Learning Strategies for Math Growth Mindset, Self-Regulation, and Performance

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  - Math growth mindset
  - Self-regulated learning (SRL)
  - Learning strategies
- Research Framework & Questions
- Learning-Strategy Instruction in Gateway Math Courses
  - Implementation
- Year-1 Results
- Next Steps

Motivation

- Introductory math courses are gateway (or gate-keeper) courses for STEM disciplines.
- Performance in gateway math courses profoundly impacts students' transitions from high school to college, their ability to remain enrolled, make progress, and ultimately graduate (Carver et al., 2017).
- Enhancing students' learning experiences and performance in these gateway courses poses a persistent challenge for higher ed. institutions.
- Several interventions have been proposed and studied to tackle this challenge.

Growth Mindset

- Growth mindset is the belief that intelligence is pliable; "intelligence is portrayed as something that can be increased through one's efforts" (Dweck, 2000, p.3).

- Students who have a growth mindset are more likely to use new strategies and change their approach when hitting a roadblock, which is vital for success in the math classroom (Dweck, 2008).

Mathematical Growth Mindset

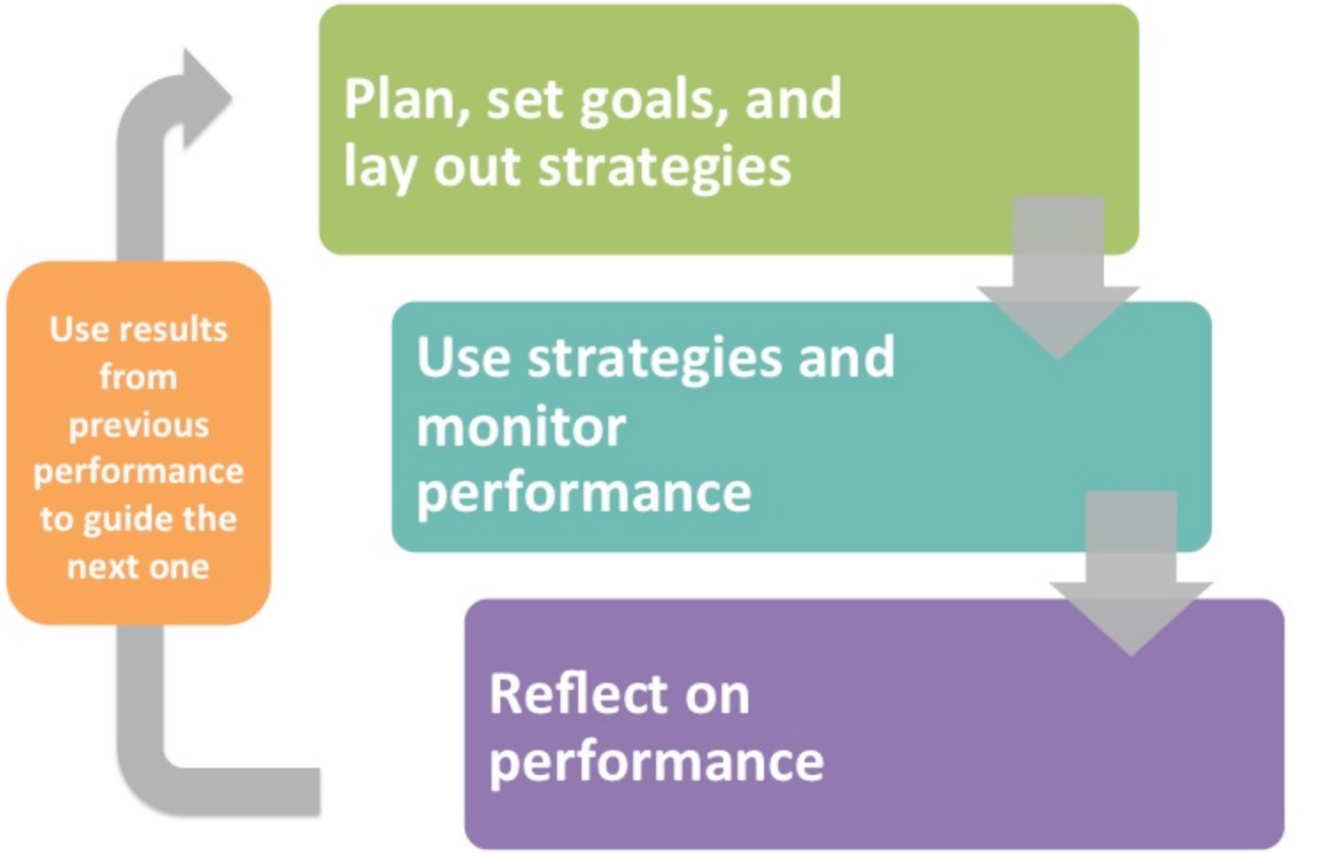
- An approach to teaching mathematics with the belief that ***mindset is more important than initial ability*** in determining the progress made by students in their mathematical understanding.
- **Faculty** who present material in a ***growth mindset framework can help protect against stereotype threat***—the perception that certain students, especially females, and minorities cannot do math.
- Research showed that ***students developed more growth mindsets when teachers presented mathematics as a subject with more opportunities for growth and learning*** (Sun, 2015).

