Blinded Abstract Body

Dynamic interplay of motivational regulation strategies and achievement: Insights from intensive longitudinal data

Purpose

Student motivation is highly dependent on the task at hand, situated in personal and social contexts (Eccles & Wigfield, 2020; Nolen, 2020; Pintrich, 2003). Importantly, motivation is inherently malleable, meaning it can be enhanced (or undermined) over time by various personal and contextual factors (Turner & Patrick, 2008). Extensive research has shown that educators can adopt various methods to motivate their students or create an adaptive motivational climate, including using real-life examples to enhance relevance, building and maintaining rapport, and providing choices to foster a sense of autonomy (Anderman et al., 2011; Hensley et al., 2021; Robinson, 2023). Recently, there has been growing attention among researchers on how students can self-regulate their own motivation, a process known as *motivational regulation* (Wolters, 2003). Emerging evidence highlights the role of motivational regulation in various outcomes such as effort, achievement, and engagement (Fong et al., 2024; Villar et al., 2024). However, researchers have overwhelmingly relied on single time-point assessments of motivational regulation (e.g., Authors, 2023; Park & Yun, 2018; Schwinger & Stiensmeier-Pelster, 2012), and this approach inevitably overlooks the dynamic nature of motivational regulation. As a result, less is known about how students overcome motivational strategies and what strategies they employ to sustain their motivation as they negotiate various commitments and course requirements each week during a semester. Our study addresses this gap by using weekly intensive longitudinal data to explore how students use various motivational regulation strategies over time, how these strategies dynamically interact with each other, and how they differentially contribute to academic achievement.

Background and Context

Based on self-regulated learning theories, students can engage in active and strategic processes to plan, monitor, control, and adjust their learning (Pintrich, 2004; Zimmerman, 2000). While students can self-regulate various areas including cognition, motivation, behavior, and context, there has been an overwhelming focus on cognitive aspects or cognitive learning strategies in the literature (Authors, 2020). Motivational regulation, a pivotal component of self-regulated learning (Pintrich, 2004; Wolters, 2003), has gained considerable attention over the past two decades. Given that motivational challenges are pervasive and often disruptive for students, it is crucial to monitor their motivation and adopt appropriate strategies to initiate, maintain, or enhance it (Zimmerman & Schunk, 2012). Engaging in various types of motivational regulation strategies has been associated with increased effort, effective use of learning strategies, and higher achievement (Authors, 2018; Kryshko et al., 2020; Schwinger et al., 2009; Wolters & Benzon, 2013). Conversely, the absence of such strategies has been linked to higher cost perceptions, procrastination, and burnout (Authors, 2020, 2023; Grunschel et al., 2016). Thus, recognizing and promoting motivational regulation among students is essential not just for their academic success but also for fostering their well-being (Fong et al., 2024). Examples of motivational regulation strategies include connecting learning material to personal experiences, rewarding oneself upon task completion, and arranging the study environment to reduce distractions. According to a meta-analysis (Villar et al., 2024), students predominantly

use extrinsic strategies such as performance-approach self-talk, where they remind themselves of the importance of learning outcomes (or grades). Conversely, intrinsic strategies such as interest enhancement or mastery self-talk are used less frequently, despite their strong association with enhanced effort (Villar et al., 2024). Students may be less familiar with these intrinsic strategies and/or consider them ineffective in competitive environments (Wolters & Benzon, 2013).

Despite growing interest (Miele & Scholer, 2018), this field remains in its early stages, with many important questions still requiring further examination to better understand the scope and impact of these strategies. Critically, a notable gap in the literature remains: researchers have largely neglected the contextual variability of motivational regulation strategies by relying primarily on single time-point measurements to assess strategy use and its outcomes. Recognizing the situated and context-dependent nature of motivational regulation is important, given that students' engagement in various motivational regulation strategies may fluctuate and shift based on the specific situation (Wolters et al., 2023). Authors (2023) also called for future research to examine how students regulate their motivation as it unfolds over time. Therefore, this study seeks to provide deeper insights into the temporal dynamics of motivational regulation strategies by utilizing intensive longitudinal data, collected weekly throughout the semester. By examining these week-to-week patterns, we will provide insights into students' exploratory processes or trial-and-error approaches as they adapt and refine their motivational regulation over time, as well as how they collectively predict academic achievement.

