

The Impact of Programming Project Milestones on Procrastination, Project Outcomes, and Course Outcomes

A Quasi-Experimental Study in a Third-Year Data Structures Course

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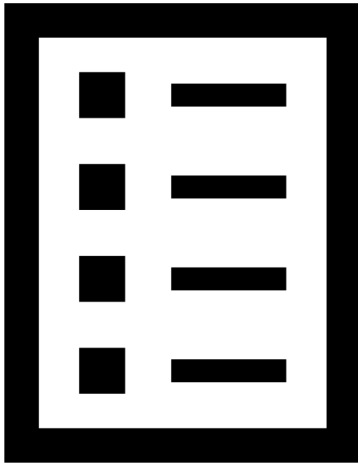
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Context



CS 2

Software Design & Data Structures



Simpler

Smaller

Scaffolded

~1–2 weeks



CS 3

Data Structures & Algorithms

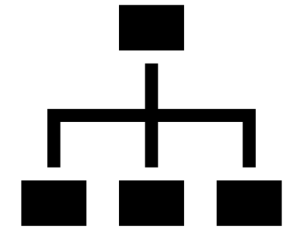
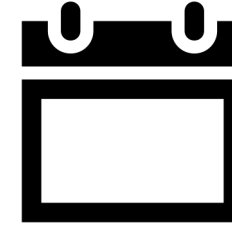


Relatively complex

Larger

Un-scaffolded

~3–4 weeks



DFW rate of 25–30%



Explicit project milestones



- ① We need to explicitly teach the necessary program management skills.
- ② Like any other skillset, these skills are best learned by practice with guided feedback.

Explicit project milestones provide a vehicle for teaching skills related to **time management** and **incremental development**.

Why do people procrastinate?

- Evidence that procrastination occurs when
 - the task's outcomes are farther in the future¹
 - the novice has low expectancy of successfully completing the task¹
 - the task offers numerous junctures for decision making²

1. Ponton et al. **Understanding the Role of Self-Efficacy in Engineering Education**. Journal of Engineering Education.
2. Song & Becker. **Expert vs. novice: Problem decomposition/recomposition in engineering design**. International Conference on Interactive Collaborative Learning.

Procrastination interventions⁴



- High rates of procrastination³
 - Late project submissions
 - Low “correctness” scores

Active reflection prompts

- Past project experiences, strategies, and outcomes

Schedule sheets

- Students explicitly set their own milestones and deadlines

Email alerts

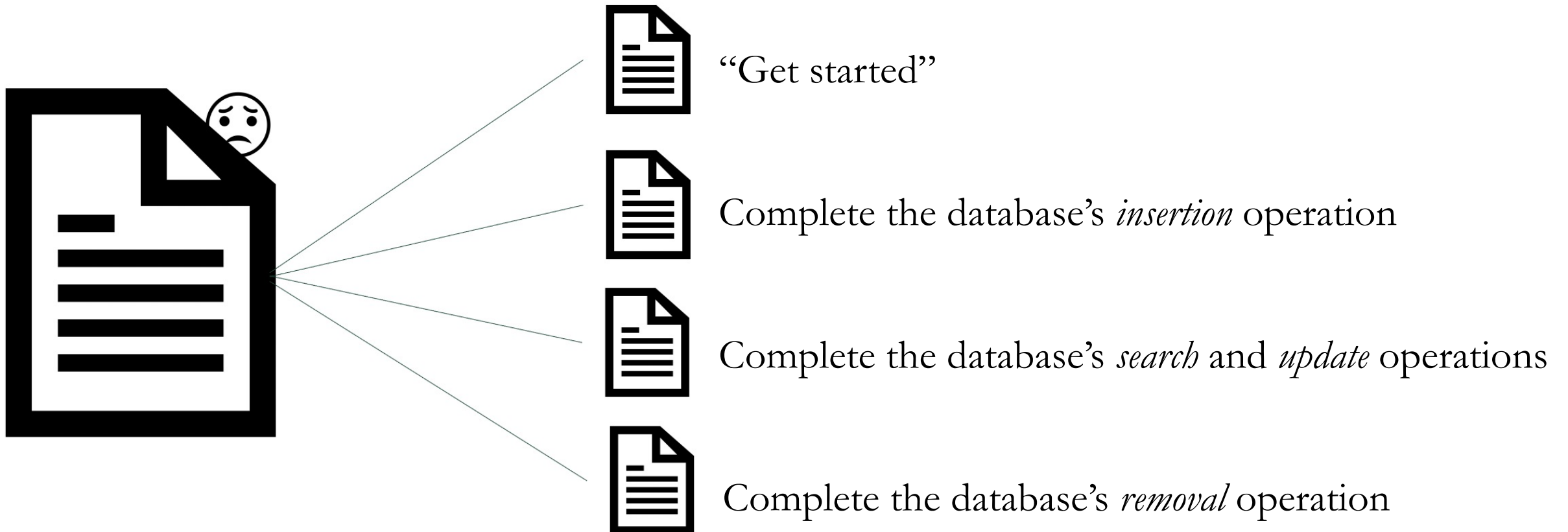
- Students were sent periodic emails about their progress
- **Fewer late submissions, more early submissions**
 - (...and grumpy students)

