WHAT CAN WE LEARN ABOUT STUDENTS THAT GRADES WON'T TEACH US?

(How can we model student success?)

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SIMIODE Expo

TEXAS STATE UNIVERSITY

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AN IDEAL STUDY

PreTest

Final Grade

Regular Math Class

PreTest

Final Grade

Modeling Approach

Compare final grades. Then we'll know: (1) The approach works and (2) students are learning.

Strengths	Drawbacks
Accepted currency	Fair and objective?
	Support claims?
	Other outcomes?
	Other benefits?

MODELING IMPACT OF MODELING

+

Achievable

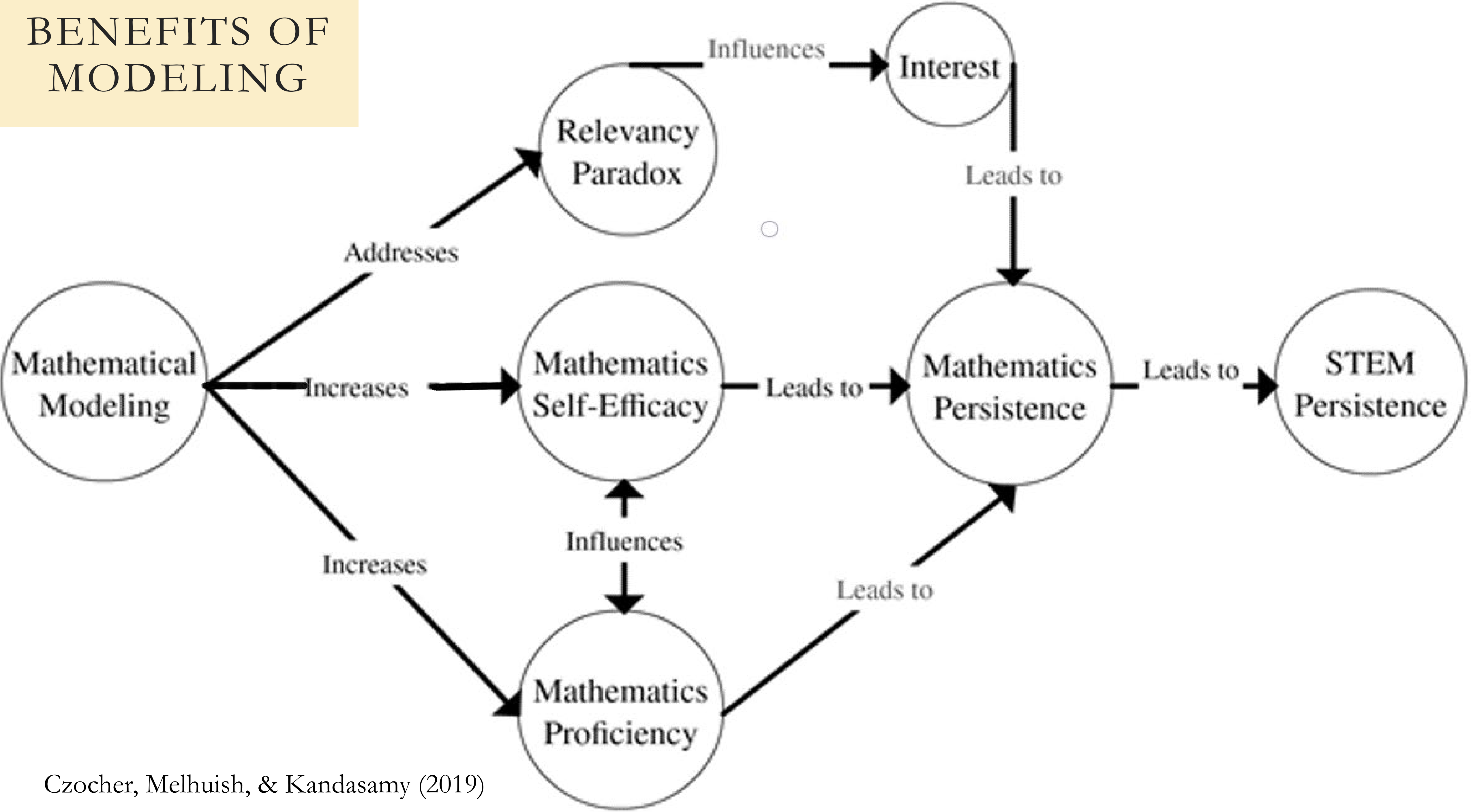
- Evidence of factors influencing achievement, success, learning?
- Under what conditions?