We address three key research questions: (1) How does the use of different motivational regulation strategies change over time? We examine the overall patterns and trends in adopting various motivational regulation strategies throughout the semester. (2) How do changes in one motivational regulation strategy predict subsequent changes in using other strategies? We explore the interrelations between these strategies, with a focus on triggers that influence later strategy choices and the roles within the strategy network. (3) How do specific motivational regulation strategies relate to academic achievement when controlling for baseline motivational beliefs? We investigate the relationship between the cumulative use of motivational regulation strategies and course grades. Overall, we advance the field by providing new insights into the complex and dynamic nature of motivational regulation strategy use, the predictive relationships between these strategies, and their unique contributions to academic success.

Method

Participants

We recruited students ($N = 223$) from a Midwestern university calculus course. The calculus course was selected because motivational regulation might play a critical role in competitive learning environments where academic performance is highly emphasized and challenging tasks are common (Hunter, 2019). This study was part of a larger intervention project, and we focused on a subgroup of students who participated in the same intervention condition and had the opportunity to plan their use of motivational regulation strategies each week. The demographic breakdown of the participants was as follows: gender distribution was 38.6% men, 59.6% women, 1% nonbinary, 1% preferred not to disclose. Reported race/ethnicity included 83.4% racial majority (75.3% White, 12.1% Asian, 3.2% Middle Eastern) and 16.6% racially marginalized groups (11.2% Black. 5.8% Latinx/Hispanic, 0.4% American Indian/Alaska Native).

Procedure and Materials

Students completed a baseline survey at the beginning of the semester to indicate their

initial motivation for the course (expectancy beliefs, interest, utility value, cost) and provide demographic information (ethnicity, gender, first-generation status). Additionally, weekly throughout the semester (a total of 13 weeks), students reported the motivational regulation strategies they planned to use. In total, we collected 1,366 responses from the weekly surveys. The average response rate of the weekly surveys was 47%, and students completed an average of 6.13 surveys (*SD* = 4.42). Finally, at the end of the semester, we collected their official course grades (0.0 – 4.0 scale) from the instructor. We used well-established scales to measure our constructs, and all items were measured on a 7-point Likert scale.

Baseline Survey. Expectancy beliefs were measured using three items (Kosovich et al., 2015; "I am confident that I will do well in my calculus class."; $\alpha = 0.79$). Utility value was measured using five items (Conley, 2012; "Calculus will be useful for me later in life."; $\alpha = 0.88$). Interest was measured using five items (Conley, 2012; " Calculus is exciting to me."; $\alpha = 0.95$). Cost was measured using 19 items from Flake et al. (2015) that included four dimensions of cost (i.e., task effort, outside effort, loss of valued alternatives, and emotional; "This class will be too much work."; $\alpha = 0.96$).

Weekly Surveys. Each week, students were presented with a checklist of motivational regulation strategies to overcome their motivational challenges in the upcoming week. Students were prompted with, "Now, we would like you to think about the work that you have to accomplish in Calculus next week. Which of the strategies below will you use to help you complete your work? Please select all that apply." Based on prior literature (Schwinger et al., 2009; Wolters & Benzon, 2013), the checklist included eight motivational regulation strategies (see Table 1).

Findings or Results

All analyses were conducted using R (R Core Team, 2021). Missing data were handled using full information maximum likelihood estimation. Overall, students completed a total of 1,366 responses from the weekly surveys. There were no significant differences in response rates between men and women, $t(184.49) = 0.90$, $p = 0.369$, racially marginalized students and racial majority students, $t(53.06) = 0.83$, $p = 0.412$, or first-generation and continuing-generation students, $t(49.61) = 0.17$, $p = 0.862$. Descriptive statistics and correlations among the general use of different strategies are shown in Table 2.

RQ1: How Does the Use of Different Motivational Regulation Strategies Change Over Time?