3. Kazerouni et al. **Quantifying Incremental Development Practices and Their Relationship to Procrastination**. ICER 2017.

4. Martin et al. **The Effects of Procrastination Interventions on Programming Project Success**. ICER 2015.

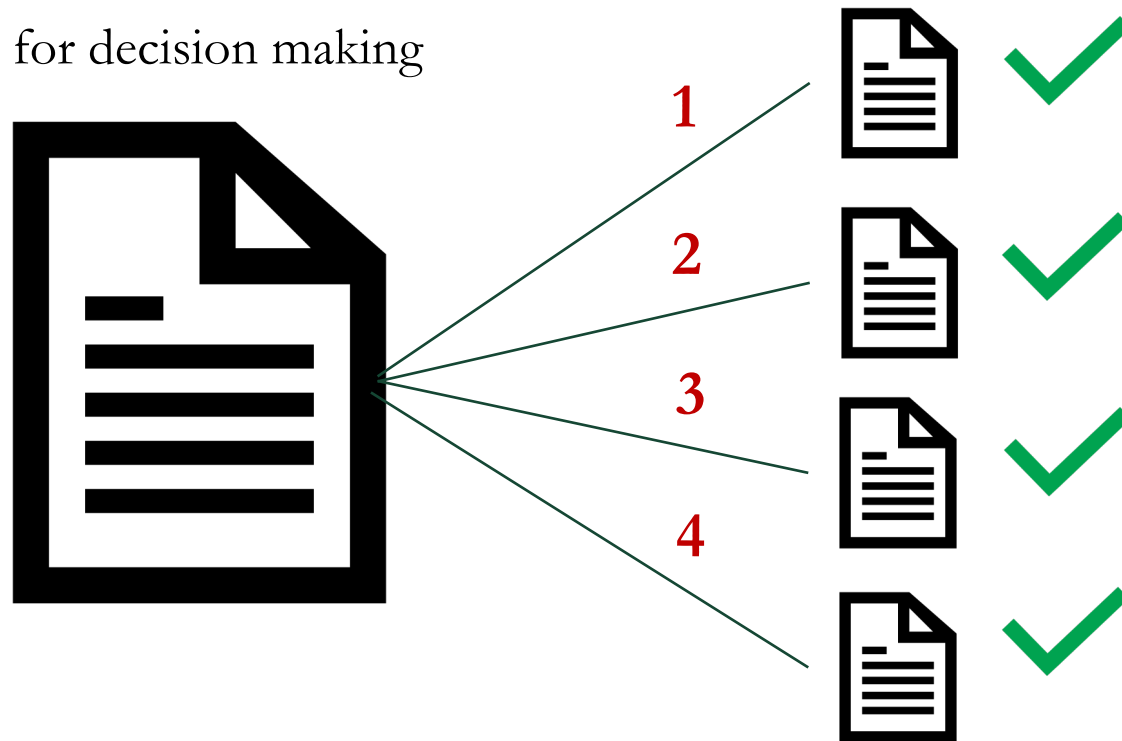
Explicit project milestones

- Example: A database for variable-length records, including a linked list for managing free blocks of memory, and a hash table for retrieving records based on a key value.



