Supporting self-regulation in classrooms: The roles of emotion regulation, self-regulated learning and instruction

Kelsey Marie Losenno

Ph.D. in Educational Psychology

Department of Educational and Counselling Psychology

McGill University

Montréal, Québec, Canada

July 2023

A thesis submitted to McGill University in partial fulfillment of the requirements of the degree of Doctor of Philosophy in Educational Psychology

Table of Contents

Abstract

Elementary-aged students' self-regulation is an important developmental process that predicts their learning outcomes across time and learning domains. Self-regulatory skills are known to change because of maturation, and exposure to environmental factors like classroom instruction. The current dissertation employs mixed-methods to assess how targets of self-regulation, including emotion regulation (ER) and self-regulated learning (SRL), operate in tandem during mathematics problem-solving, and across time. Findings from a mediated path analysis demonstrated that ER is an antecedent to SRL, and that early phases of SRL predict later phases. To better understand how elementary-aged students' ER and SRL skills change during the year, teachers self-reported instructional practices were examined in concert with observational records of their classroom instruction during mathematics learning. Findings indicated students' self-regulatory skills change over time, and classroom instruction provided opportunities to foster self-regulation at a global level in classrooms. Implications for future research and educational practice are discussed.

Keywords: emotion regulation, self-regulated learning, mathematics problem-solving, classroom instruction

Résumé

L'autorégulation des élèves d'âge primaire est un processus de développement important qui prédit à la fois leurs résultats et leurs domaines d'apprentissage à travers le temps. Les compétences d'autorégulation sont la maturité et l'exposition à des facteurs environnementaux tels que l'enseignement en classe. La présente thèse utilise des méthodes combinées pour évaluer la façon dont les objectifs de l'autorégulation, y compris la régulation des émotions (RE) et l'apprentissage autorégulé (AAR), qui fonctionnent en tandem pendant la résolution de problèmes de mathématiques, et à travers le temps. Les résultats d'une analyse de cheminement médiatisée ont démontré que la RE est un antécédent de l'AAR et que les premières phases de l'AAR prédisent les phases ultérieures. Afin de mieux comprendre comment les compétences des élèves d'âge primaire en matière d'ER et d'AAR évoluent au cours de l'année, les pratiques pédagogiques utilisées par les enseignants ont été examinées parallèlement aux enregistrements de leur enseignement en classe au cours de l'apprentissage des mathématiques. Les résultats démontrent que les compétences d'autorégulation des élèves évoluent au fil du temps, et que l'enseignement en classe a permis de favoriser l'autorégulation à un niveau global dans les salles de classe. Les implications pour les futures recherches et pratiques éducatives sont ici discutées.

Mots clés: régulation des émotions, apprentissage autorégulé, résolution de problèmes mathématiques, enseignement en classe

Dedication

I dedicate this dissertation to the younger versions of myself. Thank you for having the courage to dream outside the boundaries of what you knew.

Acknowledgements

I would first like to acknowledge my supervisor Dr. Krista Muis for her trust and support throughout my time at McGill. Under your supervision, I have grown academically and personally. In the last seven years, we have both found ways to preserver with patience, courage, and a sheer unwillingness to give up. I have long believed that we share a belief system regarding hard work and a commitment to being and doing our best. Your expertise and strength has been integral to my success and have offered me many lessons that I will carry into my future. From being the most junior to one of the most senior students in your lab, I have had the honor of participating in projects both locally and internationally that have broadened my understanding of the learning sciences, and expanded my views of the world. I cannot thank you enough for these opportunities, and your commitment to my success as an emerging researcher.

There is a great deal of gratitude to be shared with all my professors throughout my academic career but especially with Dr. Susanne Lajoie, Dr. Adam Dubé, Dr. Kristy Robinson and Dr. Alyson Hadwin. Each of these fantastic professors have sat on various committees during doctoral degree, including my comprehensive examination and dissertation defence. Dr. Lajoie has been an exceptional committee member and role model from the start of my Master's degree. You have a keen ability to guide your students' interests towards deeper understanding and the resolution of limitations that exist in our fields of research. Dr. Dubè has provided me with invaluable support in navigating a doctoral degree, and has demonstrated how to integrate ones' academic and personal interests in new and informative ways. Dr. Kristy Robinson has been integral in supporting my success as a doctoral student and researcher, having had countless conversations with me about statistics and providing me with the practice teaching and developing material for statistics students. Finally, Dr. Hadwin has been a shining example of how to support young researchers through her demonstration of genuine interest and her ability to provide critical feedback. Each of you has encouraged me to test my own abilities and believe in the quality of my work. Thank you.

I would like to thank my lab partners who have come and gone throughout the years: Cara Singh, Brendan Munzar, Courtney Denton, Maria Rizk, and Marianne Chevrier. The emotional and social support they have shown me, as well as their assistance with collecting data, have helped me to be successful during my time at McGill. Dr. Katarina Maag Merki and my peers from the University of Zürich, as well as my peers from the University of Vienna, have also had their hand in supporting my development as a researcher and individual. A special thank you to Dr. Lynda Hutchinson who started me introduced me to the field of self-regulation and encouraged me to pursue my academic dreams when very few others did. You have instilled me with your values for designing research, asking important questions, and taking a gentle approach to managing all of life's demands.

Finally, I'd like to thank my family both born and chosen. I can confidently say that without you none of this would have been possible. My success is your success.

Preface and Contributions of Authors

I am the primary author of each manuscript and am responsible for their content. I wrote Chapter 1 independently, the original version of which was prepared in partial fulfilment of my comprehensive exam. Dr. Susanne P. Lajoie and Dr. Kristy Robinson provided feedback as members of the exam evaluation committee. The manuscripts, Chapter 2 and Chapter 3, presented in this dissertation were co-authored with Dr. Muis. Modified versions of these manuscripts will be submitted to a peer-reviewed journal for publication with co-author Dr. Muis. My final discussion, Chapter 4, was written independently and reviewed by Dr. Krista R. Muis and Dr. Susanne P. Lajoie. The contributions made by myself, my co-authors, and my colleagues for each manuscript are summarized below. The conclusions drawn from this dissertation are considered original and present distinct contributions to knowledge.

Chapter 2

Losenno, K. M. & Muis, K. R., (in preparation). Emotion regulation and self-regulated learning during mathematics problem-solving. *Contemporary Educational Psychology*.

Contributions

The research design of this study is based on Losenno, Muis, Munzar & Denton (2020). I was responsible for the conceptualization of the research questions, coding half of the transcriptions, scoring the mathematics problem, conducting the data analysis, and writing the manuscript in its entirety. My colleague Courtney Denton assisted me in establishing inter-rater reliability for the coding of participants’ transcripts and coding the remainder of the transcripts. Additionally, research assistants Brendan Munzar, Cara Singh and Maria Rizk assisted with data collection in classrooms and transcribing participants’ audio recordings. Dr. Muis assisted with establishing inter-rater reliability for scoring participants' mathematics problems and both Dr. Muis and Dr. Lajoie provided expert feedback on full drafts.

Chapter 3

Citation

Losenno, K. M. & Muis, K. R. (in preparation). The development of emotion regulation and self-regulated learning in classrooms: a mixed methods study. *Learning and Instruction.*

Contributions

I was responsible for the research design of this manuscript with guidance from co-author Dr. Krista R. Muis. During the conceptualization of this manuscript, at the time of my comprehensive exams, Dr. Kristy Robison also provided feedback regarding my statistical analysis. I was responsible for the conceptualization of research questions, conducting the data analysis, and writing the manuscript in its entirety. Dr. Muis and Dr. Lajoie provided feedback on full drafts. Dr. Muis, Brendan Munzar and myself assisted with classrooms observations and establishing inter-rater reliability for the observational protocols. Courtney Denton, Cara Singh, and Maria Rizk assisted with data collection in classrooms.

List of Tables

List of Figures

List of Appendices

Chapter 1. Introduction

Self-regulation (SR) is a multi-componential process that describes how one attempts to guide and control their cognitions, emotions, motivations, and behaviors to pursue their goals and adapt to environmental demands (Efklides et al., 2018; Muis et al., 2018; Zimmerman & Schunk, 2011). Theorists agree that there are multiple targets of SR (e.g., emotion regulation, self-regulated learning) that are connected through their reliance on the same underlying processes (e.g., executive functions, metacognition). That is, one may engage in emotion regulation (ER) to modulate their affective experiences or self-regulated learning (SRL) to support their learning processes. Though research indicates that SR is a developmental process that becomes more coordinated over time (Hoyle & Dent, 2018; Usher & Schunk, 2018), and predicts academic outcomes across the life span (e.g., preschool, university; Blair & Razza, 2007; Winne & Hadwin, 1998; Zachariou & Whitebread, 2019), questions remain regarding how distinct targets of SR develop in tandem and support students learning. Specifically, the relationships between middle to upper elementary-aged students' ER and SRL during classroom-based learning and across time remain unclear.

Accumulating research also indicates that contextual variables (e.g., learning domain, instructional practices) influence the types of emotions students experience, their motivation for learning, and the types of self-regulatory strategies students select (Di Leo et al., 2019; Harley et al., 2019; Muis et al., 2016; Perry et al., 2018). Therefore, it is critical to consider how different targets of SR develop and unfold for students within different learning domains and classroom-based settings. However, limited research has examined students' ER and SRL skills during classroom-based mathematics learning, and the role of instructional practices on students' SR skills. Since mathematics is a challenging and emotionally laden learning domain for elementary-aged students (Di Leo et al., 2019), it is critical to understand how these students' SR processes unfold, and how to support their self-regulatory skills in this domain. In consideration of these open questions, the current dissertation addresses three themes related to classroom-based SR that link the following chapters: (1) ER, (2) SRL, and (3) context.

Overview of the Chapters

Chapter 2 reviews literature from the learning sciences, and cognitive, clinical, developmental, and educational psychology and highlights the developmental underpinnings of SR. Findings describe how multiple targets of SR are related through their reliance on the same underlying processes, and interact during learning. Additionally, the role of contextual factors (i.e., learning domain and classroom practices) on the efficacy of self-regulatory strategies and development of SR skills are delineated. The importance of employing multiple measures and methods for studying middle to upper elementary-aged students' SR, specifically in the context of classroom-based mathematics learning, is outlined.

Chapter 3 presents an empirical study that examined how two emotion regulation strategies (cognitive reappraisal, expressive suppression) related to elementary-aged students' engagement in the four phases of SRL: task definition, planning and goal setting, enactment, and monitoring and evaluation. Student's ER strategies were captured via self-report before they participated in a grade appropriate complex mathematics problem-solving activity. A think-aloud protocol was employed to capture students' SRL as it occurred during a complex mathematics problem-solving activity during regular classroom hours. Then, a serial path analysis was conducted to determine if students' engagement in the early phases of SRL (i.e., task definition, planning and goal setting) predicted their engagement in the later phases (i.e., enactment, monitoring and evaluation). Additionally, reappraisal and suppression were assessed as independent predictors of students' engagement in the four phases of SRL and their mathematics problem-solving outcomes. Finally, mediation analyses were included to examine if the phases of SRL mediated the role of ER strategies on students' problem-solving outcomes.