−

Not achievable

- "Prove" the intervention "works" or is "better"
- Complex system of T&L with simple causal models

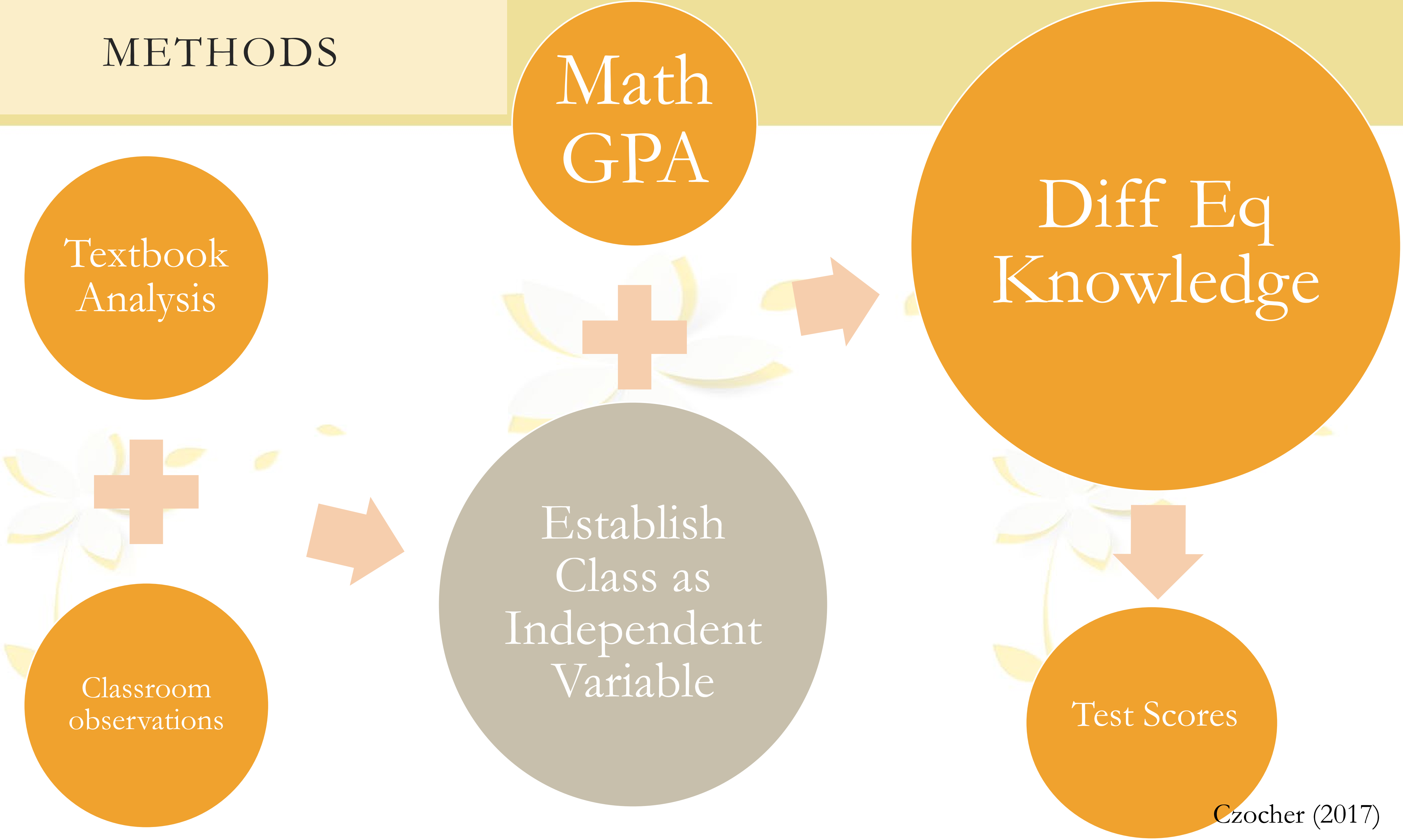
BENEFITS OF MODELING



Czocher, Melhuish, & Kandasamy (2019)

Problem (empirical):	Emphasizing analytic techniques contributes to a compartmentalized understanding of differential equations.
Conjecture (theoretical):	Emphasizing connection between a differential equation, the situation it models, and its solution, may help to address these difficulties
Research Hypothesis:	A differential equations course taught with an emphasis on mathematical modeling can positively impact student performance in differential equations.
Research Question:	**What aspects of instruction** in a differential equations course with an emphasis on modeling principles **help explain** student performance in differential equations?

METHODS



Czocher (2017)

EMPIRICALLY ESTABLISH "CLASS" AS A VARIABLE

Dr. Euler

- Content-driven
- Logico-structural or procedural style
- Establish a general procedure, demonstrate analytic and symbolic reasoning strategies between steps
- "Standard" techniques
- Concrete examples to illustrate techniques (3-4 examples/lesson)

Dr. Lagrange

- Context-driven
- Procedural or semantic style
- Connect properties & parameters to conditions & assumptions
- Connect to real-world principles
- Guess (based on RW configuration) and check
- Mathematics derived through examples (2-3 lessons per example)

Czocher (2017)

RESULTS

Source	Type I SS	df	Mean Square	F	p	Partial η^2	Observed Power
Math GPA	1382.091	1	1382.091	25.445	0	0.351	0.999
Class	324.366	1	324.366	5.972	0.018	0.113	0.668
Error	2552.881	47	54.317				
Corrected Total	4359.339	49					

A 12.4% difference in mean scores, along with a moderate effect size, and the fact that Dr. Lagrange's class had a lower mean Math GPA suggests that students at both the lower and higher ends of the performance spectrum benefit from instruction form a modeling perspective.

Czocher (2017)