Self-Regulated Learning (SRL)

Self-regulated learners

- are characterized by their **ability to be metacognitively, motivationally, and behaviorally active participants in their learning process** (Zimmerman, 1986).

- are capable of applying domain-relevant ***learning strategies*** to support their learning processes (e.g., Donker et al., 2014).



The Cycle of Self-Regulated Learning

Showing steps students can take throughout the process

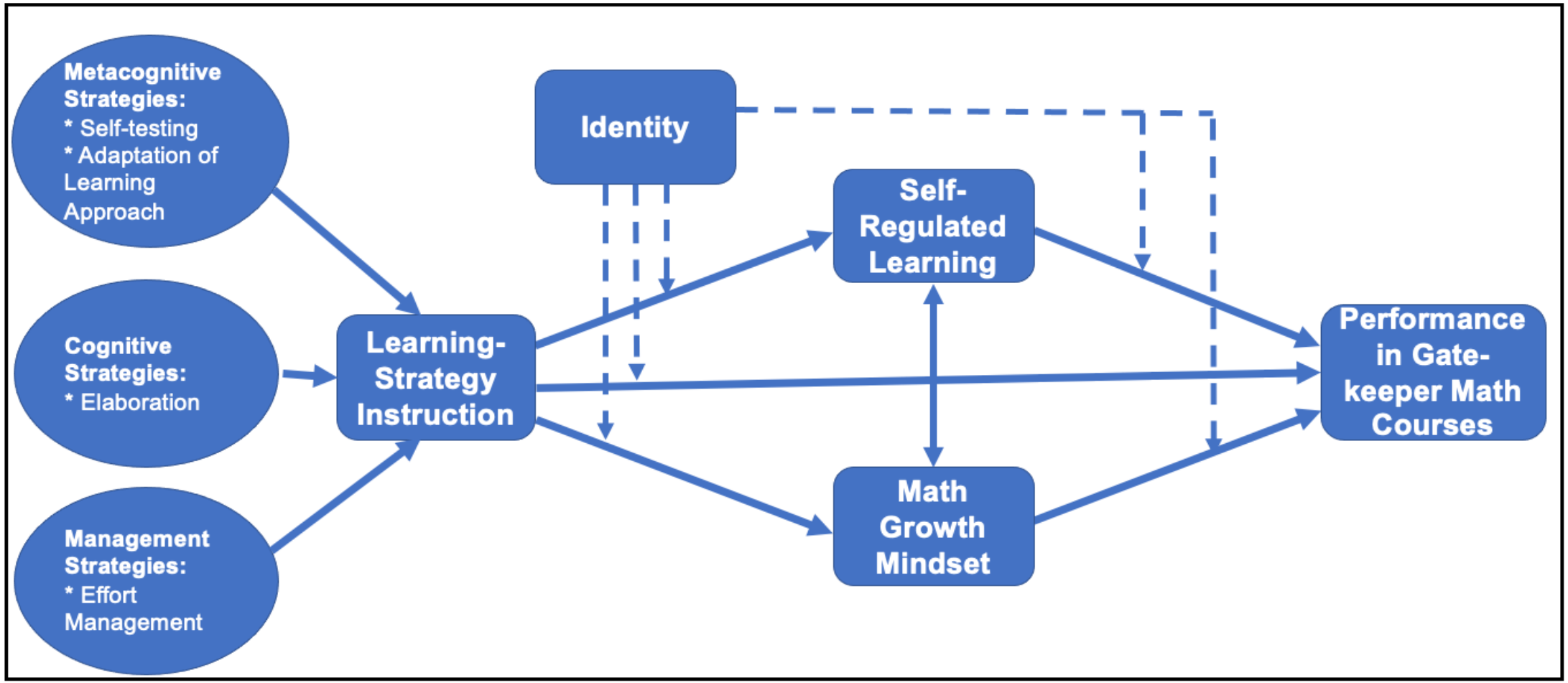
Image by Karin Kirk

Learning Strategies

- **Types of Learning Strategies**:
  - Cognitive Strategies
  - Metacognitive Strategies
  - Management Strategies

- The literature on math growth mindset and SRL suggest that ***students' knowledge and use of learning strategies can be a common facilitator of both constructs of math growth mindset and SRL***, which would in turn lead to improvements in students' performance in math.

Research Framework/Hypotheses



Research Questions

Accounting for gender, racial, and math identities,

- **RQ1**: Does integrating learning-strategy instruction within gateway math courses promote math growth mindset?
- **RQ2**: Does integrating learning-strategy instruction within gateway math courses promote SRL?
- **RQ3**: What is the nature of the association between students' math mindset and SRL?
  - ✓ When and how is math growth mindset consequential for SRL and vice versa?
- **RQ4**: Do learning-strategy instruction, math growth mindset, and SRL predict students' performance in gateway math courses?

Learning-Strategy Instruction (LSI) in Math Courses

Implementation:

- We sought to integrate LSI in four gateway math courses at NCA&T:
  - College Algebra I (MATH103) and II (MATH104)
  - Calculus I (MATH131) and II (MATH132)
- We focused on four key learning strategies:
  - Elaboration (cognitive)
  - Self-testing and Adaptation of Learning Approach (metacognitive)
  - Effort Management (management)

Learning-Strategy Instruction (LSI) in Math Courses

We focused on four key learning strategies:

- **Elaboration (cognitive)**:
  - Elaboration strategies allow students to form a math growth mindset (e.g., Sun, 2015, p.37) and directly connect to the self-reflection phase of the SRL model.