Task-related procrastination

- Evidence that procrastination occurs when
 - the task's outcomes are farther in the future
 - the novice has low expectancy of successfully completing the task
 - the task offers numerous junctures for decision making



Research questions

- Do milestones improve students' **timeliness** on software projects?
- Do milestones result in improvements to **project correctness**?
- Do milestones reduce the rates of incomplete or unsuccessful **course attempts**?

Quasi-experimental study

No Milestones (Fall 2013)

Milestones (Spring 2016)

Students

146

176

Assignments

3

3

Submissions

406

481

Median LoC

507.5

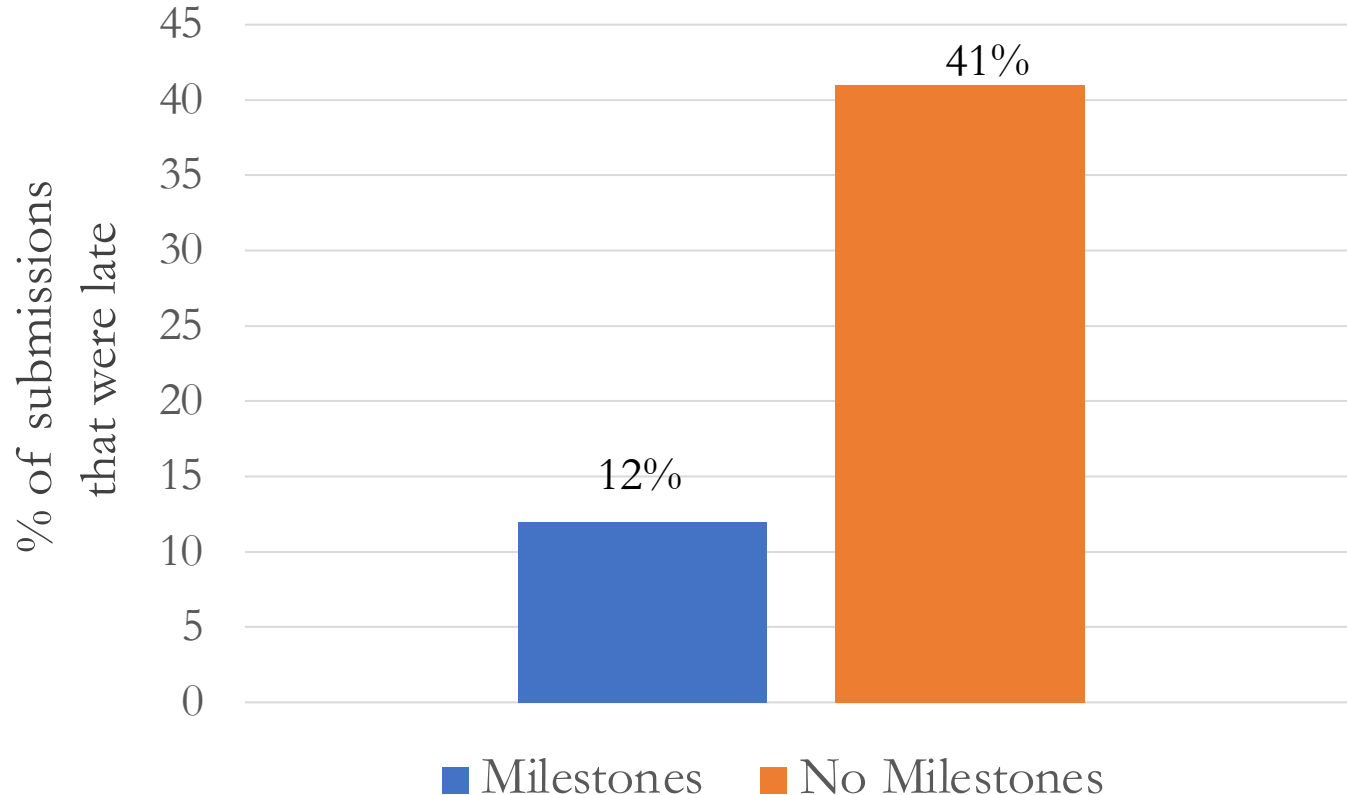
494

Median Cyclomatic
Complexity

218

234

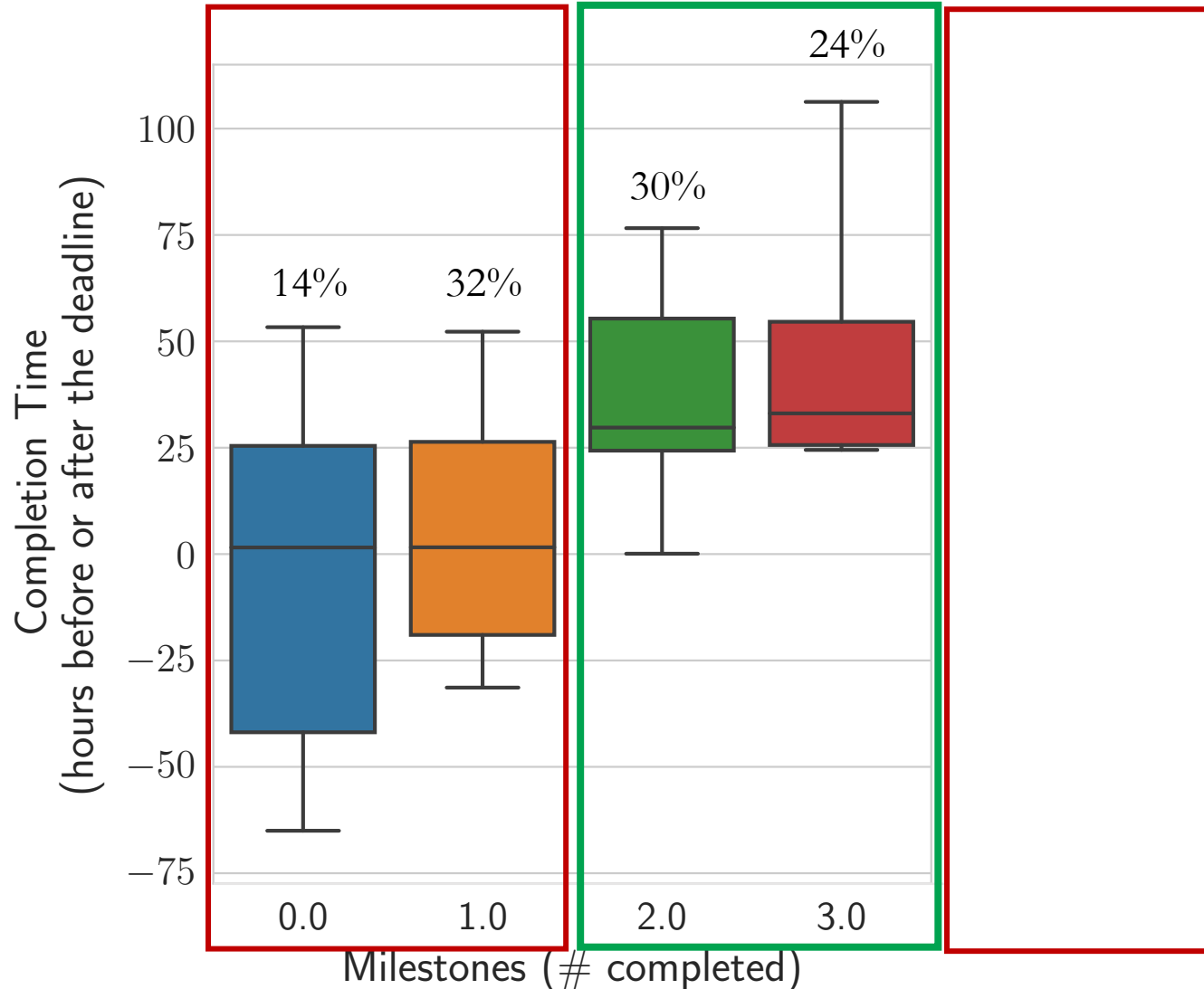
Timeliness — Rate of late submissions



Chi-squared test for differences in frequencies between categorical variables.

Significantly fewer late submissions with milestones than without.