As shown in Figure 1, which illustrates the changes in motivational regulation strategies over time, there was a noticeable overall decrease in the reported strategy use. However, the specific use of different strategies showed unique patterns of change over time. Notably, there was an emphasis on performance-oriented and behavior-focused strategies. For instance, motivational regulation strategies such as reminding oneself about the importance of the importance of grades (S4: performance-approach self-talk), minimizing distractions (S5: environmental structuring), and breaking down the workload (S7: proximal goal setting) were consistently among the most frequently used strategies throughout the semester. In contrast, value-related strategies were less likely to be used. For example, motivational regulation strategies such as relating the material to one's experiences (S8: enhancement of personal significance) and considering its helpfulness of the material (S1: enhancement of utility value) were used less often and showed a relatively lower presence across time. This indicates a potential struggle among students to maintain a connection between their studies and personal interests or perceived value of the material.

Additionally, while the overall frequency of strategy use declined, descriptive patterns indicate that the relative emphasis on various strategies also changed. The prominence of performance-oriented and behavior-focused strategies such as reminding oneself about the importance of the importance of grades (S4: performance-approach self-talk), minimizing distractions (S5: environmental structuring), and breaking down the workload (S7: proximal goal setting) showed greater decline over time. This suggests a potential shift away from more immediate, task-focused approaches as students adapted their approaches in regulating their motivation. Our findings highlight not only the overall decline in motivational regulation strategy use but also the potential for students to explore and adjust their strategies after different trials, in response to shifting demands and priorities throughout the semester.

RQ2: How Do Changes in One Motivational Regulation Strategy Predict Subsequent Changes in Using Other Strategies Over Time?

Results from the Kwiatkowski-Phillips-Schmidt-Shin Unit Root tests suggested that the assumption for stationarity was met for each variable in the network (Bonferonni corrected *ps* > 0.05). We then estimated the within-person lagged network using a panel design to better understand the predictive relationships among motivational regulation strategies (Epskamp, 2020). Panel A in Figure 2 illustrates how the use of a strategy in a given week predicts the use of the same or another strategy in the subsequent week, while controlling for prior levels of all strategies. Panel B in Figure 2 illustrates in-strength and out-strength, which refer to the weighted connections (edges) linked to each strategy (node) in a directed network, depicting how strongly strategies predict each other over time. A strategy with high in-strength is frequently influenced by other strategies, whereas a strategy with high out-strength exerts a strong influence on others in students' motivational regulation.

Interestingly, reminding oneself about the importance of grades (S4: performance-approach self-talk) demonstrated the highest in-strength. That is, students frequently returned to this performance-oriented strategy, even after experimenting with other approaches. This suggests that the emphasis on grades is a consistently prominent factor in students' motivational regulation, underscoring its central role within their overall strategy network. In contrast, engaging in self-talk to focus on the learning process (S3: mastery self-talk) and breaking down the workload (S7: proximal goal setting) showed the highest out-strength. This indicates that these strategies serve as precursors, creating sequential pathways to other approaches to regulate motivation in academic tasks. That is, when students engaged in mastery self-talk (S3) or proximal goal setting (S7) to enhance their motivation, it often led to the adoption of additional supportive strategies in the following week.

Moreover, as shown in Figure 2, there was a positive self-loop for the enhancement of utility value (S1). A self-loop in a lagged relation network indicates that the use of a strategy at one time point is directly related to its use at a subsequent time point, demonstrating temporal stability (or autocorrelation), where the strategy is influenced by its own previous use. That is, once students engaged in reflecting on the helpfulness of the materials (S1), they tended to continue doing so in the subsequent week. Although not as strong as the enhancement of utility value (S1), other strategies such as making the work seem more enjoyable (S2: Enhancement of Situational Interest), reminding oneself about the importance of the importance of grades (S4: Performance-Approach Self-Talk), and breaking down the workload (S7: Proximal Goal Setting) also demonstrated a positive self-loop.