- **Self-testing and Adaptation of Learning Approach (metacognitive)**:
  - Self-testing helps students develop a math growth mindset (e.g., Sun, 2015) and allows them to practice self-monitoring (the performance phase of SRL).
  - Presenting mathematical tasks that allow for multiple solutions sends growth mindset messages and motivates students to adjust their learning strategies for better task performance (the self-reflection phase of SRL).

Learning-Strategy Instruction (LSI) in Math Courses

We focused on four key learning strategies:

- **Effort Management & Test-Taking (management)**:
  - Frequently making effort attributions about math tasks encourages students to practice effort management strategies (forethought phase of SRL) and promote math growth mindset.

Learning-Strategy Instruction (LSI) in Math Courses

Implementation:

- We used a robust combination of activities to ***inherently*** integrate LSI in the target math courses
  - Discussion board assignments (posts and replies)
  - In-class discussions and reflections
  - Peer tutor presentations

Learning-Strategy Instruction (LSI) in Math Courses

- **Discussion board (DB) assignments**
  - » #1- What do top students do differently?
    - Top Students Learning Habits: TEDx Talk by Douglas Barton of Elevate Education
  - » #2- Introduction to the study cycle (preview, attend, review, study, and check)
    - Watch a study cycle video by the LSU Center for Academic Success
  - » #3- Time Management
    - Students take an online time management quiz and reflect on scores in DB
    - Students are provided with a sample study calendar and are asked to create their own study calendar for the math course
  - » #4- Test-taking strategies
    - » Watch a math test-taking strategies video by the EKU Student Success Center

Learning-Strategy Instruction (LSI) in Math Courses

- **In-class discussions and reflections**
  - Class discussion starts with a brief summary of the key takeaway points from the DB assignment (~5 slides provided to instructors)
  - The remainder of the discussion is integrated within the MATH problem(s) covered during the class session.
    - Course-specific example class scripts were developed for instructors to use as starters.

