FOSTERING SELF-REGULATED LEARNING IN THE CLASSROOM

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Motivation

- Learning experience at university for many first-year students result in lower than hoped-for academic performance, leading often to high levels of academic stress and mental health issues.
- A broad University-wide commitment to enhance the learning experience for first-year students led to the approval of a Teaching and Learning Enhancement Fund grant.

Goal

- Developing pedagogical strategies that help students understand themselves as learners and approach learning intentionally and strategically.

Framework

- Self-regulated learning (SRL) is key to academic success and persistence for all learners (Zimmerman 1989) and particularly for students who are struggling (Butler & Schnellert, 2015).
- SRL is malleable and can be supported through classroom activities, tasks and interactions with educators (Alexander & Greene, 2017)

Our pilot project

Our approach and goals for this project are to

- bring SRL-promoting activities into standard **first-year calculus** practice
- engage with the student population who on average has the weakest basic math skills and historically the highest failure rates in first-year calculus
- focus on **reflections and cognitive strategies** to raise students' awareness of the importance of developing adaptive studying routines and habits

The setting

- 1st year *slow pace* Differential Calculus course (MATH 110)
  - Standard topics and applications
  - Stretched over *two semesters*

- Student population
  - Mostly students in a B.A. program
  - No prior knowledge of calculus
  - A grade of 65%-80% in high school math (Pre-calculus 12 or equivalent)
  - Course size: 218 students

- Course schedule
  - 3 hours per week of lectures (3 sections, 3 instructors)
  - 1.5 hour per week of **problem-solving workshops** (11 sessions, 7 TAs)
  - Common homework and assessments

Our traditional Calculus workshops

- Small size classes (<25 students)
- Short individual work ("quiz") about 10-15 minutes at the start
- Short introductory lecture by TA, about 10 minutes
- Group work on challenging calculus problems, facilitated by TAs, about 50 minutes
- Individual and group work are graded for correctness and communication
- Workshop grade is worth 15% of final course grade

Intervention

- Kept same overall workshop structure (individual work/lecture/group work)
- Added reflections and progress monitoring tasks to individual and group components
- Changes introduced in term 2

SRL framework

Successful learners are

- able to *regulate* their learning, i.e. take deliberate, intentional control over their learning
- go through key steps (*strategic cycle*) that help them organize ideas and apply their knowledge effectively

Self-regulation involves selective use of specific processes:

- *interpreting tasks* required for success
- setting specific *goals* for oneself
- adopting effective *strategies* for attaining the goals
- *monitoring* one's performance selectively for signs of progress
- managing one's *time use* efficiently
- *self-evaluating* one's methods
- *attributing* causation to results