Notably, rewarding oneself after task completion (S6: self-consequating) emerged as an isolated node. Unlike other strategies, it was neither predicted by nor predictive of any other

strategies in the network. This lack of connections suggests that self-consequating operated separately, as students did not incorporate it into the broader network of motivational regulation strategies across the semester. The disconnect from other strategies may indicate its limited use, at least with respect to how students managed their motivation alongside other strategies.

RQ3: How Do Specific Motivational Regulation Strategies Relate to Academic Achievement When Controlling for Baseline Motivational Beliefs?

Table 3 presents the results of the path analysis, which examined the relationship between the cumulative use of specific motivational regulation strategies and academic achievement. We found that the frequent use of certain motivational regulation strategies throughout the semester was positively associated with higher final course grades. Specifically, strategies such as reminding oneself of the importance of grades (S4: performance-approach self-talk), minimizing distractions (S5: environmental structuring), rewarding oneself after task completion (S6: self-consequating), and breaking down the workload (S7: proximal goal setting) showed a positive association with academic performance (β = .14-.21). This suggests that students who employ these strategies more often may be better positioned to achieve higher academic outcomes, highlighting the importance of integrating effective motivational regulation into study practices.

Conclusions and Implications

This study advances our understanding of how students self-regulate their motivation over time using diverse strategies. This unique approach allowed us to demonstrate the week-to-week dynamics of motivational regulation strategy use, potentially signaling students' exploration processes or trial-and-error patterns in their motivational regulation over time. Given the importance of evaluation and adjustment in self-regulated learning (Raković et al., 2022), it is crucial to understand how students experiment with different tactics over time.

Overall, our study offers several key contributions. First, we highlighted that students employ multiple motivational regulation strategies concurrently and that these strategies evolve across the semester. Our findings revealed a general decline in strategy use, with a higher focus on performance- and behavior-focused strategies, which aligns well with prior literature (Villar et al., 2024). This nuanced understanding allows educators to tailor interventions not only to enhance overall strategy use to enhance motivation but also to shift towards specific strategies that emphasize interest and intrinsic value in learning. Second, we focused on the interconnected nature of motivational regulation strategy use, illustrating how certain strategies serve as catalysts for others throughout the semester. For example, by examining the temporal interplay of diverse motivational regulation strategies, we demonstrated the pivotal role of mastery self-talk and proximal goal setting in sustaining and triggering additional strategies in subsequent weeks. Finally, our findings showed that not all motivational regulation strategies are equally effective in predicting course grades. Strategies such as reminding oneself about the importance of learning outcomes and eliminating distractions were more powerful in enhancing academic achievement. We believe that our findings add to the growing evidence on how effective regulation of motivation can be a powerful mechanism to support students' academic success, but also raise questions about the relative effectiveness of various strategies. By identifying which strategies are most helpful for students in different contexts, educators would be able to offer targeted interventions or tailored guidance to support students with their motivational challenges. Moving forward, researchers should continue to investigate this mechanism to offer more nuanced implications on how the dynamic use of motivational regulation strategies, either independently or in combination with others, operates simultaneously.

Appendix A - References

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Appendix B - Tables and Figures

Table 1

List of Motivational Regulation Strategies Included in the Checklist

Motivational Regulation Strategies		
S1	Think of situations where it would be helpful for me to know the material or skills.	Enhancement of Utility Value
S2	Think of ways to make the work seem enjoyable to complete.	Enhancement of Situational Interest
S3	Tell myself that I should keep working just to learn as much as I can.	Mastery Self-Talk
S4	Remind myself about how important it is to get good grades.	Performance-Approach Self-Talk
S5	Try to get rid of any distractions that are around me.	Environmental structuring
S6	Promise myself some kind of reward if I get my studying done.	Self-Consequating
S7	Break down the workload in small segments so I get the feeling that I can handle it more easily.	Proximal Goal Setting
S8	Try to relate the learning material to my own experiences.	Enhancement of Personal Significance

Notes. Prior to viewing the list of strategies, students were prompted with, *"Now, we would like you to think about the work that you have to accomplish in Calculus next week. Which of the strategies below will you use to help you complete your work? Please select all that apply."*