RIVAL INTERPRETATIONS AND LIMITATIONS

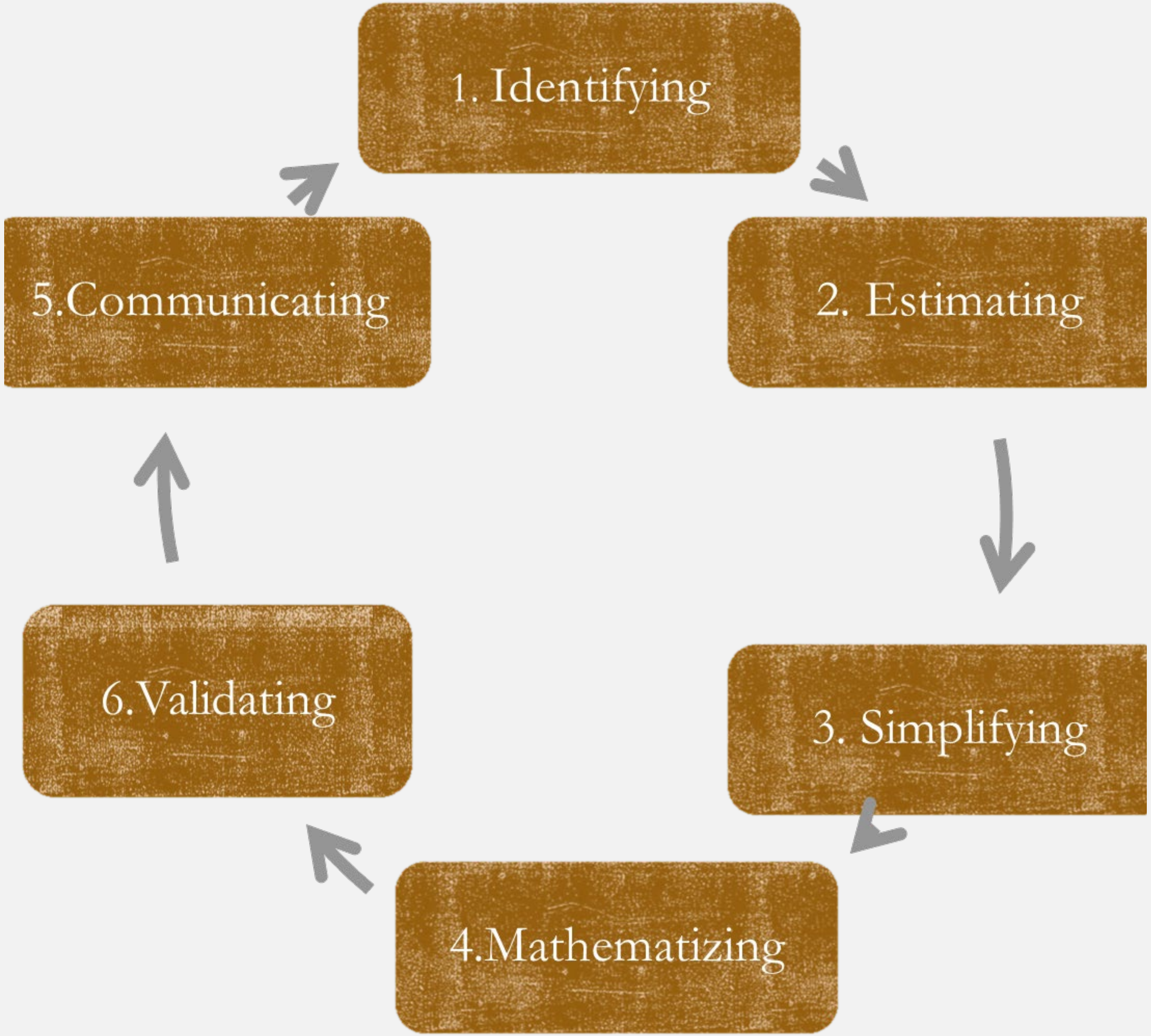
- Dr. Lagrange's students needed to memorize fewer techniques and so had a better chance of solving the problems correctly
- This is **exactly the point**
- Corroborates: focusing on conceptual connections among mathematical ideas increase student performance (Kwon et al, 2005; Rasmussen & Kwon, 2007)
- **Self-selection** of instructors to participate
- **Limited content** knowledge tested
- **Small-n**
- **De-emphasizes** cognitive, social, and cultural mechanisms that facilitated pedagogical effects on achievement differences

Czocher (2017)

AFFECT AND SELF-EFFICACY

Modelling competencies = Ability to perform the processes that are involved with the construction and investigation of mathematical models

Self-efficacy (SE) = "problem-specific assessment of an individual's confidence in their ability to successfully address a mathematics problem" (Hackett & Betz, 1989, p. 262).