Chapter 4 presents a second empirical study that assesses change in students' ER and SRL from the beginning (i.e., fall) to the end (i.e., spring) of an academic school year. Teachers reported on their students' classroom ER and SRL skills using a tool that assessed metacognitive, motivational, and strategic action processes involved in each target of SR. Additionally, a teacher-report tool was employed to assess the autonomy-supportive or directive nature of teachers' instructional practices. Researchers also conducted observations of teachers' classrooms during mathematics lessons to gain insight into whether different pedagogical practices that are known to support SRL were present. Repeated measures ANOVAs were employed to assess if there were differences between students' ER and SRL skills across the school year. Teachers, specifically their instructional practices, were included as a factor to determine whether there were significant differences in ER and SRL change between students as a function of varying classroom practices. Supplemental qualitative analyses regarding teachers reported and observed pedagogical practices during mathematics lessons were employed to gain deeper insight as to whether instructional practices may relate to changes in students' ER and SRL skills. Finally, a path analysis was conducted to assess the possible interdependent relationships between students' early and later ER and SRL. That is, direct and cross-paths were included to assess if ER skills in the fall predict SRL skills in the spring, and vice-versa.

Chapter 5 culminates with a comprehensive discussion of the conclusions gathered from the empirical research introduced in this dissertation. This includes an analysis of the contributions to the advancement of knowledge and practical applications, the limitations of the research, and offers recommendations for future research.

References

Blair, C., & Razza, R. P. (2007). Relating effortful control, executive function, and false belief understanding to emerging math and literacy ability in kindergarten. *Child Development*, *78*(2), 647-663. https://doi.org/10.1111/j.1467-8624.2007.01019.x

Di Leo, I., Muis, K. R., Singh, C., & Psaradellis, C. (2019). Curiosity Confusion? Frustration! The role and sequencing of emotions during mathematics problem solving. *Contemporary Educational Psychology, 58,* 121–137. https://doi.org/10.1016/j.cedpsych.2019.03.001

Efklides, A., Schwartz, B. L., & Brown, V. (2018). Motivation and affect in self-regulated learning: Does metacognition play a role? In D. H. Schunk & J. A. Greene (Eds.), *Educational psychology handbook series. Handbook of self-regulation of learning and performance* (pp. 64–82). Routledge/Taylor & Francis Group.

Harley, J. M., Pekrun, R., Taxer, J. L., & Gross, J. J. (2019b). Emotion regulation in achievement situations: An integrated model. *Educational Psychologist*, *54*(2), 106–126. https://doi.org/10.1080/00461520.2019.1587297

Hoyle, R. H., & Dent, A. L. (2018). Developmental trajectories of skills and abilities relevant for self-regulation of learning and performance. In D. H. Schunk & J. A. Greene (Eds.), *Educational psychology handbook series. Handbook of self-regulation of learning and performance* (pp. 49–63). Routledge/Taylor & Francis Group.

Muis, K. R., Chevrier, M., & Singh, C. A. (2018). The role of epistemic emotions in personal epistemology and self-regulated learning. *Educational Psychologist*, *53*(3), 165-184. https://doi.org/10.1080/00461520.2017.1421465

Muis, K. R., Psaradellis, C., Chevrier, M., Di Leo, I., & Lajoie, S. P. (2016). Learning by preparing to teach: Fostering self-regulatory processes and achievement during complex mathematics problem solving. *Journal of Educational Psychology*, *108*, 474–492. https://doi.org/10.1037/edu0000071.

Perry, N. E., Mazabel, S., Dantzer, B., & Winne, P. (2018). Supporting self-regulation and self-determination in the context of music education. In G. A. D. Liem & D. M. McInerney (Eds.), *Big theories revisited 2: A volume of research on sociocultural influences on motivation and learning* (pp. 295-318). (2nd ed.). Information Age Press.

Usher, E. L., & Schunk, D. H. (2018). *Social cognitive theoretical perspective of self- regulation*. In D. H. Schunk, & J. A. Greene (Eds.). Educational psychology handbook series. Handbook of self-regulation of learning and performance (pp. 19–35). Routledge/ Taylor & Francis Group. https://doi.org/10.4324/9781315697048-2

Winne, P. H., & Hadwin, A. F. (1998). Studying as self-regulated learning. In D. J. Hacker, J. Dunlosky, & A. C. Graesser (Eds.), *Metacognition in educational theory and practice* (pp. 277–304). Hillsdale: Erlbaum.

Zachariou, A., & Whitebread, D. (2019). Developmental differences in young children's self-regulation. *Journal of Applied Developmental Psychology*, *62*, 282-293. https://doi.org/10.1016/j.appdev.2019.02.002

Zimmerman, B. J., & Schunk, D. H. (2011). Self-regulated learning and performance: An introduction and an overview. In D. H. Schunk & B. J. Zimmerman (Eds.) *Handbook of self-regulation of learning and performance*, (pp. 15-26). Routledge. https://doi.org/10.4324/978020383901

Chapter 2. Literature Review

Introduction

Classrooms are important spaces for children. They are one of the first environments outside of the family system where young children spend significant amounts of time with others learning new skills. Researchers have identified self-regulation as an important process for supporting students' classroom well-being, learning, and achievement from kindergarten to university (Diamond, 2016; Hadwin et al., 2018; Vand der Stel et al., 2010; Zachariou & Whitebread, 2019). Self-regulation (SR) is a multi-dimensional and complex process that describes how basic executive functioning and higher order processes are applied to meet goals and adapt to environmental demands (Hutchinson et al., 2021; Kopp, 1982; Perry et al., 2018; Zimmerman & Schunk 2011). Previous and more recent theorists have identified that SR consists of cognitive, emotional, motivational, behavioral and social components that are distinct in what they target (e.g., emotion, learning), yet rely on the same underlying processes (Bandura, 1982; Ben-Eliyahu, & Linnenbrink-Garcia, 2015; Diamond, 2016; Perry et al., 2018; Usher & Schunk, 2018). These processes include executive functions (e.g., working memory, inhibitory control, cognitive flexibility) and higher order cognitive processes like metacognition, motivation and strategic action (Diamond, 2011; Hutchinson et al., 2021; Miyake & Friedman, 2012). Moreover, theories of SR are situated in social and cultural contexts (Butler, 2021; Hadwin, et al., 2018; Muis et al., 2018; Zimmerman, 2013), such that there are bi-directional relationships between one's SR and the environment they operate within. However, there is a paucity of research that considers how multiple targets of SR operate and develop in tandem in the context of classroom-based learning and achievement (c.f., Di Leo & Muis, 2020; Losenno et al., 2020).

Previous research has suggested that young children were not developmentally capable of engaging in these sophisticated SR processes (Davis et al., 2010; Kuhn, 1999; Perry, 1998;

Veenman & Spaans, 2005). Yet over the last three decades, literature from educational and developmental psychology has indicated that children can and do engage in SR (Bryce et al., 2015; Perry & Calkins, 2018; Raffaelli et al., 2005; Usher & Schunk, 2018; Whitebread et al., 2009; Zachariou & Whitebread, 2019). Specifically, empirical findings in developmental psychology have demonstrated that young students' early self-regulatory abilities, often measured as executive functioning, are related to higher levels of effortful control, positive teacher and peer-relationships, and positive school adjustment (Blair & Diamond, 2008; Blankson et al., 2017; Diamond, 2016; Eisenberg et al., 2004; Rimm-Kaufman et al., 2009). However, this research has predominantly been conducted in laboratories and does not take into consideration the nuance and influences of classroom processes on development, learning, and performance outcomes (Butler, 2021; Perry et al., 2015; Whitebread et al., 2007). Additionally, a bulk of this research has focused on young children (e.g., pre-school, kindergarten; Blair & Razza, 2007; Diamond, 2016; Graziano et al., 2007), and has not examined SR among middle to upper elementary-aged students (c.f., Cleary & Zimmerman, 2004). As such, developmental research on SR would benefit from classroom-based research to gain insight into childrens' SR development at school.

Research on SR in educational psychology, often studied as self-regulation for learning, indicates that students SR abilities are related to increased cognitive and metacognitive engagement during learning (Winne, 2017, 2018), and higher levels of academic achievement (Greene et al., 2021; Muis et al., 2016). These findings indicate that SR is a powerful predictor of later educational outcomes. Interestingly, childrens' abilities to employ SR can vary across distinct targets of regulation (learning, emotions; Hutchinson et al., 2015; Zimmerman & Schunk, 2011), or over time (Vand der Stel et al., 2010; Zachariou & Whitebread., 2019). That is, children may exhibit increased coordination of SR in preschool while others' SR may become more coordinated later in elementary school (Diamond, 2016; Diamond & Lee, 2011). These individual differences in SR are related to diverse learning and achievement outcomes across different learning domains (e.g., literacy, numeracy; Eisenberg et al., 2004; Davis & Levine, 2013; Graziano et al., 2007; Zachariou & Whitebread, 2019). Furthermore, individual differences in children's SR are linked to in-person (e.g., temperament, cognitive development), and environmental factors (e.g., parenting and classroom practices; Dennis et al., 2010; Derryberry & Rothbart, 1997; Feldman, 2015; Hutchinson et al., 2015; Perry, 2013) which can promote or constrain SR. Taken together, research in developmental and educational literatures clearly position SR as an important process for supporting young students' transitions into early schooling (i.e., preschool, kindergarten), and is an important predictor of educational outcomes across learning domains and life stages.

Indeed, some classroom-based research examined how differences in students' development of SR skills are related to differences in teachers' pedagogical approaches (Hamre & Pianta, 2005; Perry et al., 2018; Walker, 2008). For example, the presence of social and emotional supports (e.g., teacher/peer support, non-threatening feedback) in the classroom, and combinations of explicit and implicit teaching towards SR support students' development of SR skills (Hamre & Pianta, 2005; Michalsky, 2021; Perry, 2013). Some accumulating evidence also suggests that the learning domain in which the students and teachers are participating is an important consideration for research on students' SR (Butler, 2021; Frenzel et al., 2024; Pekrun et al., 2017; Perry et al., 2018). During complex mathematics problem-solving, a strategically and procedurally challenging activity (Muis et al., 2015, 2016), students experience a range of emotions (Di Leo et al., 2019), which can promote or hinder their engagement in SR processes

(Goetz et al., 2007; Pekrun et al., 2017). Therefore, students may need to allocate more SR resources (e.g., executive functioning, metacognition, motivation) towards the regulation of their emotion. However, individuals are understood to possess limited capacities for SR processes (Schmeichel & Baumeister, 2004; Winne, 2017). As such, students may benefit from increased directive pedagogical practices (e.g., increased scaffolding, teacher control) to support their SR and learning in particularly challenging and emotionally laden learning situations like complex mathematics problem-solving. Given the value of SR in classrooms, it is important for researchers to identify how multiple distinct targets of SR (e.g., emotion regulation, self-regulated learning) develop in tandem for children at different ages (e.g., middle- to upper-elementary school), in diverse classrooms contexts and learning domains.