Table 2

Descriptive Statistics and Correlations of Overall Use of Motivational Regulation Strategies

	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**
S1		0.04	0.02	-0.03	0.02	-0.01	-0.02	-0.01
S2	0.21***		< 0.001	0.003	-0.04	-0.04	-0.05	0.03
S3	0.17***	0.13***		0.09**	0.03	0.04	0.02	0.07*
S4	0.05	0.09***	0.19***		-0.04	0.02	-0.03	-0.002
S5	0.09***	0.14***	0.08**	0.06*		0.04	0.01	-0.02
S6	0.10***	0.14***	0.10***	0.09***	0.15***		-0.01	0.02
S7	0.03	0.07*	0.08**	0.00	0.18***	0.12***		0.01
S8	0.21***	0.17***	0.14***	0.04	0.09**	0.14***	0.12***	
M	0.26	0.31	0.29	0.50	0.44	0.26	0.40	0.09
SD	0.44	0.46	0.46	0.50	0.5	0.44	0.49	0.28

Notes. $^{*}p$ <.05. $^{**}p$ <.01. $^{***}p$ <.001. Between-person means are shown below the diagonal; within-person means are shown above the diagonal. S1 indicates "*think of situations where it would be helpful for me to know the material or skills*" (Enhancement of Utility Value); S2 indicates "*think of ways to make the work seem enjoyable to complete*" (Enhancement of Situational Interest); S3 indicates "*tell myself that I should keep working just to learn as much as I can*" (Mastery Self-Talk); S4 indicates "*remind myself about how important it is to get good grades*" (Performance-Approach Self-Talk); S5 indicates "*try to get rid of any distractions that are around me*" (Environmental Structuring); S6 indicates "*promise myself some kind of reward if I get my studying done*" (Self-Consequating); S7 indicates "*break down the workload in small segments so I get the feeling that I can handle it more easily*" (Proximal Goal Setting); and S8 indicates "*try to relate the learning material to my own experiences*" (Enhancement of Personal Significance).

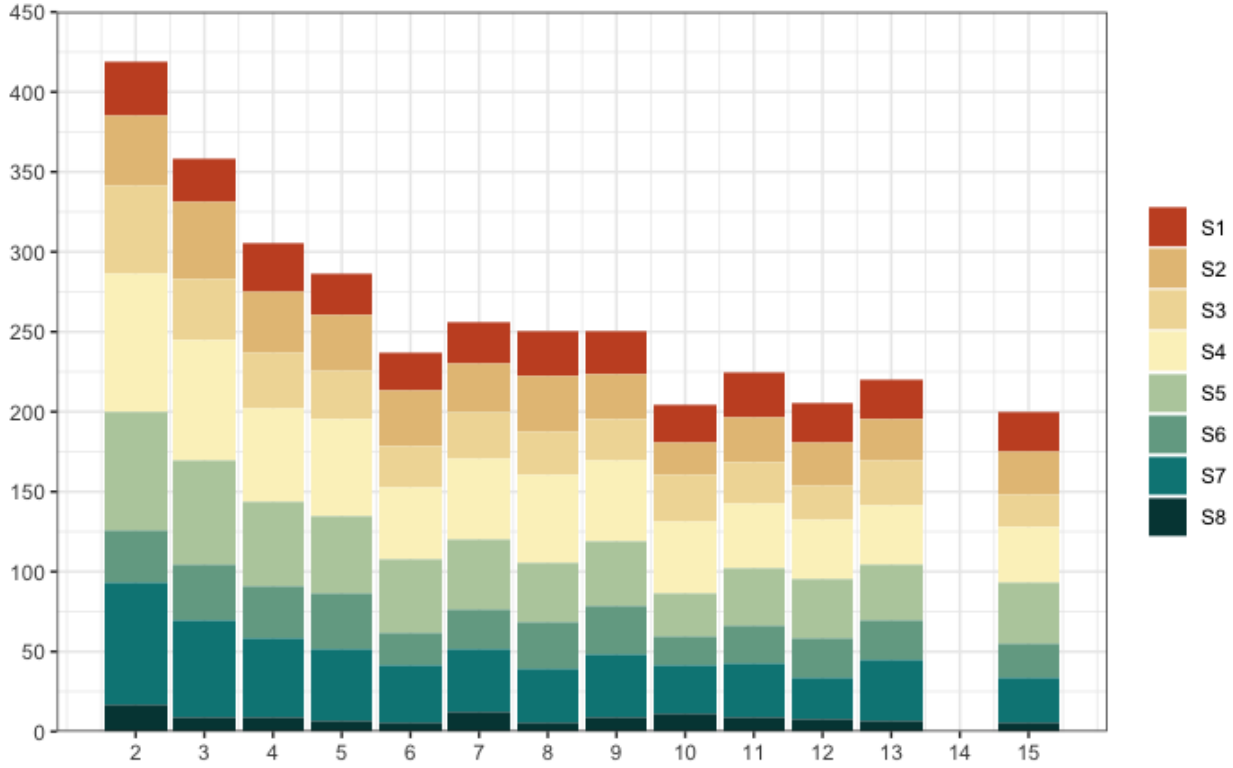
Table 3
Motivational Regulation Strategies Predicting Achievement (Standardized Coefficients)