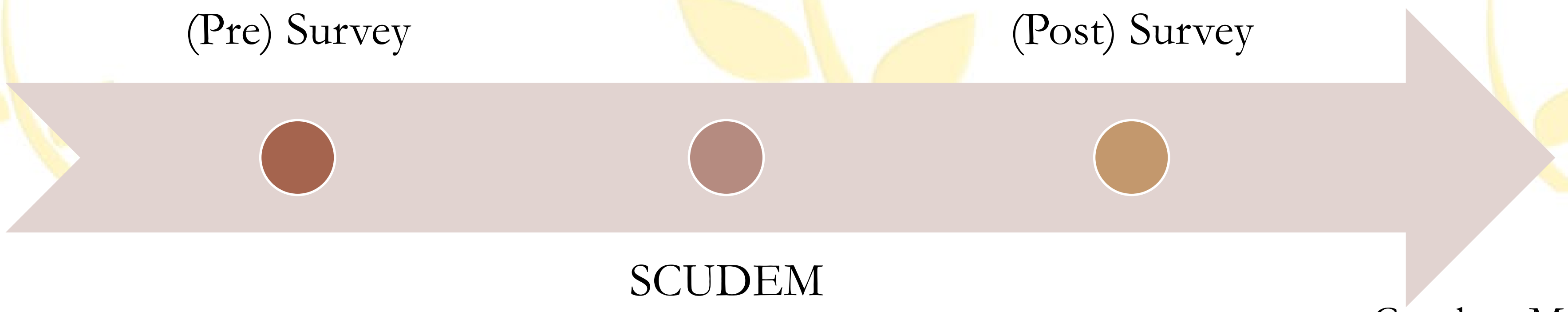


Blomhoj & Jensen (2003)

Maaß (2006)

METHODS

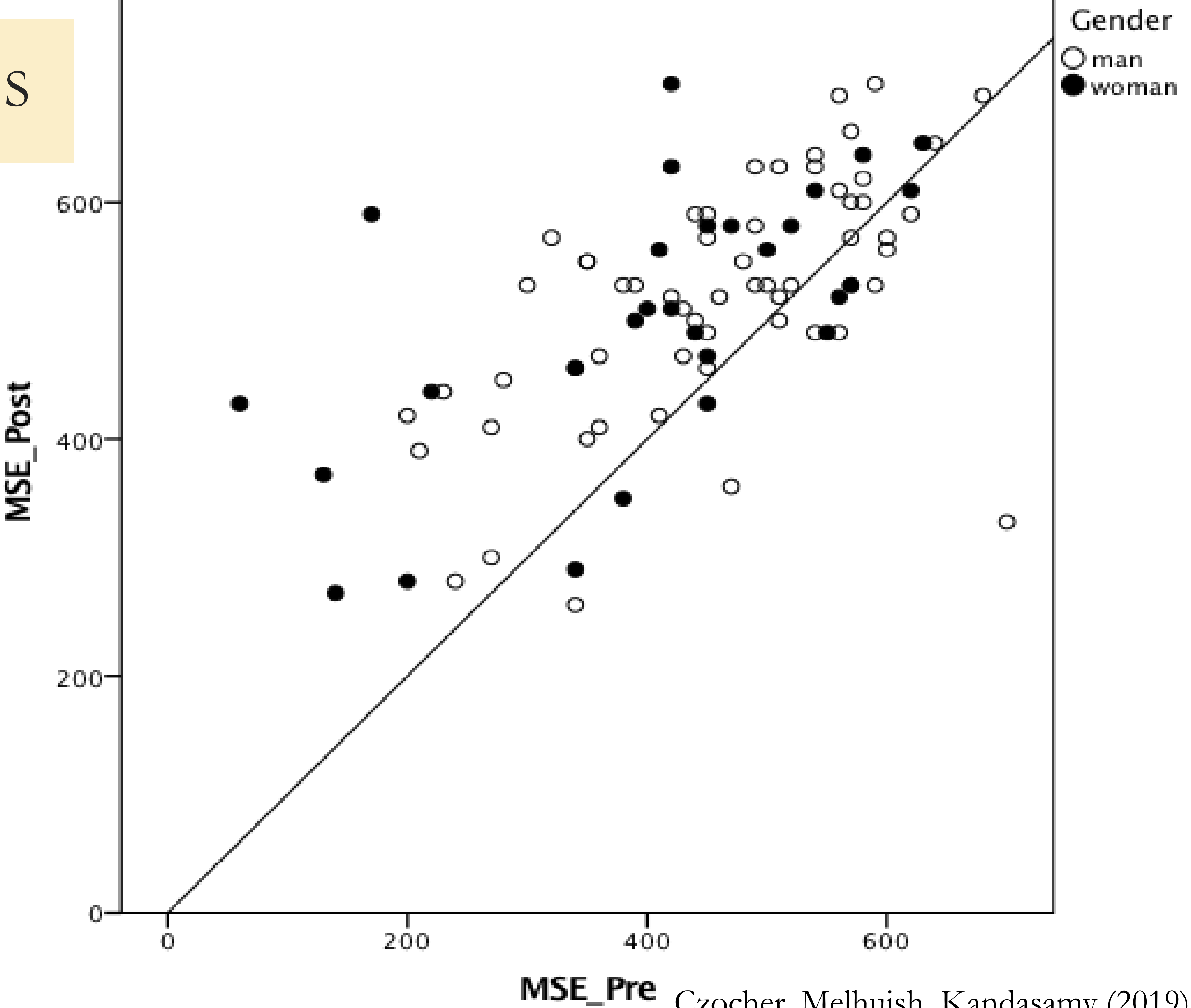
- Administer **self-efficacy surveys targeting modelling competencies** before and after the SCUDEM challenge (Bandura, 2006)
- April 2018: 93 complete pre/post sets completed
  - item-wise analysis via paired samples t-test, $\alpha = .05$
  - follow up using HLM techniques, with participant at Level 1 and site at Level 2