Pedagogical changes to promote SRL

First workshop of the term

- **Explicit instruction** on self-regulation and strategic cycle

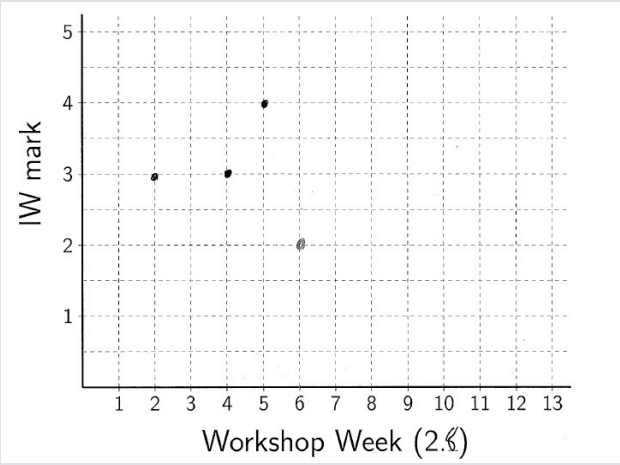
Weekly

- **Progress monitoring activities** (same every week)
  - *Start of workshop*: students plot own scores on individual work ("score chart") and reflect on own progress
  - *End of workshop*: students identify specific processes where they need to improve and make plans for improvements (back page of workshop wrappers)
- **Reflections on strategic knowledge organization** (topic-specific)
  - *Start of workshop*: individual reflections focusing on organizing mathematical knowledge at a higher level (conceptual vs. procedural), to be completed before the individual work
  - *End of workshop*: group reflections focusing on efficient knowledge organization of the techniques and strategies used in the workshop, (front page of workshop wrapper) to be completed after the group work
- **SRL processes explicitly modelled** by TA in the context of solving calculus problems: strategies for organizing information, monitoring own work, identifying similarities between problems, and other self-regulatory strategies are explicitly discussed in mini lecture and used to frame the TA's questions during group work facilitation

Progress monitoring activities

"score chart"

Every week at the beginning of workshop, plot your individual work (IW) mark from last week. Connect points as you build your graph.



Follow-up reflection and action plan

How can you improve your IW marks? What can you do to study better?

Do the WeBWorK questions for the upcoming saturday and review the notes before the workshop

identify my tasks before working away.

How can you improve your IW marks? What can you do to study better?

I can improve my marks by practicing more problems. I can study better by doing it in short bursts rather than several hours at a time.

→ follow through with inputting numbers and simplifying.

→ go through steps

…more progress-monitoring reflections

1. Did you do better on your Individual Work than last week? Why or why not?

I did do better because I spent more time practicing (Reviewed webwork, looked up more practice problems, etc.) so I was more prepared.

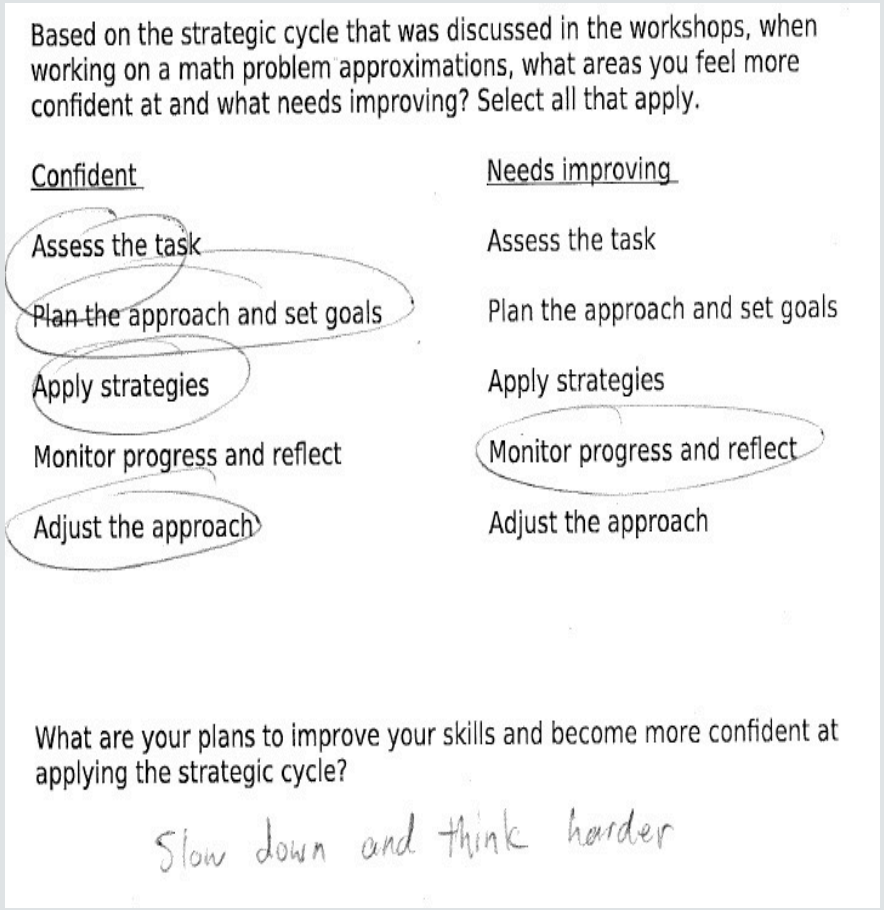
I did the same, which was still pretty bad. I just keep messing up factoring + derivatives.