Learning-Strategy Instruction (LSI) in Math Courses

- **Peer tutor presentations**
  - ~5-minute pre-recorded videos created by peer tutors
  - Peer tutors are students who have recently completed the MATH course with outstanding performance
  - Peer tutors discuss the learning strategies they used to succeed in the MATH course
  - Instructors play the video in class and/or post it in the LMS as a discussion board assignment

Research Design

- The study utilizes a **repeated-measures between-subjects** design and a **mixed methods** sequential (two-phase) approach
- **4 sections** in each of the 4 target math courses (College Algebra I/II and Calculus I/II)
  - a treatment group (2 sections) or
  - a control group (2 sections)
- ***Treatment*** students are taught about effective math learning strategies including elaboration, self-testing, effort and time management, and test-taking strategies.
- ***Control*** students, on the other hand, are taught the same course content without any instruction on learning strategies.

Data Collection

- Qualtrics Pre- and Post-Surveys
  - One survey: Math Mindset, Self-Regulated Learning, and Math, Gender and Racial Identities
- Content Knowledge Pre- and Post-Tests
- Students' demographics (gender, PELL status, and residency) and academic profile (STEM status, classification, and GPA) – from institutional records
- Focus Groups

Scales

- Hocker's (2017) modified math mindset scale was used for measuring math mindset.
- Cleary's (2006) Self-Regulation Strategy Inventory–Self-Report (SRSI–SR) was used for measuring SRL.
  - Original SRL scale, validated on a sample of high school students, had three subscales:
    - Managing Environment and Behavior (SRL-1),
    - Maladaptive Regulatory Behaviors (SRL-2), and
    - Seeking and Learning Information (SRL-3).
- Racial identity was measured using Sellers et al.'s (1997) Multidimensional Inventory of Black Identity (MIBI) for Black students and Brown et al.'s (2014) Multigroup Ethnic Identity Measure (MEIM) for non-Black students.
- Gender identity was measured using a modified version of the MIBI scale.
- Math identity was measured using Lock et al.'s (2013) math identity scale.

Year-1 Results

- Data collected in Fall 2022–Spring 2023
- The data comes from 32 sections (16 treatment and 16 control) spanning 4 math courses
  - **551** students (278 control and 273 treatment) completed both the pre- and post-content tests and the pre- and post-attitude surveys

Table 1. *Characteristics of the sample participants by their role in the study.*

Variable	Control: n (%)	Treatment: n (%)
Gender: Female	152 (65.52%)	162 (71.78%)
STEM: Yes	128 (55.17%)	100 (44.25%)
PELL: Yes	208 (89.66%)	199 (88.05%)
Residency: Out-of-State	121 (52.16%)	105 (46.46%)
GPA: >=3.00	93 (56.71%)	107 (68.15%)

Year-1 Results

* SRL-1 = Managing Environment and Behavior

* SRL-2 = Maladaptive Regulatory Behaviors

Table 2. *Estimates of regression coefficients (standard errors) from four regression models with the* response variable shown in the column and explanatory variables shown in the rows.