Emotions

Emotions, like SR, are multi-componential, unfold across time, and serve important biological, cognitive, motivational, and behavioral functions (Efklides et al., 2018; Frenzel et al., 2024; Pekrun et al., 2002; Scherer, 2000; Scherer & Moors, 2019). Theorists have demonstrated that emotions interact with cognition (e.g., metacognition), motivation, strategy use, and self-regulated learning and ultimately influence learning outcomes by means of these interactions (Efklides et al., 2018; Goetz & Hall, 2020; Obergriesser & Stoeger, 2020; Pekrun et al., 2017). As proposed in control-value theory (Pekrun et al., 2002; Pekrun, 2018), achievement emotions are generally discussed in terms of their valence (positive vs. negative) and intensity (activating vs. deactivating) such that a 4x4 taxonomy exists: positive activating (e.g., enjoyment, hope, pride), positive deactivating (e.g., relaxation, relief), negative activating (e.g., shame, anger, anxiety), and negative deactivating (e.g., boredom, hopelessness). Empirical findings have typically demonstrated that students experience a wide range of emotions during learning (Di

Leo et al., 2019; Pekrun et al., 2002), and that emotional experiences between learning domains (e.g., language, mathematics) are variable (Goetz et al., 2007). Moreover, evidence indicates pleasant emotions (e.g., enjoyment) are positively related to students' selection and application of learning strategies, as well as their learning and achievement outcomes, whereas unpleasant emotions (e.g., boredom, anxiety) are negatively related to these same variables (Ahmed et al., 2013; Goetz et al., 2007; Goetz & Hall, 2013; Pekrun et al., 2017; Pekrun, 2018). Researchers indicate that individuals have an automated tendency to approach stimuli that facilitate positive affective experiences and to avoid stimuli that produce negative affective experiences as a buffer to protect well-being (Koole & Aldao, 2016; Sheppes & Levin, 2013). However, the role of emotions on learning outcomes is not always straight forward.

Theorists posit that positive deactivating emotions like "relaxed" may be detrimental to students' learning processes and outcomes when they are not well-regulated (Pekrun et al., 2017; Goetz & Hall, 2020). That is, when students experience relaxation they may experience decreased attention and motivation in the moment, and ultimately disengage from behaviors that support their academic goal pursuits (e.g., studying). Further, it is possible that positive activating emotions like enjoyment could interfere with learning processes. For example, if a young student becomes overwhelmed with joy - whether it's a result of the academic task, or some external variable like a special event (e.g., school concert, lunch-time play, falling snow!) - they may struggle to engage their executive functions to guide their attention (e.g., focus) and behaviors (e.g., sit calmly/quietly) to meaningfully engage in learning processes. This is in line with previous research which demonstrates that children who experience high levels of positive affect also demonstrate attentional (e.g., attention deficit disorder) and behavioral difficulties (e.g., conduct disorders; Forslund et al., 2016), both of which relate to learning difficulties or poor learning outcomes (Loe & Feldman, 2007). Therefore, in the context of learning, the experience of positive emotion may lead to disruptive behaviors that can be detrimental to students learning processes and outcomes (Cole et al., 2018).

Alternatively, the down-regulation of negative affect may not always be adaptive for learning. That is, negative affect may hold important information for the individual, as negative affect may signal that an appraisal has been made that goal-pursuits are blocked or becoming increasingly difficult to attain (Cole et al., 2018). In turn, the experience of negative affect may facilitate metacognitive, monitoring, and evaluative practices which are inherent processes in SR (Muis, 2007; Winne & Perry, 2000; Zimmerman, 2013). Therefore, negative affect may not be inherently detrimental to students learning and SR processes. Research findings do indicate, however, that individuals assign higher priority to the regulation of negative emotions over positive emotions (Meinhardt & Pekrun, 2003). Interestingly, findings have also revealed differences in the relationships between emotions and learning processes, and academic outcomes for students of different ages. For example, emotions such as confusion – an epistemic emotion that relates to one's beliefs about their knowledge (Muis et al., 2018) – can lead to positive learning outcomes among adult learning populations (e.g., university; D'Mello et al., 2014). In contrast, elementary-aged students' unresolved confusion can be detrimental for learning strategy use and learning outcomes (Muis et al., 2016). As such, it is important for researchers to consider individual characteristics (e.g., age, level of education) when measuring the role of emotions on learning and SR processes.

Indeed, learning can be an emotionally laden experience (Di Leo et al., 2019; Goetz et al., 2007). Research findings indicate that the emotions one experiences during learning and achievement activities may facilitate or hinder their learning processes and outcomes (Ahmed et al., 2013; Muis et al., 2016; Pekrun et al., 2017, Tice et al., 2004). Therefore, students of all ages must be able to regulate their emotions flexibly and effectively (e.g., which emotions they experience and when; Bonanno & Burton, 2013; Gross, 2015; Kashdan & Rottenberg, 2010; Koole, & Aldao, 2016; Sheppes, 2020) during learning to pursue academic goals and standards.

Emotion Regulation (ER)

Emotion regulation (ER) refers to a set of biological, behavioral and social processes that serve to guide (e.g., modulate, maintain, inhibit) an individual's affective experiences (intensity, valence, magnitude) and support the individual to pursue their goals and adapt to changing environmental demands (Dennis et al., 2013; Gross, 2015; Eisenberg & Spinrad, 2004; McRae & Gross, 2020; Perry & Calkins, 2018). ER emerges in infancy in the form of basic self-soothing behaviors like thumb sucking and gaze-aversion within the context of secure parent-child dyads (Bowlby, 1969; Calkin & Dedmon, 2000; Hoyle & Dent, 2018; Kopp, 1989; Perry & Calkins, 2018). Secure dyads are defined by spaces wherein the parent consistently responds to the child’s emotional dysregulation in a manner that facilitates the child’s development of autonomous ER (e.g. coaching, modeling, comforting; Cole et al., 2018; Sameroff, 2010; Sroufe, 1996). As infants developmentally mature into childhood, regions of the brain that support executive functioning (e.g., prefrontal cortex; PFC) typically reach a point of maturation that supports more sophisticated and coordinated application of executive functioning (e.g., effortful control) and higher order cognitive processes like metacognition (Davidson et al., 2006; Davis et a1., 2010; Dennis et al., 2010; Graziano et al., 2007). As such, children become prepared to employ their metacognition, motivation, and strategic action for ER to pursue their learning goals and adapt to academic expectations. Metacognition for ER is represented by students’ abilities to identify and describe their emotions, as well as ascertain which strategies are best for modulating their affective experiences during learning (Davis et al., 2010; Koole & Aldao, 2016). Motivation for ER is demonstrated by students' attempts to modulate or maintain emotional states (e.g., curious, calm, joy) that support their learning goals (Di Leo & Muis, 2020; Hutchinson et a., 2021). Finally, strategic action represents how students apply different ER strategies to pursue their learning goals (Hutchinson, 2013; Perry et al., 2018). Though findings suggest that metacognition, motivation, and strategic action underlie SR and are integral to understanding how distinct targets of SR develop (i.e., ER; Perry et al., 2018), limited research has assessed how these processes develop for elementary-aged students.

In all, literature from both developmental and educational psychology have evidenced that ER is an important aspect of SR that predicts learning outcomes (Cole et al., 2018; Davis & Levine, 2013; Schutz & Davis, 2000; Strain & D'Mello, 2015). For example, findings from developmental psychology have demonstrated that children's ER skills are related to differences in executive functions like attentional control and inhibition (Calkins & Marcovitch, 2010; Hudson & Jacques, 2014), and positive parental (e.g., maternal) interactions (Eisenberg et al., 2004; Graziano et al., 2011). That is, children's early ER skills are predicted by and predict the relational quality and types of interactions (e.g., sensitive, well-aligned) they have with their parental figures (Feldman, 2015). Together, increased executive functioning and positive relationships with important others are positively related to behavioral regulation in kindergarten and developmental outcomes over the first 10 years of life (Graziano et al., 2011; Vernon-Feagans et al., 2016), which are known to support learning outcomes (Blair & Razza, 2007; Howse et al., 2003). Additionally, scholars have posited that students' repertoire of ER strategies become more robust and sophisticated during childhood (Cole et a., 2018). Interestingly, research findings have demonstrated that kindergarteners can identify effective ER strategies on par with university students, but chose to employ ineffective strategies (e.g., venting, rumination), unlike university students who are able to identify and select effective ER strategies (Dennis & Kelemen, 2009). This implies that students' knowledge of strategies does not guarantee adaptive application. Rather, students may require explicit teaching and opportunities to practice strategy use during learning and achievement situations.

In educational psychology, research has demonstrated that children's ER skills support their development and application of other cognitive, motivational, and behavioral processes that are necessary for meaningful classroom-based learning and SR (Di Leo et al., 2019; Gross, 2015; McRae & Gross, 2020; Strain & D'Mello, 2015). Specifically, findings have demonstrated that students with effective ER skills offer more positive feedback regarding their learning challenges, experience more positive affect, are more deeply engaged in learning, and demonstrate better achievement outcomes (Di Leo et al., 2019; Hutchinson, 2013; Richards & Gross, 2000; Strain & D'Mello, 2015). Moreover, students' ER skills are related to their teacher and peer relationships, such that students who display effective ER skills experience these relationships more positively than their less-skilled counterparts (Graziano et al., 2007; Rudasill & Rimm-Kaufman, 2009). These relationships support students' ER development and overall learning outcomes as positive classroom relationships (e.g., teachers, peers), like parental relationships, may lead to meaningful opportunities to engage in ER and learning. Taken together, findings from both literatures suggest that ER holds important implications for students' learning and achievement outcomes. As such, it is an important goal to support childhood development of ER as doing so may support multiple important developmental and learning processes (Calkins & Marcovitch, 2010; Perry & Calkins, 2018). Scholars should continue to explore which ER strategies reflect effective ER for elementary-aged students, and how and in which contexts (e.g., classroom variables) students develop effective and adaptive ER skills for learning.

Process Model of Emotion Regulation

To better support students' ER and learning, a bulk of ER research has focused on identifying which distinct ER strategies support or constrain a host of educational outcomes. Using the Process Model of Emotion Regulation (PMER; Gross & Thompson, 2007), ER strategies have been classified into 5 distinct families based on when these strategies arise during emotional experiences: situation selection, situation modification, attentional deployment, cognitive reappraisal, and expressive suppression. Of these families of ER strategies, a great deal of research has examined how cognitive reappraisals and expressive suppression relate to cognitive, affective, and behavioral processes (see Frenzel et al., 2024; Gross, 2015; McRae & Gross, 2020, Sheppes, 2020). Cognitive reappraisal is an antecedent strategy, that involves systematically altering one's appraisals of their affective experiences and response tendencies, prior the activation of those response tendencies. On the other hand, expressive suppression is a response strategy that involves a conscious effort to inhibit the response-tendencies elicited by emotions, once that have already been activated (Gross & Thompson, 2007). Empirical findings have indicated that students who employ reappraisal, compared to suppression, experience more positive affect, better memory recall, increased engagement in learning, and better inter-personal functioning (Gross & John, 2003; Richards & Gross, 2000; Strain & D'Mello, 2015). Taken together, these findings suggest that reappraisal, compared to suppression, is an effective ER strategy to employ as it does not overly tax the cognitive resources required to engage in learning processes (e.g., self-regulated learning, procedural processes). However, the PMER is decontextualized from learning settings as it does not consider the role of classroom-based learning processes, including different pedagogical approaches, features of task, and learning domains (Harley et al., 2019).