Yes, I did two points better so thats progress! I believe I did better because I was a little more prepared.

I didn't do better on my individual work last week.

because I didn't factor out, ~~the~~ ~~fact~~ when I am doing my problem.

…more monitoring tasks in the workshop wrapper

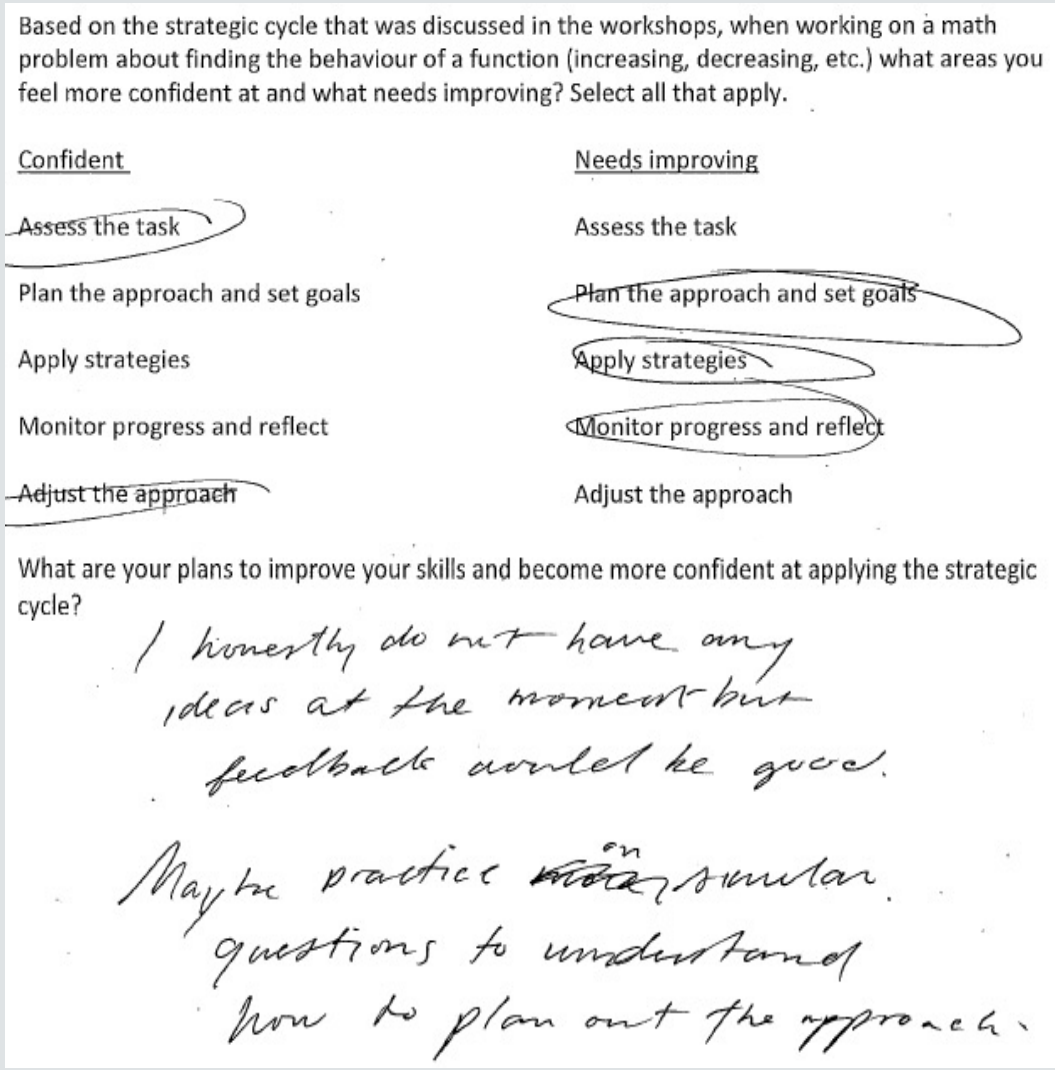


Based on the strategic cycle that was discussed in the workshops, when working on a math problem approximations, what areas you feel more confident at and what needs improving? Select all that apply.