Timeliness — Time of completion

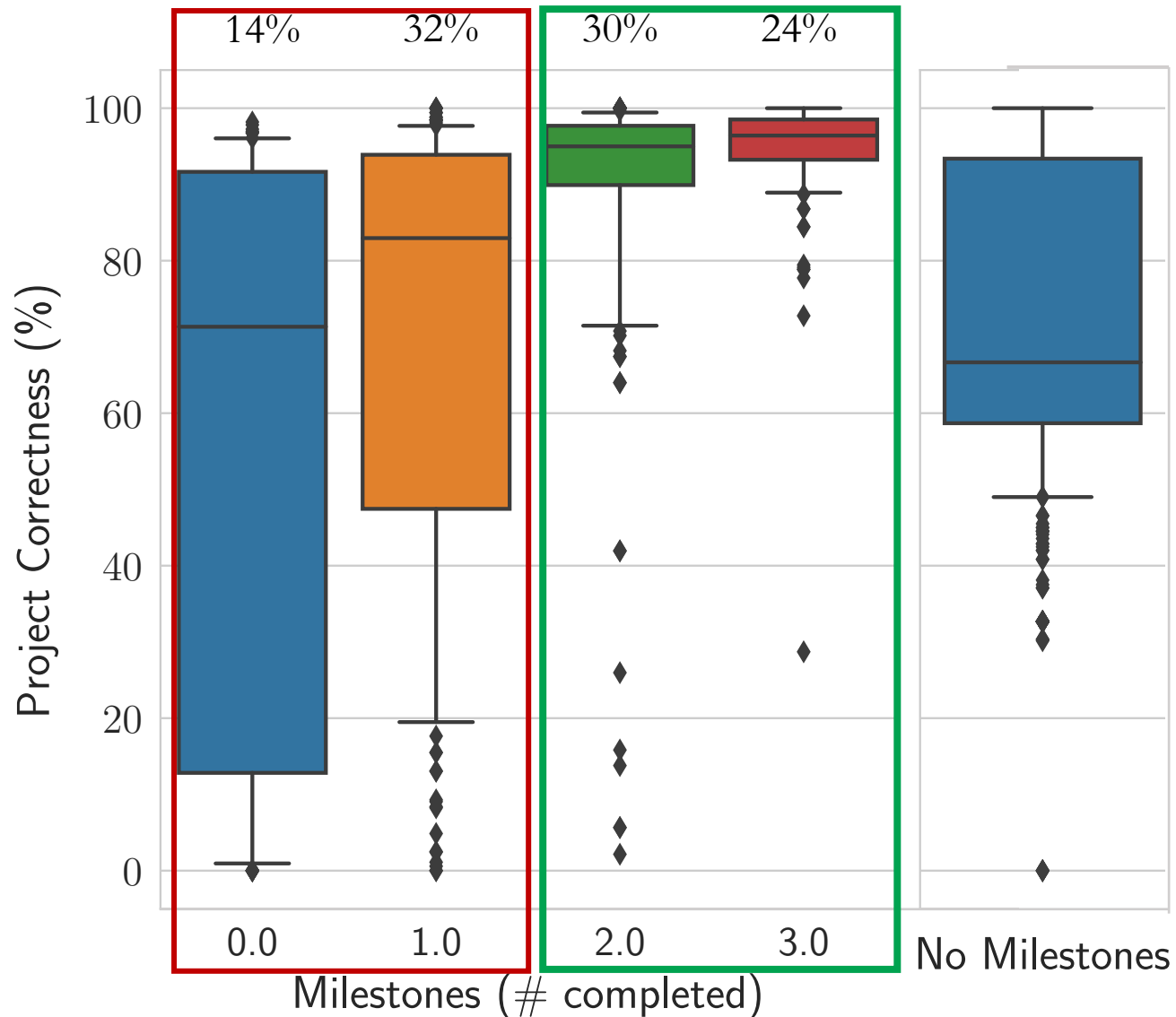


One way ANOVA using the Kruskal-Wallis test.

- Dependent var.: Completion time
- Independent var.: # Milestones completed

Students who completed more milestones tended to finish their projects earlier.