Czocher, Melhuish, Kandasamy (2019)

EMPIRICAL RESULTS

Participating in SCUDEM led to gains in modeling self-efficacy, especially for women



Czocher, Melhuish, Kandasamy (2019)

THEORETICAL: MECHANISMS FOR SUCCESS

Blue = Present in SCUDEM

Research Experience	Community Involvement	Mentoring
Collaborating with peers	Collaborating with peers	Emotional support from instructor
Team work	Faculty mentorship	Academic support from peers
Opportunities to apply and extend lessons from class	Career planning	Encouragement from instructor to discuss their work
Earn recognition from the professional community	Authentic problems	Requirement to explain thinking
Social networking		Active involvement encouraged
Faculty mentorship		
Guidance for graduate studies		

Czocher, Melhuish, Kandasamy (2019)

What about students?

Designers

- Modeling experience
- Modeling proficiency
- Confidence
- Appreciation of modeling
- Academic recognition
- Teamwork
- Communication skills
- Resume development
- Professional networking

Researchers

- Self-efficacy (Czocher, Melhuish, & Kandesamy, 2019)
- Teamwork, engagement in authentic mathematics, prestige, persistence in STEM (Kenderov, 2006; Thrasher, 2008).
- Leadership skills
- Hands-on learning
- Interest and motivation (Wankat, 2005; Gadola & Chindamo, 2019)

Roan & Czocher (2020)