Confident	Needs improving
Assess the task	Assess the task
Plan the approach and set goals	Plan the approach and set goals
Apply strategies	Apply strategies
Monitor progress and reflect	Monitor progress and reflect
Adjust the approach	Adjust the approach

What are your plans to improve your skills and become more confident at applying the strategic cycle?

Slow down and think harder



Based on the strategic cycle that was discussed in the workshops, when working on a math problem about finding the behaviour of a function (increasing, decreasing, etc.) what areas you feel more confident at and what needs improving? Select all that apply.

Confident	Needs improving
Assess the task	Assess the task
Plan the approach and set goals	Plan the approach and set goals
Apply strategies	Apply strategies
Monitor progress and reflect	Monitor progress and reflect
Adjust the approach	Adjust the approach

What are your plans to improve your skills and become more confident at applying the strategic cycle?

I honestly do not have any ideas at the moment but feedback would be good.

Maybe practice on similar questions to understand how to plan out the approach.

Reflections to promote knowledge organization and adjusting strategies

Conceptual knowledge: what key calculus concept needed to be applied to solve the IW problem? Were you successful at applying this concept? why or why not? (if not, think of what you can do next time to be more successful)

derivatives, factoring, algebra skills. I know the concept of finding intervals but I have not been applying derivative rules very well so I will practice that.

Procedural skills: Looking at your work, can you describe a procedure (a list of steps) you could use again and again in similar problems? Which of those steps did you find more challenging? What is your plan to overcome this challenge?

First, I should see if the question is asking for concavity. Then I should find the second derivative and set that equal to 0 to find the infection points, then use intervals to find where it's negative/positive. The solving for 0 can be challenging so I will remember not to expand before doing so

Group reflections in workshop wrappers

Today you worked on problems involving the sign of a derivative. What are some strategies you can use to check...

1) whether your derivative computations are correct?

Plug values into x → undefined? zero?

Re check your work
correct formula?

2) whether you are using the derivative(s) correctly?

Reread the question, what is it actually looking for?

3) whether your sign chart is correct?

Check with more than 1 point.
↳ plug in again
Graph.

Today you worked on problems involving linear and quadratic approximations.

1) What are the key concepts needed to construct a linear approximation?

- Slope of a line
- Derivative of the given function
- functional value of the a.

2) What are some strategies you can use to check whether your approximations are correct?

Check if if the value is close enough to the point we assume it is near to it
if we are approximating x close to a,
the approximation of x should be close to when we substitute a in the same function.

Project evaluation

1. Student Exit Survey, collected online in the last week of workshops, 152 respondents (out of 218 students)
2. Perception of Competence and Control (PoCC) survey administered at the start and end of term (along with the exit survey), 103 (out of 218) students completed pre and post surveys