Recall that students who demonstrate patterns of effective ER skills tend to display increased executive functioning skills (Blair & Razza, 2007; Calkins & Marcovitch, 2010), better inter-personal functioning (Eisenberg et al., 2004; Feldman, 2015; Graziano et al., 2011), and learning outcomes (Di Leo et al., 2019; Graziano et al., 2007; Howse, et al., 2003). Without considering the context in which learning and achievement occur, the unilateral classification of the effectiveness of ER strategies can be detrimental to scholars' understanding of ER for learning (Frenzel et al., 20204; Harley et al., 2019). To date, there is accumulating evidence that suppression, traditionally characterized as ineffective due to its relationships to increased cognitive demands, may be effective for supporting learning processes (Frenzel et al., 2024). For example, findings have demonstrated that preschoolers use of suppression supports their regulation of emotional displays and does not decrease verbal memory (Gunzenhauser & Suchodoletz, 2014). Additionally, among older students (e.g., university) suppression can be effective for reducing exam-anxiety (Rottweiler et al., 2018) and increases students' experience of positive emotions in disliked courses (Schutz & Davis, 2000). These empirical findings align with theorists' suggestions that context, such as learning activities (e.g., activity/task type, learning domain), can influence how effective an ER strategy may be for supporting a learner in reaching their goal-state (Koole & Aldao, 2016). Moreover, research has demonstrated reappraisal is not employed as often as students believed (Suri et al., 2015), and that reappraisal is best suited for the regulation of moderate- to low-intensity emotions (McRae & Gross, 2020; Shafir et al., 2015). For example, Sheppes and Levin (2013) examined the role of emotional intensity in relation to the selection of reappraisal and suppression (i.e., disengagement) strategies. Compared to low intensity, the experience of high emotional intensity leads to favoring disengagement strategies as opposed to reappraisal. This difference is likely to arise because blocking emotional intensity can help modulate emotional experiences and is cognitively simpler than generating reappraisals, which requires one to attend to and process their affective experiences before being able to reframe or modulate their affect (Shafir et al., 2015; Sheppes & Meiran, 2007). Therefore, suppression may prove to have advantages over reappraisal during emotionally laden learning activities, high-stakes learning/achievement activities, and for courses that students dislike.

Though research has traditionally focused on identifying adaptive and maladaptive ER strategies (Gross & John, 2003; Richards & Gross, 2000; Strain & D'Mello, 2015), scholars suggest that the impact of any one ER strategy on psychological health is limited (Aldao & Nolen-Hoeksema, 2012). Rather, adaptive ER is more closely related to one's ability to flexibly apply and switch between ER strategies (Aldao et al., 2015; Bonanno & Burton, 2013; Kashdan & Rottenberg, 2010). This is in line with previous research that has demonstrated that the availability of cognitive resources (i.e., working memory) can influence one's ability to successfully employ reappraisal strategies (Schmeichel et al., 2008), and that the timing of strategy use relates to differences in emotional experiences (Gross, 2015; Kalokerinos et al., 2017). This reinforces the possibility that under the right conditions, suppression may be an effective ER strategy such that it leads to positive learning and achievement. To date, little research has assessed both reappraisal and suppression in relation to students' learning processes and outcomes during particularly emotionally laden learning activities. Moreover, literature has not clearly delineated how middle to upper elementary-aged students' ER skills are fostered during classroom-based learning. Given the relationship between students' ER and various educational outcomes (e.g., learning processes, achievement, inter-personal relationships), it is important to investigate what constitutes effective ER, and gain insight into how ER unfolds during learning in relation to other targets of SR like self-regulated learning.

Self-Regulated Learning

Self-regulated learning (SRL) is the study of how self-regulation develops to supports learning in both formal and informal learning settings. Research on SRL considers how one applies basic executive functions and higher order processes like metacognition, motivation, and strategic action to pursue learning goals and adapt to environmental demands (Perry et al., 2018; Schunk & Greene, 2017; Zimmerman, 2013). Metacognition is demonstrated by students' ability to identify their learning strengths and weaknesses, as well as the efficacy of strategies in different learning situations (Winne, 2018). Motivation for SRL is reflected in students' willingness to persist in the face of challenging tasks, and adoption of incremental beliefs about learning which reflect growth mindsets (Dweck, 2006). Finally, strategic action is represented by students' application of strategies during learning scenarios to pursue academic goals (Perry et al., 2018). Researchers have indicated that SRL, like all forms of SR, is a developmental process that can be learned overtime (Hoyle & Dent, 2018). As is the case with ER, important others (e.g., teachers, parents, friends) play important roles in the one's development of effortful SRL skills as they are learned through modeling, scaffolding, and practice (McCabe et al., 2004; Stefanou et al., 2004; Wentzel, 2002; Zimmerman, 2013). This highlights the socio-cognitive or socio-cultural perspectives of SRL that many theorists adopt (Hadwin, et al., 2018; Usher & Schunk, 2018; Zimmerman, 2000). From this perspective, one's executive functions and higher order cognitions (e.g., metacognition, motivation) are understood as operating within and as well as being influenced by the social or cultural context (e.g., classroom, society) in which the individual is functioning (Ben-Eliyahu & Bernacki, 2015; Butler, 2021, Zimmerman, 2013). Therefore, students' SRL skills influence the ways in which one interacts with their learning environments (e.g., learning activities and outcomes, quality of relationships that one forms with their teachers and peers); and in the same breath, one's learning environments also influence opportunities (e.g., frequency, quality) for SRL (Feldman, 2015; Rimm-Kaufman et al., 2009; Rudasil & Rimm-Kaufman, 2009; Perry et al., 2021).

Given the developmentally complex and multi-faceted nature of SRL, theorists previously suggested that young children (e.g., preschool, elementary-age) were not developmentally capable of participating in effortful SRL processes (Dweck, 2002; Kuhn, 1999; Perry, 1998; Turner, 1995, Veenman & Spaans, 2005). However, empirical research findings have accumulated which demonstrate that preschool and elementary-aged children can and do engage in metacognitive processes, demonstrate motivation for learning, and behave strategically to attempt to regulate their learning (Bryce et al., 2015; Grau & Whitebread, 2012; Hutchinson et al., 2021; Muis et al., 2016; Zachariou & Whitebread, 2019). Moreover, researchers have indicated that young learners demonstrate differences in cognitive, affective, motivational, and behavioral processes which can influence their development and engagement in adaptive forms of SRL (Diamond, 2016; Dweck, 2002; Hutchinson et al., 2021; McCabe et al., 2004; Perry, 2013). For example, findings revealed that attending a program that supports executive functioning supports later SRL skills (Blair & Diamond, 2008; Diamond, 2012, 2016), and that young students (i.e., 5 and 7-year-olds) with adaptive executive functioning upon school entry display better metacognitive skills and educational outcomes (Bryce et al., 2015). These findings suggest that adaptive patterns of SRL are characterized by developmentally appropriate executive functioning and metacognitive skills, as students who display these patterns are better prepared to engage in SRL, and adapt to academic expectations. Additionally, research with kindergarten-aged students whose teachers report that they engage in adaptive forms of SRL also demonstrate adaptive forms of motivation as they tend to adopt learning goals that demonstrate a preference for challenging learning activities and hold positive beliefs about their abilities (Compagnoni & Losenno, 2020). Moreover, students who engage in adaptive forms of SRL have been shown to be deliberate and proactive (Greene, 2017), engage in deeper levels of learning (e.g., cognition, metacognition; Winne, 2017), employ effective learning strategies, and experience better learning outcomes (Muis et al., 2015, 2016).

On the other hand, ineffective patterns of SRL are characterized by approaches to learning wherein students report low or misaligned levels of self-concept, hold beliefs that learning is a fixed trait that does not develop, display preferences for easier academic tasks, and students disengage from deep learning, and use shallow learning strategies (Compagnoni & Losenno, 2020; Dweck, 2002; Thomas & Gadbois, 2007; Winne, 2018). Students who display ineffective SRL also demonstrate poor executive functioning, decreased cognitive and metacognitive abilities, and have difficulties recognizing when one needs help and requesting help while learning (Bryce et al., 2015; Dunn et al., 2014; Graziano et al., 2007; Perry, 2013), which may lead to difficulties meeting academic expectations. Together, these findings indicate that SRL is an important predictor of students' educational success, and that it is an important goal to support students' development of adaptive SRL skills in classrooms (Butler, 2021; Butler & Schnellert, 2015; McClelland & Cameron, 2011; Perry et al., 2018). Interestingly, students whose SRL skills reflect maladaptive practices tend to engage in negative thinking (e.g., self-blame), and may experience more negative emotion (e.g., frustration, anxiety, sadness; Linnenbrink, 2005; Ryan et al., 2007; Thomas & Gadbois, 2007), which are known to disrupt learning processes, influence learning strategy selection, and lead to poor learning outcomes (Muis et al., 2015; Pekrun et al., 2002; Pekrun et al., 2017). These findings suggest that there is an important link between students' SRL and ER such that students' abilities to engage in SRL may result in less negative emotion (Tice et a., 2004), and therefore the requirement to regulate those emotions. As a target of SR, SRL is recognized as a finite process in that the cognitive, affective, motivational, and behavioral resources one draws upon to engage in SRL can be depleted (Winne, 2018). Therefore, reducing one's need to regulate emotions should free up the resources needed to engage in effective SRL and support learning outcomes. Despite the empirical advances which demonstrate that children do engage in SRL and the processes underlying SRL (Bryce et al., 2015; Muis et al., 2016; Zachariou & Whitebread, 2019), it remains a relatively understudied subject among elementary-aged children. Moreover, theoretical contributions on SRL outnumber empirical research regarding how children engage in SRL during learning, how SRL develops in classrooms, and how SRL interacts with other important targets of SR like ER.

Process Models of Self-Regulated Learning

Processes models of SRL (Muis, 2007; Winne & Hadwin, 1998) also adopt socio-cognitive perspectives and describe three or four broad phases of regulation which students engage in during learning including task definition, planning and goal setting, enactment, and monitoring and evaluation; and five core aspects for regulation such as cognition, motivation, affect, behavior, and context. During the first phase of regulation, learners build conceptualizations of the task at hand which can be influenced by their cognition (e.g., prior knowledge), motivation (e.g., motivational goals, self-efficacy), affect (e.g., achievement emotions), behavior (e.g., effort) and context (e.g., instructional cues; Butler & Cartier, 2004;

Muis & Franco, 2009). The products that are generated during task definition can feed into and influence the second phase of SRL, planning and goal setting. That is, the ways in which the individual conceptualizes the task and the components of regulation that are activated (e.g., prior knowledge, achievement emotions, instructional cues) can influence the types of goals they set, and the types of plans they prepare to pursue their goals (Muis, 2007). Enactment begins when the learner undertakes the activity at hand by applying the strategies they have selected from their repertoire of learning strategies (e.g., hypothesizing, calculating; Richter & Schmidt, 2010). During each of the phases, learners generate evaluations of the success or failure of their strategy use and task outcomes. As such, the products from each phase of SRL feed into each other and provide feedback that learners can employ to adjust their SRL strategies to pursue their goals and adapt to environmental demands. During the final phase, monitoring and enactment, learners react and reflect about their successes or failures in previous phases, about the products generated for the task, and/or about themselves in context. The feedback that is generated during this phase can be used to evaluate if products meet standards; and should they not, the feedback produced during monitoring will serve adaptive functions for adjusting the relevant processes in previous phases (Muis et al., 2018). This highlights the critical role of metacognition not only during monitoring and evaluation, but in all phases of SRL such that monitoring, and adjustment processes are ongoing during learning (Winne, 2018). That is, products of each phase feed into one another, directly or indirectly, in the same or subsequent learning cycles and reflect the cyclical nature of SRL (Muis, 2007; Winne & Hadwin, 1998).