Project correctness



Welch's unequal variances t -test.

- Dependent var.: Project correctness
- Independent var.: Milestones/No Milestones

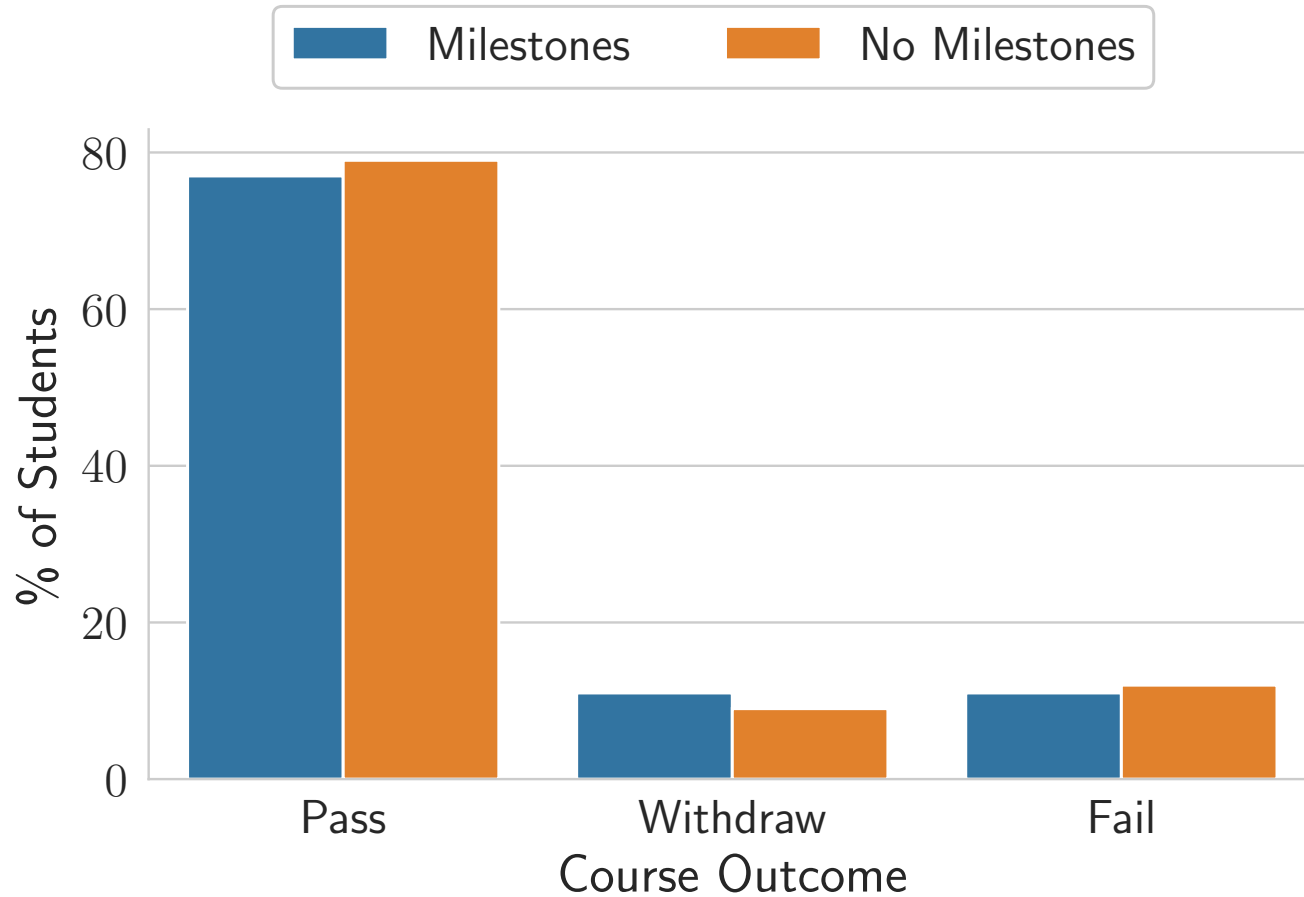
Projects were more correct with milestones than without.