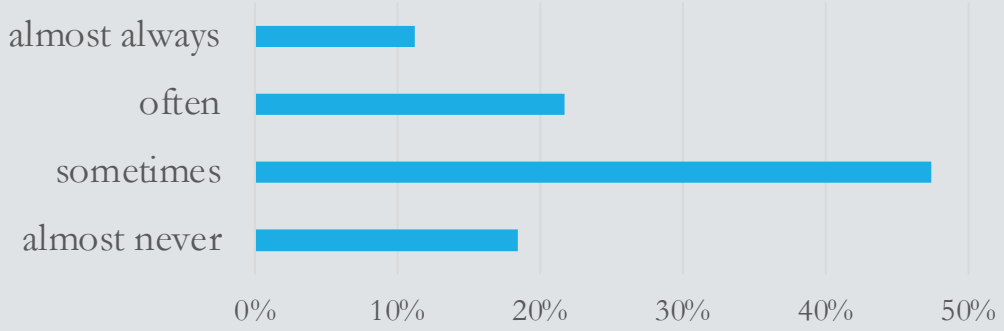
NOTE

This project took place in Winter 2020 and was affected by the outbreak of the COVID-19 pandemic. Lectures and workshops were moved online for the last 3 weeks of term, the format of the final exam and the course overall grading scheme were changed substantially, and the overall student attitude and engagement in the course changed. This made any meaningful comparison of grades across years not possible.

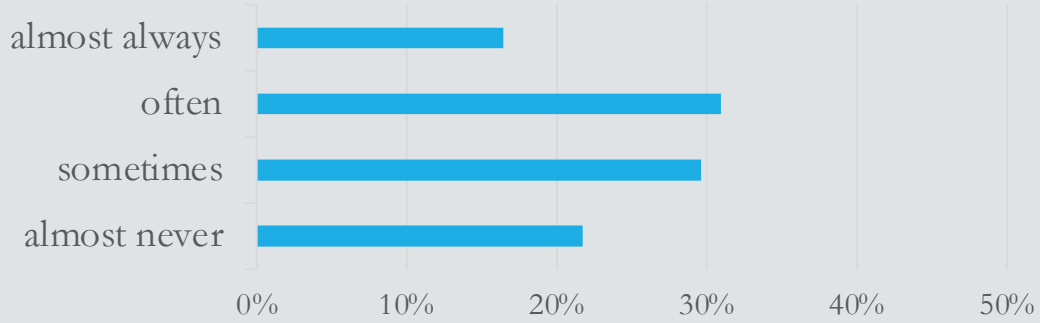
Exit survey: What students found helpful

Question: During the workshops this term I found the following activity to be helpful…

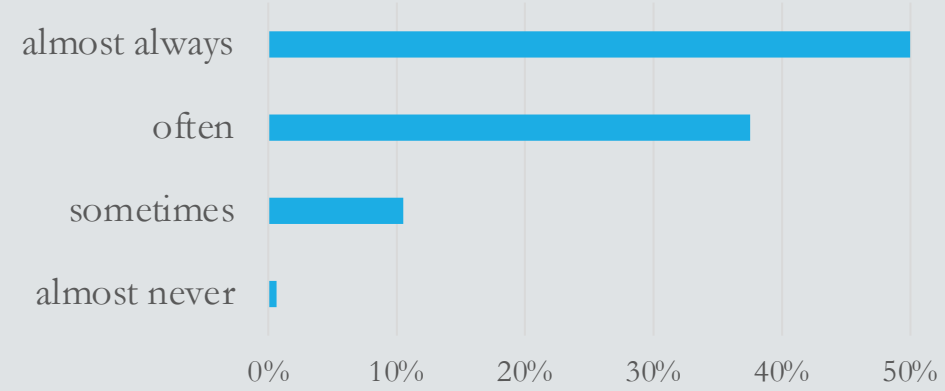
…answering **reflection questions** at the beginning of each workshop



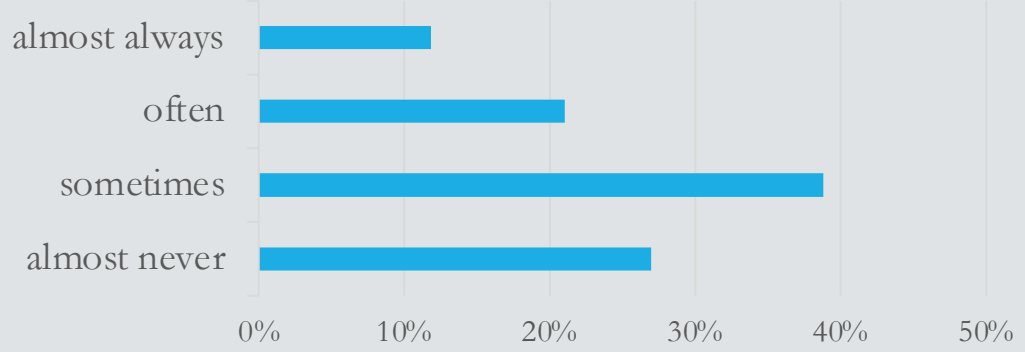
…monitoring my own progress by plotting my individual work score after each individual work.