Theoretically, these phases of SRL are cyclical, wherein one typically moves through each phase in a loosely linear manner (Muis et al., 2018; Winne & Hadwin, 1998; Zimmerman, 2013). However, a bulk of research has statistically modeled the phases of SRL as operating in parallel and little work has statistically modeled the phases of SRL as unfolding in a linear fashion (Greene & Azevedo, 2009; Muis et al., 2015). Some previous research findings have demonstrated that within the context of mathematics problem-solving, elementary-aged students switch between the first two-phases of SRL (i.e., task definition, planning and goal setting) before they engage in the final two phases (i.e., enactment, monitoring and evaluation; Muis et al., 2016). Moreover, the generation of products and the evaluation processes that take place during enactment co-occur and predict mathematics problem-solving outcomes (Losenno et al., 2020; Muis et al., 2016, Muis et al., 2015a). Additionally, research has demonstrated that cognitive reappraisal is an important predictor of engagement (Strain & D'Mello, 2015), as well as each of the four phases of SRL (Losenno et al., 2020). Though some research considers how multiple targets of SR interact during elementary-aged students learning (Di Leo et al., 2019; Losenno et al., 2020), there is little research that considers how multiple targets of SR develop together during the school year. Evidently, SRL is an important predictor of students' learning and achievement outcomes (McClelland & Cameron, 2011; Losenno et al., 2020; Muis et al., 2015) and shares relationships with ER via metacognitive, motivational, affective, behavioral, and contextual processes (Efklides et a., 2018; Hutchinson et al., 2021; Muis et al., 2018; Perry et al., 2018; Usher & Schunk, 2018). Yet, there is limited research that examines how these two targets of SR interact during learning and develop in classrooms. Moreover, given the theoretical and empirical findings that SRL unfolds in a loosely linear manner, and that early phases of SRL predict later phases (Losenno et al., 2020; Muis et al., 2018; Strain & D'Mello, 2015), it is important to consider how SRL unfolds and during classroom-based learning and achievement activities. Continued research which assesses the potential interdependent relationships between

ER and SRL during learning and across time is critical for the design of pedagogical practices and interventions that support SR at a global level in schools.

Contemporary Perspectives of Self-Regulation (ER and SRL)

It is well noted in literature on SR that early and recent theorists posit that there are important relationships between students' cognition, emotion, motivation, and behavior (Efklides et al., 2018; Muis et al., 2018; Perry & Calkins, 2018; Perry et al., 2018; Usher & Schunk, 2018). Recall that ER refers to ones' ability to influence which emotions they experience and when (Gross, 2015), whereas SRL refers to the ways in which one intentionally guides their executive functioning and higher order cognitive processes to pursue their learning goals (Perry et al., 2018). Understanding how ER and SRL are related to each other during learning, as well as developmentally over time holds important theoretical insights about the antecedents of effective ER and SRL (Ben-Eliyahu & Linnenbrink-Garcia, 2013; Frenzel et al., 2024; Hoyle & Dent, 2018; Perry et al., 2018). Though ER and SRL are theoretically linked by their reliance on the same underlying SR processes (e.g., executive functioning, metacognition, motivation), empirical findings demonstrate that ER and SRL are conceptually distinct targets of SR which independently contribute to students' educational outcomes in classrooms (Hutchinson et al., 2021; Losenno et al., 2020). However, these distinct facets of SR are considered interdependent (Ben-Eliyahu, & Linnenbrink-Garcia, 2015; Usher & Schunk, 2018; Perry et al., 2018), such that they may interact with one another so that the development or effectiveness of one facet (e.g., ER) may influence the development or effectiveness of another facet (e.g., SRL; Blair et al., 2010; Calkins & Fox, 2002; Hoyle & Dent, 2018; Howse et al., 2003). Therefore, it is possible that a reciprocal relationship exists between ER and SRL (Usher & Schunk, 2018; Perry et al., 2018), and that students may display different levels of abilities across different facets of SR

(Hutchinson et al., 2015). As such, it is important to statistically test the possible reciprocal relationships between students' ER and SRL skills.

Developmental literature on SR demonstrates that the underlying SR processes (e.g., executive functioning, metacognition) develop due to physiological maturation (Cole et al., 2018; Diamond, 2016; Kopp, 1989; Perry & Calkins, 2018; Raffaelli et al., 2005). That is, both ER and SRL skills should naturally develop overtime because of increasing coordination between regions of the brain (i.e., PFC) that support the processes involved in SR (e.g., executive functions, metacognition; Davidson et al., 2006; Davis et a1., 2010; Dennis et al., 2010; Perry & Calkins, 2018). Recall, that differences in the development of these processes relate to individual differences in students' SR abilities (Diamond, 2016; Diamond & Lee, 2011). Of the limited research that considers students ER and SRL in tandem (Di Leo & Muis, 2020; Losenno et al., 2020), rarely have these distinct targets of SR been measured at the level of their shared underlying processes (e.g., metacognition, motivation, strategic action; c.f., Hutchinson et al., 2021). Rather, researchers have employed measures of elementary-aged students' ER strategy use (e.g., reappraisal, suppression), and their engagement in the different phases of SRL by way of self-reports and cognitive think/emote alouds (Di Leo et al., 2019; Muis et al., 2016). Moreover, a great deal of research has captured young students' SR skills during single learning activities, in laboratory settings, or within the context of interventions (Blair & Razza, 2007; Bryce et al., 2015; Di Leo & Muis, 2020; Hutchinson et al., 2021; Karabenic et al., 2012; Losenno et al., 2020; Muis et al., 2015) and less is known about how ER and SRL develop together among elementary-aged students over the course of a school year. Researchers have called for studies that employ multiple measures of students' SR (e.g., self-report, teacher reports, cognitive protocols), assess appropriate time-scales (e.g., multiple learning cycles, across time), and consider the context in which SR is taking place (Azevedo et al., 2013; Ben-Eliyahu & Bernacki, 2015; Cole et al., 2018; McCardle & Hadwin, 2015; Whitebread et al., 2009). Therefore, it is an important methodological step for researchers to employ measures of ER and SRL that consider the shared underlying processes between ER and SRL overtime in classrooms.

There is some evidence which suggests that there are unidirectional relationships between ER and SRL, as students' ER skills have been recognized as an important antecedent to their engagement in effective SRL (Davis & Levine, 2013; Frenzel et al., 2024; Strain & D'Mello, 2015). That is, students with adaptive ER skills may be able to engage in SRL more effectively as their cognitive, affective, motivational, and behavioral resources are not depleted by their efforts to regulate emotions (Tice et al., 2004). For example, findings have illustrated that young children who engage in ER while learning (e.g. overcoming negative affect when receiving feedback indicating they need to revise their work) are more likely to be successful in their attempts at SRL in school (e.g. Perry & VandeKamp, 2000). Additionally, findings suggest that elementary-aged students' use of cognitive reappraisal is an important antecedent to their engagement in all four phases of SRL, and ultimately their mathematics problem-solving outcomes (Losenno et al., 2020). Moreover, there is accumulating evidence that students' use of expressive suppression can support motivation and decrease negative emotional experiences for disliked courses (Rottweiler et al., 2018; Schutz & Davis, 2000). However, this research has taken place with older students (e.g., university), and limited research has considered how suppression may support elementary-aged students' engagement in SRL during learning.

It should be noted that empirical findings have demonstrated that SRL may also be an important antecedent to ER (Strain & D'Mello, 2015). That is, students who demonstrate adaptive patterns of SRL tend to employ effective learning strategies which support the pursuit of their learning goals and their ability to meet academic expectations (Hutchinson et al., 2021; Muis et al., 2015, 2016). Ultimately, students who display positive patterns of SRL may experience less negative affect and therefore would not need to engage in ER. As a result, the cognitive resources required to engage in ER would be free to use for SRL processes and support learning outcomes (Tice et al., 2004). Together, these findings reinforce the necessity for researchers to match their theoretical contributions regarding the shared relationships between ER and SRL during learning activities and across time with empirical research that examines the possible reciprocal relationships between ER and SRL.

Contextual Considerations

Previous research has demonstrated that SR is a developmental process that continues to evolve as one matures (Hoyle & Dent, 2018; Kopp, 1982; Vand der Stel et al., 2010; Zachariou & Whitebread, 2019), and is an acquired skill that is teachable and can be supported (Butler & Schnellert, 2015; Perry et al., 2020). However, the question remains whether contextual factors support students' SR skills (i.e., ER, SRL) over time. Recall that theories of SR are rooted in social/cultural contexts (Hadwin, et al., 2018; Usher & Schunk, 2018; Zimmerman, 2000). From literature in developmental psychology, the opportunity to witness developmentally appropriate and effective SR skills from a critical reference point/ model (e.g., parent) provides different opportunities for children to practice and eventually integrate SR skills (Cole et al., 2018; Leerkes et al., 2015). These relationships are a hallmark of co-regulation, a target of SR wherein a more knowledgeable or capable other (e.g., parent, teacher) models, supports, and facilitates another's (e.g., child, student) self-regulatory processes (Cole et al., 2018; Eisenberg et al., 1998; Hadwin et al., 2018). That is, when young children are met with sensitive caregiving, they tend to form secure relationships (Bowlby, 1982), develop a strong sense of their abilities to cope with affect, are not cognitively preoccupied with negative affect (Mikulincer et al., 2003), and demonstrate better physiological regulation of affect (Calkins & Dedmon, 2000), even in infancy. Alternatively, when they are met with insensitive or punitive interactions (i.e., poor maternal relationships), young children develop a sense that they are not able to manage their affect effectively (Blair et al., 2010) and demonstrate poor physiological regulation of affect (Calkins et al., 2008). This suggests that differences in caregiving and forms of support during the early childhood year relate to differences in early SR abilities. However, this work has heavily focused on children's ER, and is often rooted in early biological processes (e.g., heart-rate recovery) or rudimentary actions (e.g., thumb sucking, gaze aversion; Calkins & Dedmon, 2000; Kopp, 1989), and provides limited empirical research that considers how ER and SRL develop in classroom contexts for middle to upper elementary-aged students.

Findings from research in educational literatures on SRL in classrooms have begun to amass and suggest that different pedagogical practices can facilitate or hinder students' development of classroom-based SRL skills. For example, a recent special issue in *Metacognition and Learning* (2021) amalgamated theoretical contributions and empirical research regarding teacher practices that support students' metacognition and SRL development. General conclusions from this special issue suggest that explicit and implicit teaching for SR (Michalsky, 2021), and teacher-directed and child-centered instruction (van Loon et al., 2021) are critical to students SRL development. Previously, approaches to instruction were often dichotomized (e.g., child centered or teacher centered), when what is necessary to support students' SRL is a combination of instructional approaches (Butler, 2021). Moreover, findings have indicated that instructional support through appropriate scaffolding affords students important opportunities to practice SRL and foster their adaptive expertise (Butler, 2021;

Palincsar & Brown, 1984; Perry, 2013). Interestingly, instrumental support from teachers and peers, and appropriate scaffolding are also known to support students' ER skills (Cole et al., 2018; Hamre & Pianta, 2001, 2005). These findings, taken in consideration with the knowledge that all targets of SR operate in response to environmental demands (Usher & Schunk, 2018; Zimmerman, 2013) suggest that not only should researchers consider how features of classroom instruction and learning tasks may support or hinder students' SRL, but also their ER. This is a critical next step in classroom-based SR research as to date, there is a paucity of empirical research that has explored how pedagogical practices such as features of instruction and learning tasks may promote or curtail young students' ER in classrooms.