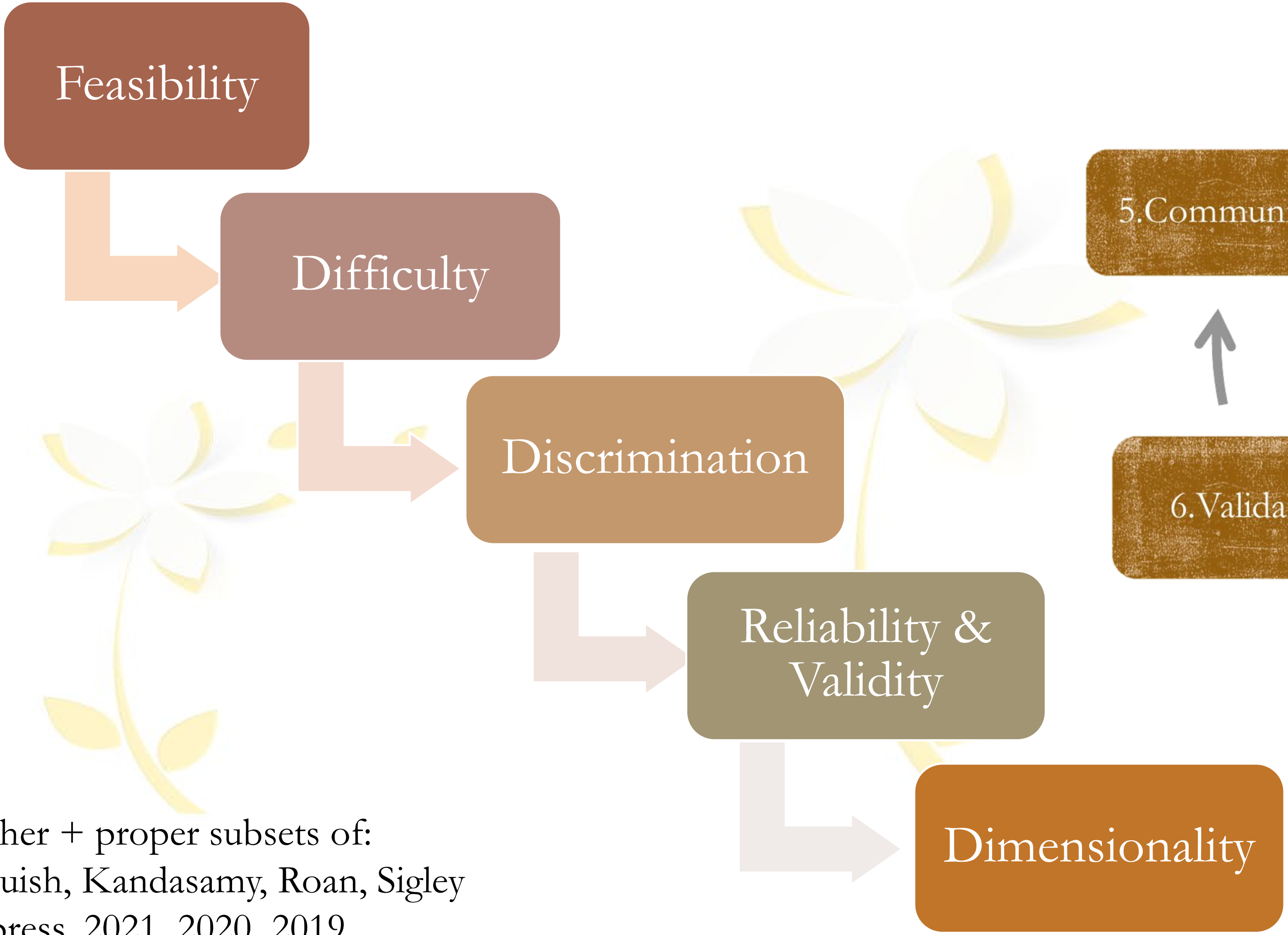
EXPECTATIONS (N=199) AND LEARNED (N=62)