…mini lecture before group work



…answering **workshop wrapper** questions at the end of each workshop



Exit survey: Open-ended comments

Question: For the activities that you didn't find helpful, what did you find unhelpful about them?

- Felt too repetitive "The workshop wrapper was very repetitive. Would be helpful once, but not every time."
- Seemed redundant "I was explaining things I already knew in the wrappers/surveys"
- Inefficient use of time "Reflecting is an inefficient use of allotted time as most of us do it on our own anyways."
- Hard to interpret score chart in terms of progress when scores fluctuated a lot or are very consistent
  - "For monitoring my progress, I wasn't really affected in anyway by it, but maybe that's because my score didn't change."
  - "plotting IW scores didn't really help monitor my progress because the grades fluctuated so much based on what topic the questions were about"
- Need to be more connected with math
  - "The workshop wrappers didn't reinforce ideas we learned in the workshop. I instead found it helpful when we reviewed "steps" for solving a problem in the reflection questions"
  - "…I didn't feel like the questions inspired me to come up with ideas or perspectives I didn't already have…but I do think that if the questions had more specific implications for learning strategies and such it would be more worth doing, it's good to make students reflect instead of just get through the course :) "
- There were also (unsolicited) positive comments:
  - "I found all of the activities really helpful because it showed me what I did understand and what I didn't"
  - "I find all of them somewhat useful, as each is important in contributing to being able to be effective at solving problems"

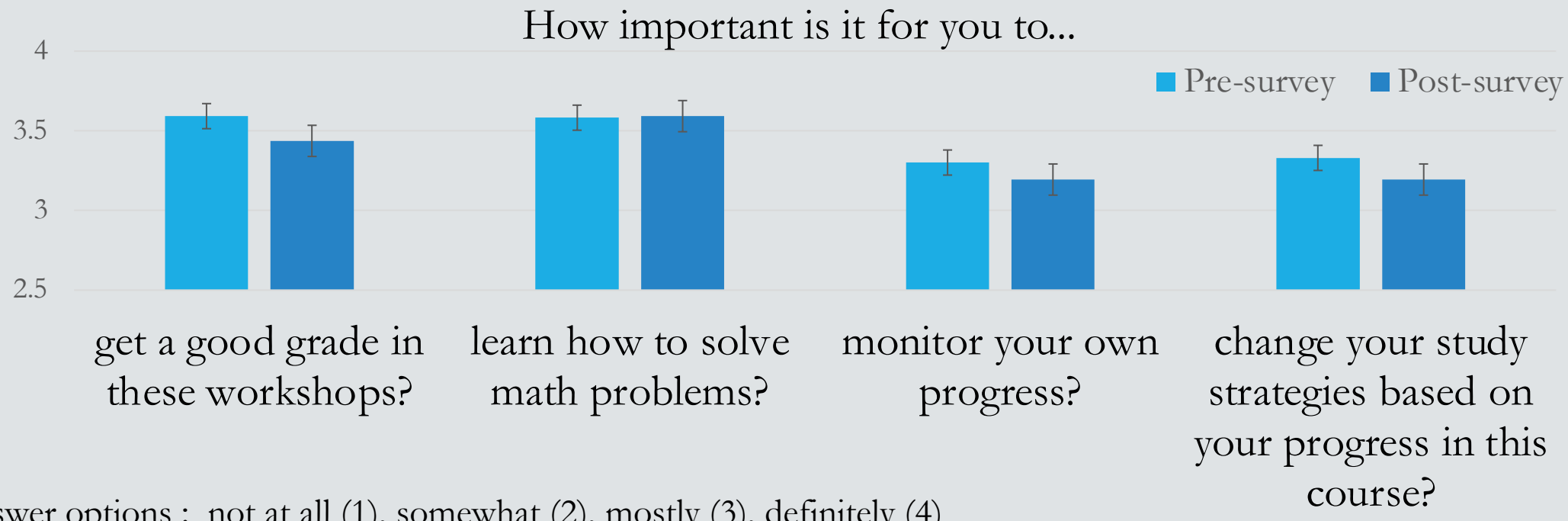
Perceptions of Competence and Control questionnaire (pre/post)