	S1	S2	S3	S4	S5	S6	S7	S8
Strategy	0.03	0.10	0.08	0.21**	0.18**	0.14*	0.17*	-0.03
Expectancy	0.10	0.08	0.09	0.08	0.09	0.11	0.12	0.10
Interest	0.28**	0.27**	0.27**	0.28**	0.29**	0.26**	0.28**	0.28**
Utility value	-0.12	-0.12	-0.12	-0.13	-0.14	-0.13	-0.13	-0.11
Cost	-0.08	-0.07	-0.08	-0.06	-0.03	-0.05	-0.03	-0.08
URM	-0.26***	-0.26***	-0.26***	-0.27***	-0.25***	-0.24***	-0.25***	-0.25***
Women	0.10	0.08	0.09	0.08	0.07	0.06	0.05	0.09
FG	-0.13	-0.12	-0.14*	-0.14*	-0.14*	-0.14*	-0.14*	-0.14*

Notes. S1 indicates "*think of situations where it would be helpful for me to know the material or skills*" (Enhancement of Utility Value); S2 indicates "*think of ways to make the work seem enjoyable to complete*" (Enhancement of Situational Interest); S3 indicates "*tell myself that I should keep working just to learn as much as I can*" (Mastery Self-Talk); S4 indicates "*remind myself about how important it is to get good grades*" (Performance-Approach Self-Talk); S5 indicates "*try to get rid of any distractions that are around me*" (Environmental Structuring); S6 indicates "*promise myself some kind of reward if I get my studying done*" (Self-Consequating); S7 indicates "*break down the workload in small segments so I get the feeling that I can handle it more easily*" (Proximal Goal Setting); and S8 indicates "*try to relate the learning material to my own experiences*" (Enhancement of Personal Significance). URM indicates underrepresented minority status. FG indicates first-generation status.