Ultimately, research demonstrates that exposure to different learning environments may relate to differences in one's SR abilities. However, research also indicates that different learning domains relate to different emotional experiences for students (Goetz et al., 2007) which may thereby influence their ER, SRL, and learning and achievement outcomes (Di Leo et al., 2019; Muis et al., 2015; Pekrun et al., 2017). For example, findings demonstrate that students employ different types of strategies to regulate aspects of their learning when they are completing courses that they do not enjoy (Rottweiler et al., 2018). Moreover, designing research that is situated in naturalistic learning settings supported Whitebread and colleagues (2007) in demonstrating that young children could engage in SR processes previously believed to be inaccessible to them (e.g., metacognition). Therefore, it is important to consider not only whether differences in classroom practices relate to differences in students' SR but how different learning domains may influence opportunities for students to engage in and develop ER and SRL skills.

Pedagogical Approaches

Given that important others and context are significant to the study of students SR (Hoyle & Dent, 2018; Perry et al., 2018; Usher & Schunk, 2018), researchers have turned their focus to understanding the classroom practices including pedagogical approaches to the design and implementation of instruction and tasks that may facilitate or hinder students' development of SR (Butler, 2021; Michalsky, 2021; Perry, 2013; Perry et al., 2020a; Perry & VandeKamp, 2000). Over the last 30 years, Nancy Perry and colleagues have conducted a program of classroom-based SRL research to determine the ways in which classrooms facilitate or hinder students' SRL through different pedagogical practices that emphasize students' SRL (Perry, 1998, 2013; Perry & VandeKamp, 2000; Perry et al., 2018b, Perry et al., 2020b). In a recent study, Perry and colleagues (2020a) adapted and put forth a set of categories that describe individual features of instruction that emphasize self-determination and support students' SRL (Deci & Ryan, 1985; Reeve et al., 2018; Perry, 2013). Theory and research on motivation (Jang et al., 2010; Reeve, 2006; Stefanou et al., 2004), and SRL (Hadwin et al., 2018; Hutchinson, 2013; Perry, 1998, 2013) were considered in the development of these categories which include: (1) SRL supportive structures, (2) scaffolding/co-regulation, (3) community, and (4) student influence/autonomy (Perry et al., 2020a). Each category consists of different features of instruction such as complex tasks, choice, teacher and peer support, non-threatening evaluation that reflect specific pedagogical practices that teachers implement in their classrooms that emphasize opportunities for students to engage in SR (Perry et al., 2018). It should be noted that these categories are not mutually exclusive. Rather, features of instruction in each category overlap other categories such that they support one another (e.g., community is related to scaffolding/co-regulation practices; Hutchinson, 2013; Perry et al., 2020a). In the following sections structures that support SRL are discussed as complex tasks that extend over multiple learning periods, embed assessment, and provide opportunities for students to engage in self-evaluation. Scaffolding and co-regulation are discussed as instrumental support from teachers and peers in the classroom, and include discussion on non-threatening feedback and integrate findings on the role of community during classroom-based learning. Student influence and autonomy is discussed as autonomy-supportive practices including opportunities for students to make meaningful choices and to exert control over their learning.

Complex tasks. An important consideration for researchers of classroom-based SR are the learning tasks that are used during instruction, given that tasks interact with students' affect, motivation, and cognition (Blumenfeld et al., 1987; Doyle, 1983). Specifically, findings have demonstrated that complex tasks are related to learners' motivation, SRL and academic achievement (Hutchinson, 2013). Complex tasks are learning tasks that address multiple learning goals (e.g., hypothesizing, collaboration) and integrate multiple learning domains (e.g., language and mathematics; Perry et al., 2006). Additionally, complex tasks require students to engage in various learning processes (e.g., reading, writing, problem-solving, Lodewyk et al., 2009), and allow the learner to produce several products that evidence their learning (e.g., final answers as well as work leading up to those answers). Lastly, tasks which are considered complex tend to extend over time (e.g., multiple learning units or work periods) and are not restricted to single learning-cycles (Perry et al., 2006). For example, Lodewyk et al. (2009) assessed how the assignment of well or ill-structured tasks in grade 10 science influenced students' SR. Students who completed well-structured tasks (e.g., worksheets), which typically have linear and hierarchical procedural routines, employed fewer learning strategies compared to their counterparts. On the other hand, ill-structured tasks tend to align with definitions of complex tasks as they are characterized as being ambiguous, have goals embedded into the assignment, and require learners to synthesize information and apply knowledge. Students who completed these ill-structured science tasks demonstrated increases in critical thinking, effort regulation, and peer learning. These findings suggest that educational tasks, especially complex tasks, may provide unique opportunities for students to engage in important learning processes like critical thinking, learning strategies and SRL.

However, student characteristics (e.g., age, grade), and their abilities must be taken into consideration when designing and implementing complex tasks. Complex tasks are not meant to be overly difficult; rather, they should be designed to be optimally challenging for a student (Perry et al., 2004). A task that is too complex can become confusing and constrain students' motivation and understanding (Lodewyk & Winne, 2005) and when left unresolved this confusion can lead to ineffective SRL and poor achievement outcomes (Di Leo et al., 2019). Complex tasks are optimal when they challenge student's abilities within their zone of proximal development (ZPD; the difference between a child's actual developmental level as evidenced in their independent work and their potential developmental level as evidenced by their problem-solving abilities with support from a more capable other; Vygotsky, 1978). Therefore, instrumental support from teachers (e.g., sensitive feedback, scaffolding) is integral to designing and implementing complex tasks that operate within the ZPD, and ultimately the success of those complex tasks in fostering students' SR (Stefanou et al., 2005; Reeve, 2006). Though, it is possible that in learning domains that are particularly challenging, students may require more teacher scaffolding (e.g., unsolicited procedural and evaluative feedback). As a bulk of the research regarding whether complex tasks foster learning and SR processes has been conducted with middle to upper-elementary-aged students during literacy learning, there is a gap in scholars' insight pertaining to whether complex tasks support students SR at this age in learning domains like mathematics problem-solving.

Well-designed complex tasks offer opportunities for self-evaluation and are be embedded with opportunities for self-assessment, both of which have been linked to children's SR processes (i.e., metacognition) in classrooms as students must reflect on their processes and outcomes on tasks (Hillyer & Ley, 1996; Perry, 2013; Perry et al., 2006). Engaging in self-evaluations supports the processes that underlie SR as they promote a shift in responsibility for students to monitor their own learning (Stipek, 1981). When implemented appropriately, self-evaluation practices support students in framing mistakes as learning opportunities, where the learning process is emphasized and progress is celebrated (Perry, 1998). Practical examples of self-evaluations include the use of checklists and rubrics that support the learner in gauging whether they have met the goals of the task (a metacognitive process of monitoring, evaluation), or journaling activities that require students to answer metacognitive questions (e.g., what are your learning strengths and weaknesses in spelling; Lodewyk et al., 2009; Perry et al., 2006; Schunk & Zimmerman, 2007). As a result, the opportunity for self-evaluations may promote the student to develop an internal locus of control and a sense of autonomy (Deci & Ryan, 1985), which is important for self-regulatory (e.g., motivation) and learning processes (Corno, 2001). For example, Perry and Vandekamp (2000) investigated how children respond to teacher provided feedback and self-evaluate the products of their writing tasks (i.e., story telling). Although some children reported experiencing negative affect, these emotions did not endure, nor did they have a lasting impact on their learning. Rather, findings indicated that children dealt with negative affect by integrating feedback and self-evaluation into their stories, which they positively evaluated thereafter.

Together, these findings highlight that pedagogical practices that support SR are not mutually exclusive. Instead, complex tasks, which require teacher support, embed assessment, and provide opportunities for self-evaluations support the development of multiple SR processes (e.g., cognition, metacognition, motivation). However, a bulk of extant research has examined whether complex tasks support students SRL, and as a result little is known about whether complex tasks supports students' ER. While theoretically, the notion that these pedagogical practices may also influence ER development is reasonable, additional empirical research is needed to assess how complex tasks, embedded assessment, and self-evaluation support or hinder ER development in classrooms. Moreover, since learning domains like mathematics tend to rely on highly structured tasks (e.g., work sheets that require hierarchical procedures), research regarding the nature of complex tasks, embedded assessment, and self-evaluation for students' SR and academic outcomes is needed across learning domains.

Instrumental support. Indeed, scholars have indicated that teachers play important roles in facilitating their students' development of SR processes (e.g., metacognition, motivation, strategic action) and learning outcomes (Feldman, 2015; Rimm-Kaufmann et a., 2009; Walker, 2008; Wentzel, 2002, 2004). That is, teachers serve important functions as a more knowledgeable other, and an informative point of reference such that they meet students' needs, support them within their ZPD, and promote their abilities during individual learning activities (Kopp, 1982; Perry et al., 2018; Vygotsky, 1978; Wentzel, 2002). Therefore, the ways in which teachers support their students are relevant to classroom-based SR research (Reeve, 2006; Stefanou et al., 2004). For example, empirical findings have indicated that student's relationships to their teachers are related to cognitive, academic, and behavioral outcomes (Hamre & Pianta, 2001, 2005; Koole & Veenstra, 2015). Specifically, kindergarteners who relationships with their teachers reflect high relational conflict and dependency, had poor work habits and learning outcomes in early elementary schooling. Interestingly, these early relationships were related to behavioral and academic difficulties in the eighth grade but were mediated by early elementary year scores in those same domains (Hamre & Pianta, 2001). However, when kindergarteners who demonstrated attentional, behavioral, social, and academic difficulties were provided strong instructional and emotional support, their outcomes measured on-par with their low-risk peers at the end of grade one (Hamre & Pianta, 2005). These findings indicate that the ways in which teachers interact with and support their students contributes to differences in young learners' SR processes, and their school adjustment and success. Though findings indicate that social and emotional support from teachers facilitates students' development and application of SR strategies (Cole et al., 2005 Hamre & Pianta, 2005; Koole & Veenstra, 2015), little research has examined whether teacher practices support elementary-aged students' ER skills.

Moreover, scholars indicate that teachers who integrate non-threatening feedback in their classrooms, such as the use of probing questions, peer editing tasks or personal reflections on learning, promote a sense of safety within their classrooms where students focus on their own progress as opposed to their performance relative to their classroom peers (Linnenbrink, 2005; Zimmerman, 2008). For example, students who perceive their teachers' behaviors to reflect supportive practices (i.e., cooperation between the teacher and student) as opposed to corrective practices (e.g., reflects teacher criticism and assessment, strictness), demonstrate positive increases in motivation, learning strategy use, and learning satisfaction (Pierro et al., 2009; van Grinsven & Tillema, 2006). Additionally, non-threatening evaluations provide students with opportunities to engage their metacognitive processes (Zimmerman, 2008) and are related to the experience of more positive affect and less negative affect, increased motivation and the engagement in SRL (Linnenbrink, 2005). Though these findings indicate that presence of non-threatening evaluation during instruction may increase student's motivation, reduce their experience of negative affect, and support their engagement in SR processes, there is limited research that has considered how non-threatening evaluations support students' development of ER in classroom-based learning.