Explanatory Variable	Mindset Diff	SRL-1Diff	SRL-2 Diff	Performance Diff
	Estimate (S.E.)	Estimate (S.E.)	Estimate (S.E.)	Estimate (S.E.)
Role: Treatment	0.180 (0.106) ·	0.023 (0.058)	-0.083 (0.074)	-3.924 (2.418)
Mindset Difference	-	-0.003 (0.032)	0.155 (0.040) ***	2.834 (1.348) *
SRL-1 Difference	-0.010 (0.107)	-	0.172 (0.074) *	3.281 (2.414)
SRL-2 Difference	0.319 (0.082) ***	0.107 (0.046) *	-	4.438 (1.891) *
Gen Identity Reflection	-0.100 (0.046) *	0.058 (0.025) *	-0.003 (0.032)	0.588 (1.070)
Gen Identity Centrality	0.069 (0.045)	-0.008 (0.025)	0.042 (0.032)	0.503 (1.028)
Racial Identity	0.173 (0.073) *	-0.028 (0.040)	-0.050 (0.051)	-1.932 (1.665)
Math Iden: Competency	0.063 (0.115)	-0.068 (0.063)	-0.121 (0.080)	3.265 (2.619)
Math Iden: Recognition	0.148 (0.072) *	0.013 (0.400)	-0.023 (0.050)	1.524 (1.171)
Math Iden: Interest	-0.178 (0.016) **	0.000 (0.034)	0.093 (0.043) *	-1.450 (1.429)
Gender: Male	0.136 (0.126)	0.046 (0.069)	-0.042 (0.088)	-5.338 (2.880) ·
STEM: Yes	-0.120 (0.125)	-0.053 (0.069)	-0.040 (0.087)	-1.983 (2.861)
GPA	0.014 (0.089)	0.034 (0.049)	-0.009 (0.062)	1.456 (2.003)
PELL: Yes	0.243 (0.178)	0.165 (0.098) ·	-0.090 (0.124)	1.462 (3.665)
Residency: Out-of-State	0.052 (0.110)	-0.031 (0.060)	0.059 (0.076)	-0.699 (2.498)
Class: Sophomore	-0.012 (0.116)	0.004 (0.064)	-0.118 (0.081)	-0.432 (2.646)
Class: Junior	-0.282 (0.242)	0.062 (0.133)	0.166 (0.169)	-4.430 (5.683)
Class: Senior	-0.506 (0.940)	-1.115 (0.513) *	-0.360 (0.655)	-7.612 (20.76)
Course: Algebra II	-0.111 (0.138)	0.021 (0.076)	0.043 (0.096)	8.757 (3.097) **
Course: Calc I	0.081 (0.166)	0.102 (0.091)	0.003 (0.115)	-8.352 (3.765) *
Course: Calc II	-0.003 (0.181)	0.040 (0.099)	0.313 (0.125) *	18.017 (4.166) ***
Adjusted R^2	0.078	0.014	0.088	0.212

Note: Reference category is "Control" for Role, "Female" for Gender, "No" for STEM and PELL, "In-State" for Residency, "Freshman" for Classification, and "Algebra I" for Course.
Significance codes: '***' ≡ P-value <0.001; '**' ≡ P-value <0.01; '*' ≡ P-value <0.05; '·' ≡ P-value <0.1

Year-1 Results

- Accounting for students' SRL, identities, background characteristics, and course, learning-strategy instruction (LSI) **was associated with positive**, yet marginal (coef. = 0.18, p-value = 0.0903), improvement in math growth mindset.

I don't think that anyone … is just incapable of … being good at math. … [I]t's just something that you have to put your mind to. … [N]ot everybody is really good at math, so it's kinda … you have to … strive to do better in math.

~Algebra student (treatment)

Year-1 Results

I think your instructor can 100 percent influence your abilities, because I think you could be good at math but if you have a bad instructor, it will make you think you're bad at it, so you might … turn away from it …

~ Calculus student (treatment)

Year-1 Results

I've had great math teachers where they teach and I automatically understand what's happening. And then I get to college and it's like I'm dealing with people who feel like they don't have the time to spare to help you or help you understand what's being given. And it's frustrating because as a professor, I feel like you have to work your way to that level, to that position, and just for you to … throw things in students' faces, that's not a real professor to me.

~Algebra student (control)

Year-1 Results

- Accounting for students' math mindset, identities, background characteristics, and course, LSI **was not significantly** associated with changes in SRL.

I thought … some of the study tips were very helpful. It was just things I didn't think about doing before. … I didn't really change a lot. I kinda just – well I picked up … a couple minor things but nothing drastic changed.