PoCC (Roll I. et al., 2018) is a brief survey that measures student sense of competence and control, i.e. confidence, self-efficacy, and success attributions, about specific learning activities.

- PoCC questions were adapted to reflect math-related specific activities
- Pre-survey was administered in the workshops at the **start of the term**
- Post-survey was administered online in the **last week of term***
- **103 students** (out of 218) completed both pre and post surveys

*after the COVID-19 pandemic outbreak

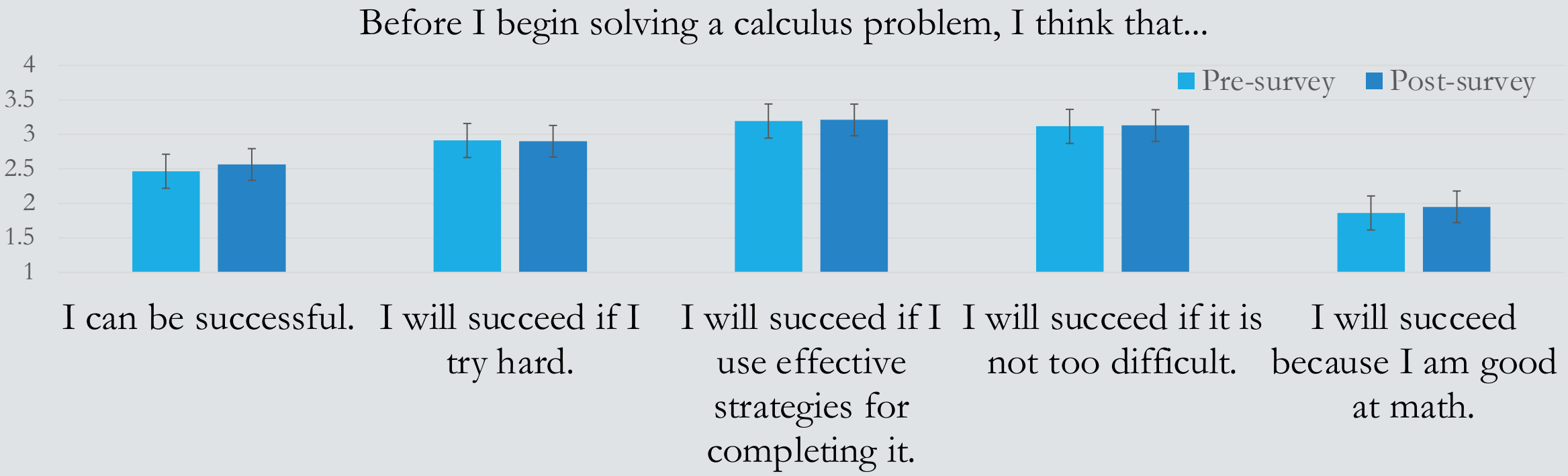
PoCC: Task value



Answer options : not at all (1), somewhat (2), mostly (3), definitely (4)

We observe a significant drop in perceived value of earning good grades ($p=0.02$), and only weakly significant drops in perceived value of progress monitoring and study strategies adjusting ($p=0.10$) (Wilcoxon Signed-Rank Test)