Like teachers, peers can provide instrumental support in classroom-based learning. Research findings demonstrate that peer collaboration may provide students opportunities to share ideas and problem-solve, to cope with and resolve affectively challenging learning situations, and to engage social forms of metacognition (e.g., perspective-taking), all of which can contribute to the development of cognitive, communicative, and collaborative skills important in classroom-based SRL and ER (Eisenberg et al., 2004; Järvenoja & Järvelä, 2009; Hadwin et al., 2018; Whitebread et al., 2007). Moreover, empirical findings indicate that students report less fear of judgment during help-seeking or in the face of failures when peer support is present during classroom learning (Paris & Newman,1990). Ultimately, the presence of peer support may facilitate student's motivation to persist in the face of challenges and to frame mistakes as opportunities to learn. Additionally, findings indicate that students' classroom behaviors, specifically the degree to which they demonstrate social competence, influences their adjustment to school and their learning outcomes (Diamond, 2007; Eisenberg et al., 2004; Wentzel, 2004). For example, children who demonstrate low ER (e.g., are highly emotional in response to anger-eliciting events) are more likely to become aggressive with their peers in classroom-contexts (Eisenberg et al., 1994; Fabes & Eisenberg, 1992), which can be detrimental to their peer-relationships. Taken together these findings demonstrate that social functioning in classrooms influence and is influenced by young learner's SRL and ER abilities.

Taken together, students benefit from well-developed SR skills as they support their engagement in appropriate peer-relationships, which in turn provide important opportunities to practice and develop skills that underlie diverse targets of SR (e.g., ER, SRL). However, research findings have also demonstrated that children between 3 and 5 years-old who display high levels of affect and motivation regulation preferred to work independently when afforded opportunities for paired or small-group activities (Whitebread et al., 2007). These findings suggest that although peer support is evidenced to support SRL and ER development, it may not be appealing for children with well-developed ER abilities. Alternatively, it may be that students require high levels of ER to be successful in independent work and that classroom-based tasks that afford peer-collaboration are a means of developing that ability. Therefore, future research should examine whether instrumental peer support facilitates the elementary-aged student's classroom-based ER during classroom-based learning activities.

Autonomy-supportive practices. Within classroom-based learning, providing children with opportunities to make meaningful choices and exert control over their learning supports childrens' autonomy development (Deci & Ryan, 1985). Specifically, these opportunities support childrens' understanding about how their decisions are related to their academic outcomes (Walker, 2008). Research has indicated that the opportunity for students to make meaningful choices (e.g., what to work on and when, where to work, whom to work with) promotes students to find meaning in their work (Perry 1998; Perry & VandeKamp, 2000; Lodewyk et al., 2009), which may support students' motivation. Moreover, the opportunity to make choices supports students in developing their metacognition. That is, a student's ability to choose appropriately challenging tasks requires coordinated monitoring and evaluation abilities to form well-calibrated self-representations of their strengths and weaknesses as a learner. For example, Perry and VandeKamp (2000) explored classrooms where students were permitted to select their reading materials on the basis that these materials were appropriate aligned with the students' reading level. Findings demonstrated that these students, compared to students in classrooms with limited choice, were more likely to identify their reading strengths and weaknesses (i.e., engage in metacognition) such as which books were appropriate (e.g., longer sentences than others) or chose to read within pairs as opposed to independently. Though these findings indicate that opportunities to make choices about ones' learning can support the development of their underlying SR processes (e.g., metacognition, motivation), limited research has examined whether choice facilitates student's ER skills.

Additionally, the inclusion of instructional practices that promote student choice come with a caveat placed by Stefanou et al. (2004) that providing children with opportunities to make choices may not be sufficient in supporting the development of processes that support SR. Rather, like complex tasks, choice must be accompanied by instrumental teacher support (scaffolding, co-regulation) to guide students in their decision making (e.g., selecting appropriately challenging materials/activities, or peers to work with). For example, students who have opportunities to make meaningful choices may not be metacognitively prepared to do so. That is, students who are unable to identify books that are appropriately challenging may select a book that is too challenging and ultimately experience increased negative affect and poor learning outcomes. Alternatively, students who select reading materials that do not challenge their abilities within the ZPD (e.g., too easy) may experience less positive motivation. As such, continued research that explores multiple features of instruction in natural classroom settings is needed. This is especially true across multiple learning populations (e.g., elementary vs. university) and multiple learning domains (e.g., literacy compared to mathematics).

Beyond having opportunities to make choices regarding one's learning, research findings indicate that students who have perceptions of control over their learning display increased motivation and learning strategy use (Eshel & Kohavi, 2003; Pierro et al., 2009; van Grinsven & Tillema, 2006). For example, students who held perceptions of personal control in the sixth grade, compared to on-par perceptions of teacher-student control, demonstrated positive increases in their use of SRL strategies, motivation for learning, self-efficacy, and achievement in math (Eshel & Kohavi, 2003). Additionally, older students who perceive their teachers to be supportive, compared to directive or corrective, have increased perceptions of autonomy, experience increased motivation, employ more learning strategies, and experience higher levels of satisfaction (Pierro et al., 2009; van Grinsven & Tillema, 2006). Indeed, opportunities for choice and perceptions of control within the classroom can influence students' metacognitive engagement, promote their motivation for learning, and influence learning outcomes.

However, research demonstrates that directive instruction (e.g., explicit teaching of procedures and strategies), that may remove opportunities for choice and control, also supports young students learning and SR processes (Camron & Morrison, 2011; Lillard, 2005; Nowacek et al., 1990). Research indicates that instructional practices that orient students to tasks (e.g., telling students what to do and how to do it), have been demonstrated to positively predict classroom functioning and academic outcomes (Bohn et al., 2004; Cameron et al., 2009; McWilliam et al., 2003). Though directive instruction may limit students' opportunities to make choices about, and exert control over their learning (e.g., how to approach solving a problem, which strategies to use), theorists indicate that directive instruction likely alleviates the cognitive load required to plan and enact complex cognitive and behavioral practices (Cameron & Morrison, 2011; Lillard, 2005). Since children are still physiologically maturing and their academic knowledge and skills are developing alongside their abilities to plan and control behavior (Cameron et al., 2009), teachers' use of directive instruction may support their students' abilities to initiate, remain engaged in, and effectively execute independent learning activities. For example, research findings with preschoolers demonstrated that children enrolled in classrooms wherein teachers provided direction (i.e., step-by-step information, elaborations) as opposed to responding to, or asking questions, was positively related to childrens' active participation in the classroom learning task (McWilliam et al., 2003). However, a great deal of this research has been conducted with young students (e.g., preschool, grade 1; McWilliam et al., 2003) or in literacy learning (Cameron et al., 2009). Given previous research findings regarding perceptions of teacher control with older students (Pierro et al., 2009; van Grinsven & Tillema, 2006), continued research is required to examine whether autonomy-supportive and directive instructional practices support middle to upper elementary-aged students' SR skills (i.e., ER, SRL) across various learning domains.

Summary. Together these findings highlight the importance of teacher's instructional practices for their student's underlying SR abilities (e.g., metacognition, motivation, strategic action) at various stages of their education (e.g., preschool to secondary school). However, questions remain regarding whether instructional practices directly support student's ER skills. As such, future research is needed to assess whether different pedagogical approaches to instruction (i.e., complex tasks, instrumental support, autonomy support), promote elementary-aged students' classroom-based ER. These investigations may extend theory, and inform instructional design, and the development of school-based SR interventions. Moreover, understanding whether these pedagogical approaches support students' self-regulatory and learning needs in different learning domains is a topic of important consideration. Since learning domains like mathematics prove to be procedurally complex, strategically challenging, and emotionally laden, it is possible that students require adapted forms of classroom instruction (e.g., more direction, more feedback) to promote positive patterns of SR and learning success.

Mathematics Problem-Solving

Mathematics problem-solving is a particularly challenging learning domain for students as they are required to recall, maintain, and work with relevant information like content (e.g., the question, numerical values) and procedural and strategic processes (Montague et al., 2000; Vilenius-Tuohimaa, 2008). Cognitive research in mathematics has demonstrated that learners must engage their executive functions and higher order cognitive processes like metacognition during learning and achievement activities (Bull & Lee, 2014; Cragg & Gilmore, 2014; Gilmore et a., 2017; Schneider & Artlet, 2010; Veenman, 2006). For example, mathematics problem-solving requires the coordination of memory to activate prior knowledge and maintain interim arithmetic solutions and problem representations (Gilmore et al., 2014; Fuchs & Fuchs, 2002). Attention focusing supports learners in sifting through their repertoire of strategies (Gilmore et al., 2018), and inhibitory control enables them to suppress their impulses to apply ineffective but well-practiced strategies (Robinson & Dubé, 2013). Additionally, to be successful in mathematics problem-solving, students must employ mathematical and learning strategies, monitor, and evaluate the success of their learning strategy use, and integrate problem information as products of their solutions become available (see Verschaffel et al., 2015). Moreover, findings have demonstrated that differences in students' abilities to employ their executive functions and higher order processes are related to differences in mathematics outcomes from preschool to adolescence (Bull & Lee, 2014; Carr et al., 1994; Cragg et al., 2017; Gilmore et al., 2014; Throndsen, 2011; Yeniad et al., 2013).

Together, the procedural and strategic complexity of mathematics problem-solving means that students' ability to engage in SRL is central to their success in this domain (Ahmed et al., 2013; Jacobse & Harskamp, 2012; Schoenfeld, 1982; Throndsen, 2011). Indeed, researchers have indicated that many of the processes inherent in mathematics problem-solving are SRL processes (e.g., metacognition, planning, monitoring, and evaluation; Carr et al., 1994; Schnieder & Artlet, 2010). For example, findings have demonstrated that students' patterns of SRL and use of learning strategies are predictors of their mathematics problem-solving outcomes (Muis et al., 2016; Throndsen, 2011). Additionally, some research indicates that students' cognitive abilities are related to their experiences of math anxiety, such that students who display increasingly skilled cognitive abilities experience less math anxiety than their counterparts (Douglas & LeFevre, 2018). Though research within and outside of mathematics learning has demonstrated that emotions interact with student's cognitive processes, motivational processes, and learning outcomes (Di Leo et al., 2019; Efklides et al., 2018; Pekrun et al., 2017), there is a lack of research that has examined how students' engagement in ER may relate to their SRL processes during mathematics problem-solving and ultimately their learning and achievement outcomes.

Recall that research findings from a study with a sample of elementary-aged students indicated that students experience a variety of emotions during mathematics problem-solving, (Di Leo et al., 2019) and that ER is an important skill that supports their learning (Calkins & Markovich, 2010; Perry & Calkins, 2018). Though previous findings have demonstrated that there are increasingly positive outcomes for individuals who employ cognitive reappraisal compared to expressive suppression during learning situations (Gross, 2015; Gross & John, 2003; Richards & Gross, 2000; Strain & D'Mello, 2015), the potential consequences of each of these strategies have not been measured in tandem during student's mathematics problem-solving. Since employing reappraisal requires the individual to actively engage with the emotional stimuli to reframe it (e.g., seeing confusion as an opportunity for learning; Gross, 2015), engaging in this ER strategy may consume the cognitive resources required to effectively engage in SRL and mathematics problem-solving processes (e.g., recall, reasoning, decision making, monitoring, and evaluation). Alternatively, suppression does not require active engagement with the stimuli that facilitate the emotional response (Gross, 2015) and may preserve a learner's finite cognitive resources. In turn, students may focus their efforts on their learning processes instead of their physiological, emotional, and behavioral response tendencies associated with the emotions they experience during mathematics problem-solving. Research that assesses these two ER strategies in tandem during mathematics problem-solving may provide important theoretical insight and support future SR research and interventions for mathematics instruction.

