared to those who engaged less?*

- Most students perceive the flipped class teaching method positively, with the "active" students perceiving this to a greater extent than the "passive" ones.
- Least positive perceptions was for PDC, which was not flipped in its entirety.

Addressing RQs

RQ2. *Did the students who engaged most with the course resources and activities achieve better learning outcomes than those who engaged less?*

- Students that are more engaged with their studies usually achieve better outcomes than those who engage less.
- Most striking example is the case of PDC, where the class can be divided into high- and low-performing subsets according to the degree of their engagement.

Addressing RQs

RQ3. *Which of the three versions of flipping achieved the best results, and why?*

- Best results achieved by elective course INM (flipped in its entirety), taught to a small group of dedicated students.
- Worst student perceptions and performance achieved was with PDC, which was taught in a combination of lecture-based and flipped formats, and in which many students opted not to engage.
- The one-week heat integration workshop achieved intermediate success, with the materials taught implemented into projects at least as well as with previous experience.

Conclusions

The four main takeaways are:

- If a course is “flipped,” it should apply to the entire course. The least successful approach had a lecture-based first half with little focus on mastery, followed by a flipped second half, leading to many students giving up and cramming, causing a high failure rate.
- The elective course on numerical methods, taught entirely as a “flipped” course, was a success. The small class was highly engaged. No significant difference was found between the most and least engaged students.
- The flipped workshop on heat integration was successful.
  Even the least engaged students feeling it helped their learning.
- To get reliable results from student surveys, it's important to separate responders into those who engage significantly with course resources and those who engage less, as their perceptions can differ greatly.