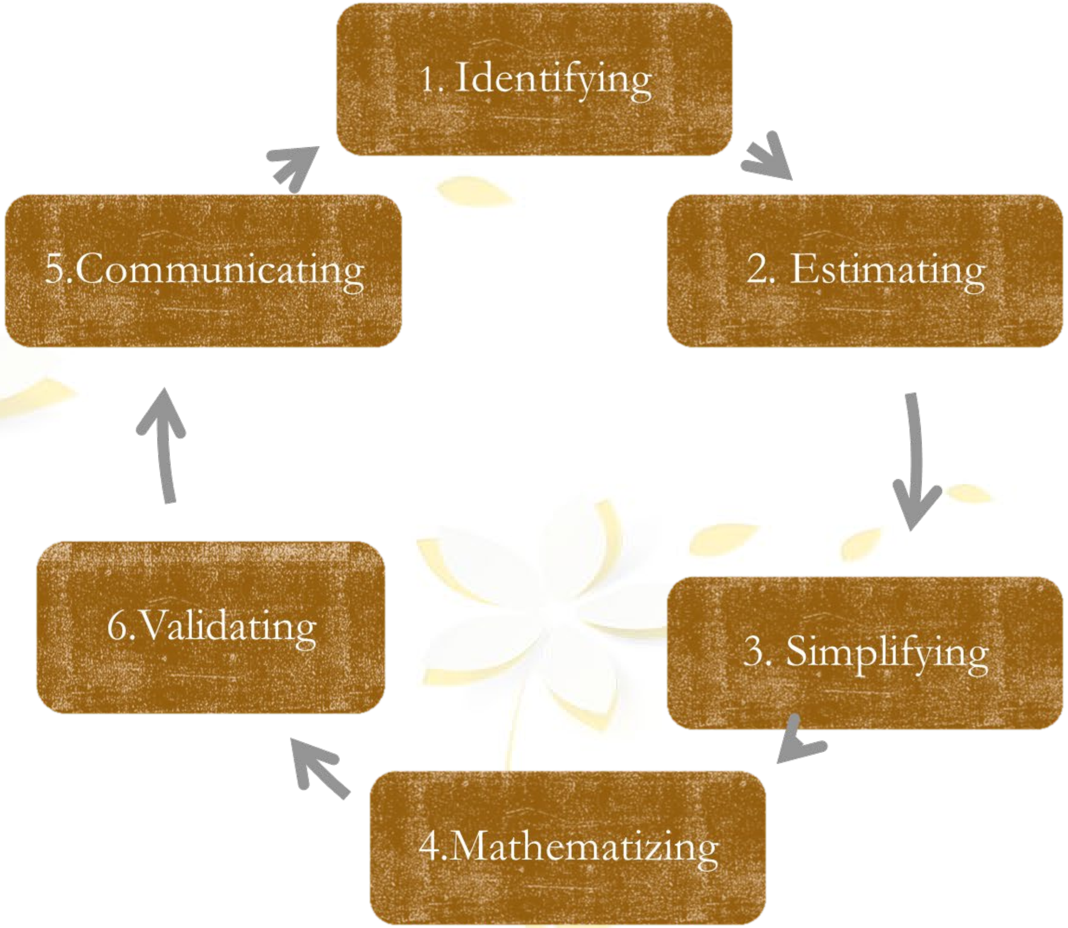
	Pre	Post
Experience in modeling	34.2%	14.5%
Gain confidence in modeling	3.5%	3.2%
Appreciation of modeling	12.1%	16.1%
Gain recognition	0.5%	0%
Teamwork skills	9.6%	16.1%
Communication skills	9.56%	4.8%
Proficiency in modeling	29.7%	35.5%
Networking	5.0%	0%
Increase interest in mathematics	0%	0%

	Pre	Post
Increase motivation for math	1.0%	0%
Self-Study skills	10.1%	9.7%
Practice solving DEs	8.5%	11.3%
Practice problem-solving	6.5%	8.1%
Practice critical thinking	3.0%	4.8%
Career building	6.0%	4.8%
Leadership skills	0%	0%
Extracurricular math experience	1.0%	1.6%

Roan & Czocher (2020)

MODELING COMPETENCIES





Czocher + proper subsets of:
Melhuish, Kandasamy, Roan, Sigley
* in press, 2021, 2020, 2019

WHAT WE LEARNED

- Student expectations: top 4 responses to “what you learned” question were **proficiency, experience, appreciation, and teamwork**.
- SCUDEM meets the top three most common expectations and also gives the students the chance to build soft skills (e.g., teamwork). (2019)
- Participants would recommend to a friend because: **learning experiences, having fun, seeing real-world applications** (2019)
- Positive association between modeling self-efficacy and modeling competency is statistically significant. (2018, 2019, 2020)
  - **Both are vital for student success!**

WHAT ELSE?

- Revision of models is an

So: How do we operationalize success and what goes into the model?

  - why they take up or ignore facilitators' suggestions

How does a student change her model over time?

Do her changes meet the purpose of those changes?

QUESTIONS, COMMENTS, COMPLAINTS?

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