Multiple Welch's t -tests with Bonferroni correction.

- Dependent var.: Project correctness
- Independent var.: # Milestones completed

Students who completed more milestones produced more correct projects than students who completed fewer milestones.

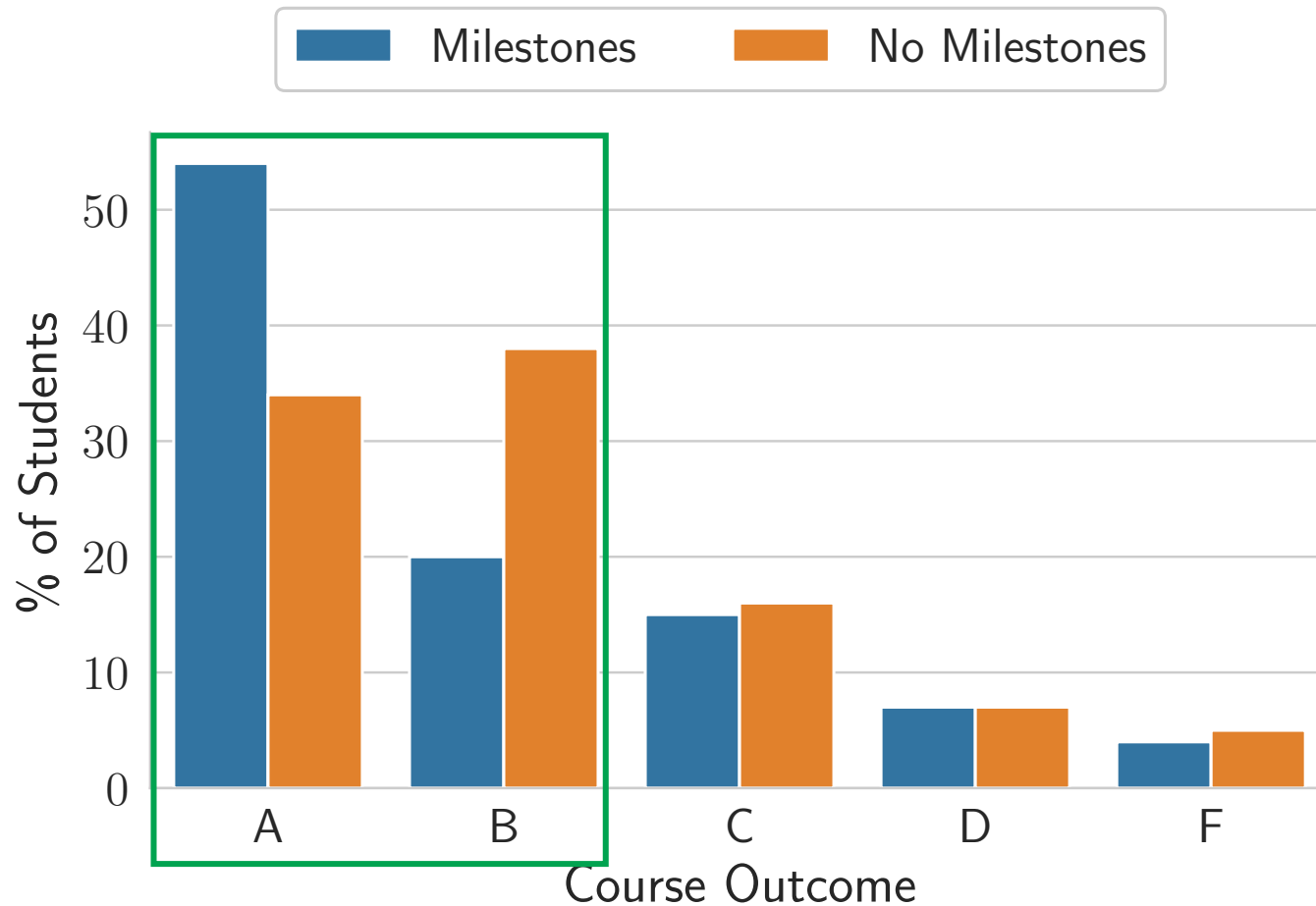
Pass, fail, withdraw status



Chi-squared test for differences in frequencies between categorical variables.

No differences in Pass, Withdraw, Fail rates between the treatment and control semesters.

Final course grade



Chi-squared test for differences in frequencies between categorical variables.

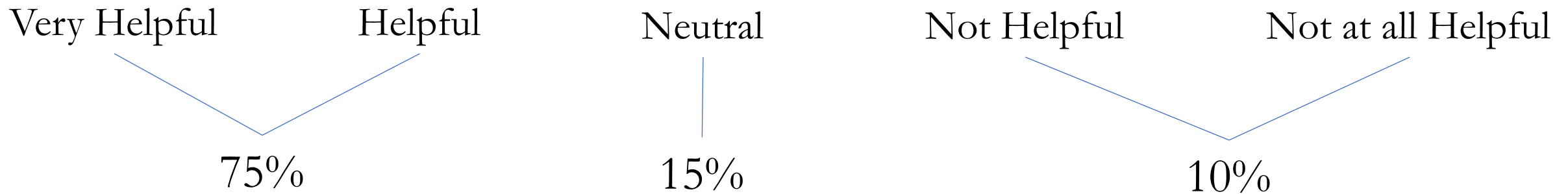
Significant difference in the number of A and B final grades.

Student perceptions

(Fall 2016)

How helpful did you find the Milestones in completing your programming projects on time?

Please explain why you gave this response.



Students said...

Milestones helped them avoid procrastination.

“I’m a procrastinator and they kept me on track.”

Milestones provided encouragement as they worked on the project.

“The milestones reminded me to work and keep track of where I am... It felt nice seeing my progress on WebCAT”

Milestones helped break down the project into subtasks.

“It was really hard for me to figure out how to divide up projects, so not only did it divide up the projects for me, but it actually helped me learn how to divide up projects on my own.”

Milestones got in the way of the student’s development plan.

Milestones were stressful.

Milestone deadlines were too close to each other.

“We did the work for them”

- Learning any skill requires **guided** practice
- Explicitly setting the milestones makes them **checkable**
 - Previous unguided interventions showed no impact on rates of late submissions
 - Because they were unguided? Or because they were ungraded?
- Worthwhile future work
 - Do the project management skills “stick” in future courses?
 - Fading the scaffolding over time
 - Explicit milestones → suggested milestones → student-set milestones

- ① We need to explicitly teach the necessary program management skills.
- ② Like any other skillset, these skills are best learned by practice with guided feedback.

Explicit project milestones provide a vehicle for teaching skills related to **time management** and **incremental development**.

Project milestones — Summary

Approximately one letter grade improvement for middle-performing students

- Top performing students had no more room for improvement
- Other strategies must be explored to address students who are still struggling

Provide a practical way to explicitly practice project management skills

- It's important to be explicit about *why* milestones are being used