~ Calculus II student (treatment)

Year-1 Results

One [module] was about when making a schedule, time management. Another one was about your test-taking skills. … I feel like it was good for people to know … [but] it's like yeah, it's common knowledge. … Well I did stop cramming for tests … I used to be that person right before the exam, I would be studying. I don't – the day of, I'm not studying now.

~ Calculus II student (treatment)

Year-1 Results

- Both gains in math mindset and gains in SRL-2 **were positively associated** with gains in students' performance on the content tests (Mindset: coef. = 2.83, p=0.0364; SRL-2: coef. 4.44, p=0.0197)
  - but LSI **was not significantly associated** with performance gains.

Year-1 Results

- Correlation analyses were conducted to test the bidirectional association in **RQ3**.
- **Bivariate Pearson correlation analysis** between students' math mindset scores and SRL scores showed that
  - students' initial mindset and SRL scores **were positively correlated** with their post-semester mindset and SRL scores
    - mindset: cor. = 0.53, $p < 0.001$
    - SRL-1: cor. = 0.69, $p < 0.001$
    - SRL-2: cor. = 0.50, $p < 0.001$
  - students' post-semester mindset score **was positively correlated** with their initial SRL-2 scores (cor. = 0.36, $p < 0.001$) but not their initial SRL-1 score.

Year-1 Results

- Correlation analyses were conducted to test the bidirectional association in **RQ3**.
- **Cross-lagged correlation analysis** revealed that
  - students' initial math mindset **was not predictive** of their end-of-semester SRL (SRL-1: coef. = 0.004, p = 0.8720; SRL-2: coef. = 0.041, p = 0.1750) given their pre-semester SRL score.
  - only students' initial SRL-2 **was predictive** of their end-of-semester math mindset (coef. = 0.291, p <0.0001) given their pre-semester math mindset.

Next Steps

- **Retrospective pretest-posttest approach**
  - Year-2: Fall 2023/Spring 2024
  - Accounts for the fact that students may tend to overestimate their math growth mindset, SRL, and math identity
- **Qualitative data (Focus Groups) analysis for Year-2**
- **Explore additional factors**
  - Instructor, attendance, participation in DB and class reflections, etc.
- **Evaluate if/how students use learning strategies in future STEM courses**

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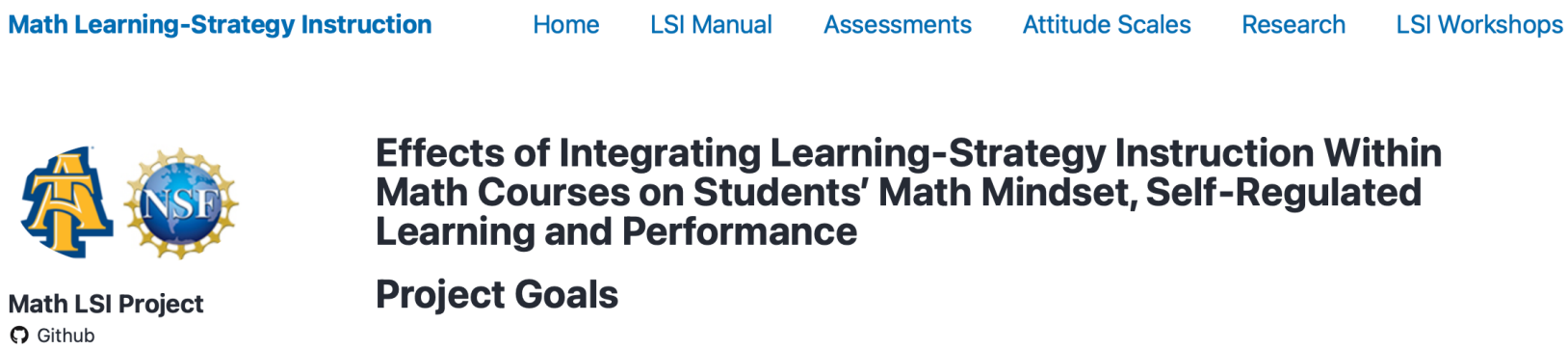
  - For more info, see the project's website: https://mathlsincat.github.io



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THANK YOU!