Figure 1

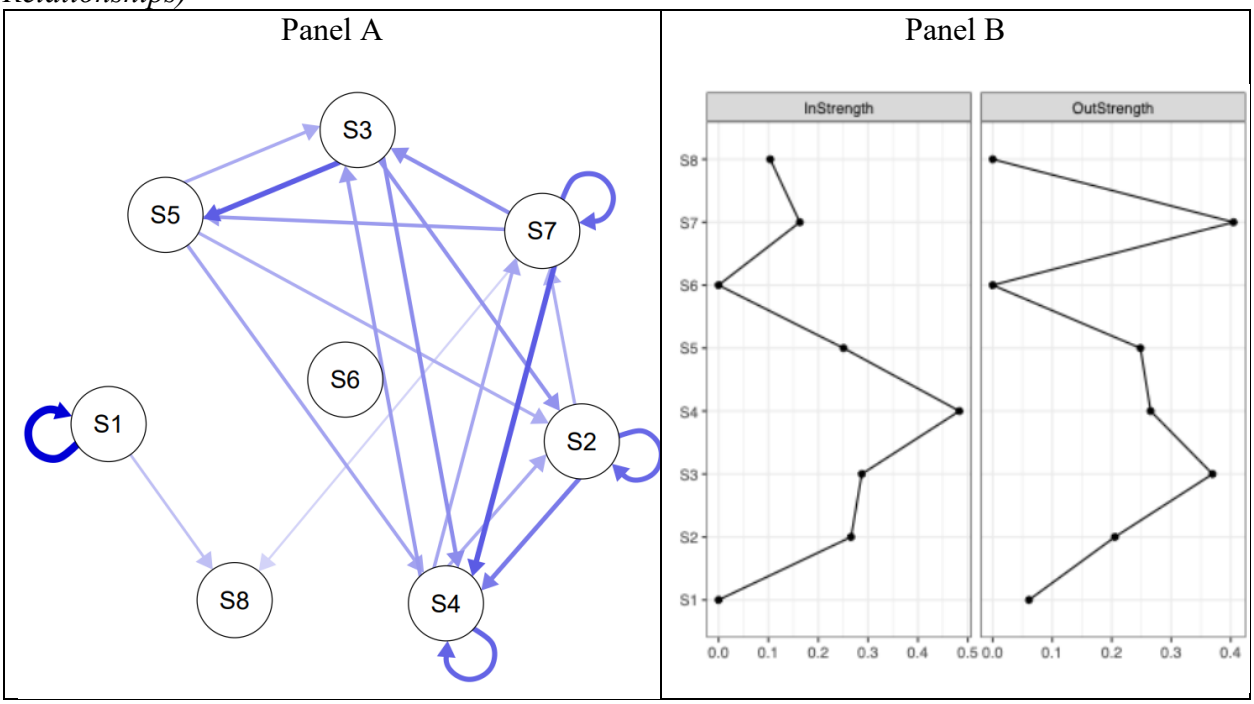
Students' Selection of Motivational Regulation of Strategies Throughout the Semester



Notes. The x-axis represents weeks throughout the semester, with week 14 omitted from the data collection due to the Thanksgiving holiday. S1 indicates "*think of situations where it would be helpful for me to know the material or skills*" (Enhancement of Utility Value); S2 indicates "*think of ways to make the work seem enjoyable to complete*" (Enhancement of Situational Interest); S3 indicates "*tell myself that I should keep working just to learn as much as I can*" (Mastery Self-Talk); S4 indicates "*remind myself about how important it is to get good grades*" (Performance-Approach Self-Talk); S5 indicates "*try to get rid of any distractions that are around me*" (Environmental Structuring); S6 indicates "*promise myself some kind of reward if I get my studying done*" (Self-Consequating); S7 indicates "*break down the workload in small segments so I get the feeling that I can handle it more easily*" (Proximal Goal Setting); and S8 indicates "*try to relate the learning material to my own experiences*" (Enhancement of Personal Significance).

Figure 2

Predictive Relationships Among Motivational Regulation Strategies (Within-Person Lagged Relationships)



Notes. Panel A illustrates the within-person lagged network among eight types of motivational regulation strategies; Panel B shows in-strength and out-strength of each node (strategy use) over time; S1 indicates "*think of situations where it would be helpful for me to know the material or skills*" (Enhancement of Utility Value); S2 indicates "*think of ways to make the work seem enjoyable to complete*" (Enhancement of Situational Interest); S3 indicates "*tell myself that I should keep working just to learn as much as I can*" (Mastery Self-Talk); S4 indicates "*remind myself about how important it is to get good grades*" (Performance-Approach Self-Talk); S5 indicates "*try to get rid of any distractions that are around me*" (Environmental Structuring); S6 indicates "*promise myself some kind of reward if I get my studying done*" (Self-Consequating); S7 indicates "*break down the workload in small segments so I get the feeling that I can handle it more easily*" (Proximal Goal Setting); and S8 indicates "*try to relate the learning material to my own experiences*" (Enhancement of Personal Significance).