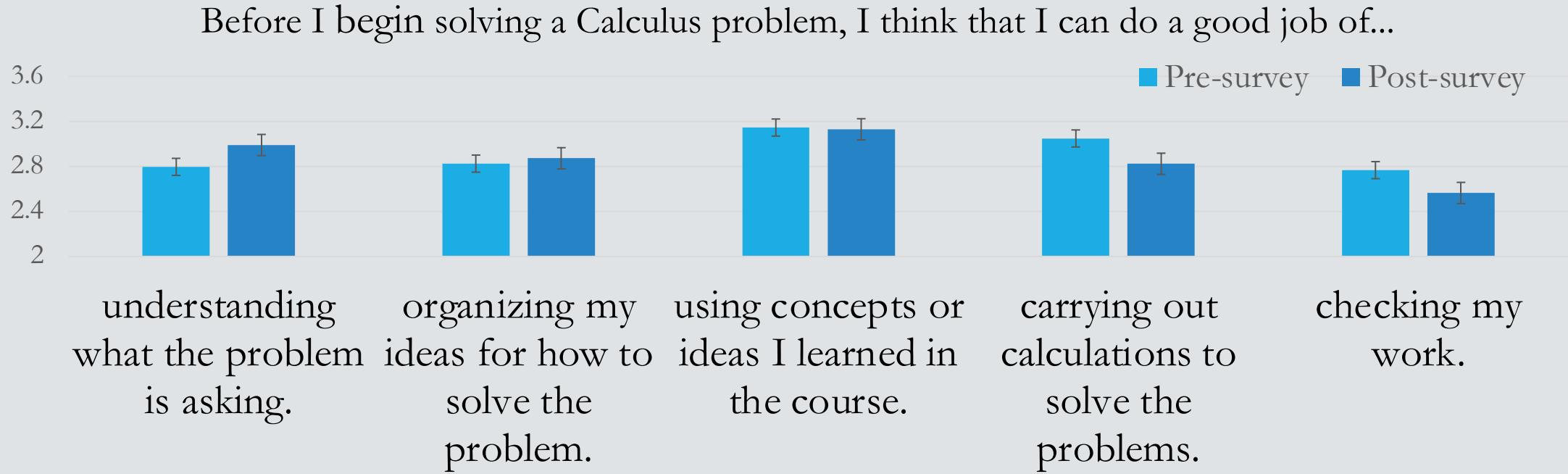
PoCC: Confidence



Answer options : almost never (1), sometimes (2), often (3), almost always (4)

Marginal gains are observed in overall level of confidence (Q1 p-value =0.15, Q5 p-value =0.20, using a Wilcoxon Signed-Rank Test)

PoCC: Competence



Answer options : almost never (1), sometimes (2), often (3), almost always (4)

We observed a weak gain in the perceived level of competence at understanding what a calculus problem is asking (p-value =0.15), but also significant drops in perceived competence at carrying out calculations (p-value <0.01) and checking own work (p-value <0.02) (Wilcoxon Signed-Rank Test)

Summary

- We incorporated SRL-promoting practice in regular class activities in the form of reflections and progress-monitoring tasks in a first-year calculus course.
- We observed some encouraging outcomes
  - Most students engaged in all SRL activities every week despite not being worth many points
  - Most students found SRL activities somewhat useful, with the explicit discussion of strategies in the mini-lecture being the most useful, followed by the progress monitoring activities and reflections
  - Marginal gains in confidence and perceived competence in specific problem-solving tasks (understanding what the problem is asking) were observed over time, though changes were not statistically significant
- We identified some issues in design and implementation
  - The frequency of personal reflections on progress and confidence rating was too high, turning the activity into a repetitive task
  - Dedicating class time to explicit reflection activities may feel redundant for students who are already regulating their learning
  - The connection between reflections and specific mathematics learning was not sufficiently explicit for some students to value this SRL activity

References

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Thank you!

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