Indeed, mathematics problem-solving is both emotionally laden and strategically challenging for students, and their self-regulatory skills (i.e., ER, SRL) are significant predictors of their learning and achievement outcomes. However, there is a limited body of SR research that examines whether pedagogical practices implemented during mathematics lessons support students' development of SR (i.e., ER, SRL) skills. Recall that research findings indicate that teachers who employ instructional practices that support learners' autonomy tend to facilitate students' development of SRL (Perry et al., 2020) and likely ER (Cole et al., 2018; Hamre & Pianta, 2000). Given the procedurally complex and strategically challenging nature of mathematics problem-solving and the various cognitive and affective processes that occur in concert during mathematics learning and problem-solving (Montague et al., 2000; Vilenius-Tuohimaa, 2008), students may not experience the same benefits from autonomous instructional practices as they do in other learning domains (e.g., literacy). Rather, students may benefit from increasingly directive pedagogical practices including limited choice and control over their learning (e.g., the teacher selects a learning activity or mathematical procedure to match levels of difficulty to students' abilities) and increased teacher support (e.g., teacher cued monitoring).

These findings suggest that directive instructional practices may provide opportunities for students to develop their SRL during mathematics problem-solving. In turn, students may experience fewer negative emotions as they may be more successful in their learning endeavors. Therefore, increasingly directive pedagogical practices during mathematics instruction may support students' development of ER skills. Since limited research on self-regulation has examined how teachers implement different pedagogical practices during mathematics problem-solving, future lines of inquiry should examine how classroom instruction may be related to differences in students' development of ER and SRL in this domain.

The Current Dissertation

In the last three decades, the field of educational psychology has progressed in its understanding of ER and SRL in learning and achievement situations. Moreover, researchers have broadened their scopes to include considerations of elementary-aged students' classroom-based SR (i.e., ER, SRL) and contextual variables like learning domain and instructional practices. However, important questions remain regarding the dynamic interactions between multiple targets of SR and the classrooms in which these processes are practiced and habituated. Additionally, less research has been devoted to understanding how multiple SR processes operate in the context of mathematics based learning (c.f., Di Leo et al., 2019) and whether instructional practices support or hinder students SR skills in this domain. For example, researchers must still consider: How does SRL unfold for elementary-aged students during complex mathematics problem-solving? Which ER strategies are effective for supporting students' learning processes (e.g., SRL) and outcomes during mathematics problem-solving? Are there interdependent relationships between the development of elementary-aged students' ER and SRL? Do differences in teachers' pedagogical approaches relate to differences in students' ER and SRL outcomes during the school year?

In the following chapters, I will integrate research from developmental and educational perspectives of SR to demonstrate that considering ER, SRL, and contextual variables (i.e., learning domain, pedagogical approaches) in tandem provides important theoretical and practical insights. Namely, this work may reveal how different ER strategies can be effectively employed to support SRL and learning outcomes, and how students SR develops and can be supported in classrooms. To this end, the first study presented in this dissertation (Chapter 3) addressed the following research questions: (1) Do ER strategies (i.e., cognitive reappraisal, expressive suppression) have reciprocal relationships with the four phases of SRL (i.e., task definition, planning/goal setting, enactment of learning strategies, monitoring/evaluation)? (2) Do ER strategies predict the four phases of SRL and mathematics problem-solving outcomes? (3) Do the four phases of SRL mediate the relationships between ER strategies and mathematics problem-solving outcomes?

Additionally, the following research questions were addressed in the second research study (Chapter 4): (1) Do elementary students' classroom-based ER and SRL skills change from the fall to spring, and does change differ across classrooms as function of teacher practices? (2) Do observed instructional practices during mathematics learning support students' SR development in this domain? (3) Are there interdependent relationships between students' classroom-based ER and SRL such that ER skills in the fall predict SRL skills in the spring, and vice-versa?

In examining these research questions, this dissertation extends researcher understandings of how SRL unfolds during mathematics problem-solving and the relationships between multiple targets of (i.e., ER, SRL) among elementary-aged students. Furthermore, the pedagogical approaches that facilitate elementary-aged students' development of ER and SRL during mathematics problem-solving lessons are examined. Together, these works may provide important practical implications for the design and implementation of interventions that support students' SR during mathematics problem-solving in classrooms.

References

Ahmed, W., van der Werf, G., Kuyper, H., & Minnaert, A. (2013). Emotions, self-regulated learning, and achievement in mathematics: A growth curve analysis. *Journal of Educational Psychology*, *105*, 150-161. https://doi.org/10.1037/a0030160

Aldao, A., & Nolen-Hoeksema, S. (2012). When are adaptive strategies most predictive of psychopathology? *Journal of Abnormal Psychology*, *121*(1), 276-281. https://doi.org/10.1037/a0023598

Aldao, A., Sheppes, G., & Gross, J. J. (2015). Emotion regulation flexibility. *Cognitive Therapy and Research*, *39*(3), 263-278. https://doi.org/10.1007/s10608-014-9662-4

Azevedo, R., Harley, J., Trevors, G., Duffy, M., Feyzi-Behnagh, R., Bouchet, F., & Landis, R. (2013). Using trace data to examine the complex roles of cognitive, metacognitive, and emotional self-regulatory processes during learning with multi-agent systems. In *International handbook of metacognition and learning technologies* (pp. 427-449). Springer, New York, NY.

Bandura, A. (1989). Regulation of cognitive processes through perceived self-efficacy. *Developmental Psychology*, 25, 725– 739. https://doi.org/10.1037/0012-1649.25.5.729

Ben-Eliyahu, A., & Bernacki, M. L. (2015). Addressing complexities in self-regulated learning: A focus on contextual factors, contingencies, and dynamic relations. *Metacognition and Learning*, *10*, 1-13. https://doi.org/10.1007/s11409-015-9134-6

Ben-Eliyahu, A., & Linnenbrink-Garcia, L. (2015). Integrating the regulation of affect, behavior, and cognition into self-regulated learning paradigms among secondary and post-secondary students. *Metacognition and Learning*, *10*(1), 15–42. https://doi.org/10.1007/s11409-014-9129-8

Blair, C., Calkins, S., & Kopp, L. (2010). Self-regulation as the interface of emotional and cognitive development: Implications for education and academic achievement. In R. H. Hoyle (Ed.), *Handbook of personality and self-regulation* (pp. 64–90). Wiley Blackwell. https://doi.org/10.1002/9781444318111.ch4

Blair, C., & Diamond, A. (2008). Biological processes in prevention and intervention: the promotion of self-regulation as a means of preventing school failure. *Development and Psychopathology*, *20*(3), 899–911. https://doi.org/10.1017/S0954579408000436

Blair, C., & Razza, R. P. (2007). Relating effortful control, executive function, and false belief understanding to emerging math and literacy ability in kindergarten. *Child Development*, *78*(2), 647-663. https://doi.org/10.1111/j.1467-8624.2007.01019.x

Blankson, A. N., Weaver, J. M., Leerkes, E. M., O'Brien, M., Calkins, S. D., & Marcovitch, S. (2017). Cognitive and emotional processes as predictors of a successful transition into school. *Early Education and Development*, *28*(1), 1-20. https://doi.org/10.1080/10409289.2016.1183434

Blumenfeld, P., Mergendollar, J., & Swarthout, D. (1987). Task as a heuristic for understanding student learning and motivation. *Journal of Curriculum Studies, 19*, 135-148. https://doi.org/10.1080/0022027870190203

Bohn, C. M., Roehrig, A. D., & Pressley, M. (2004). The first days of school in the classrooms of two more effective and four less effective primary-grades teachers. *Elementary School Journal*, *104*, 269–287. https://doi.org/10.1086/499753

Bonanno, G. A., & Burton, C. L. (2013). Regulatory flexibility: An individual differences perspective on coping and emotion regulation. *Perspectives on Psychological Science*, *8*(6), 591-612. https://doi.org/10.1177/1745691613504116

Bowlby, J. (1982). Attachment and loss: retrospect and prospect. *American Journal of Orthopsychiatry*, *52*(4), 664-678. https://doi.org/10.1111/j.1939-0025.1982.tb01456.x

Bryce, D., Whitebread, D. & Szűcs, D. (2015). The relationships among executive functions, metacognitive skills and educational achievement in 5 and 7-year-old children. *Metacognition and Learning 10*, 181–198. https://doi.org/10.1007/s11409-014-9120-4

Bull, R., & Lee, K. (2014). Executive functioning and mathematics achievement. *Child Development Perspectives, 8*(1), 36–41. https://doi.org/10.1111/cdep.12059

Butler, D. L. (2021). Enabling educators to become more effective supporters of SRL: Commentary on a special issue. *Metacognition and Learning*, *16*(3), 667-684. https://10.1007/s11409-021-09282-8

Butler, D. L., & Cartier, S. C. (2004). Promoting effective task interpretation as an important work habit: A key to successful teaching and learning. *Teachers College Record*, *106*(9), 1729-1758. https://doi.org/10.1111/j.1467-9620.2004.00403.x

Butler, D. L., & Schnellert, L. (2015). Success for students with learning disabilities: What does self-regulation have to do with it? In T. Cleary (Ed.), *Self-regulated learning interventions with at-risk youth: Enhancing adaptability, performance, and well-being* (pp. 89–111). American Psychological Association. https://doi.org/10.1037/14641-005

Calkins, S.D., & Dedmon, S.E. (2010). Physiological and behavioral regulation in two-year-old children with aggressive/destructive behavior problems. *Journal of Abnormal Child Psychology, 28*, 103–118. https://doi.org/10.1023/A:1005112912906

Calkins, S. D., & Fox, N. A. (2002). Self-regulatory processes in early personality development: A multilevel approach to the study of childhood social withdrawal and aggression. *Development and Psychopathology*, *14*(3), 477-498. https://doi.org/10.1017/S095457940200305X

Calkins, S. D., Graziano, P. A., Berdan, L. E., Keane, S. P., & Degnan, K. A. (2008). Predicting cardiac vagal regulation in early childhood from maternal–child relationship quality during toddlerhood. *Developmental Psychobiology: The Journal of the International Society for Developmental Psychobiology*, *50*(8), 751-766. https://doi.org/10.1002/dev.20344

Calkins, S. D., & Marcovitch, S. (2010). Emotion regulation and executive functioning in early development: Integrated mechanisms of control supporting adaptive functioning. In S. D. Calkins & M. A. Bell (Eds.), *Human brain development: Child development at the intersection of emotion and cognition* (pp. 37–57). American Psychological Association. https://doi.org/10.1037/12059-003

Cameron, C. E., & Morrison, F. J. (2011). Teacher activity orienting predicts preschoolers' academic and self-regulatory skills. *Early Education & Development*, *22*(4), 620-648. https://doi.org/10.1080/10409280903544405

Cameron Ponitz, C. E., Rimm-Kaufman, S. E., Brock, L. L., & Nathanson, L. (2009). Early adjustment, gender differences, and classroom organizational climate in first grade. *Elementary School Journal, 110*, 142–162. https://doi.org/10.1086/605470

Carr, M., Alexander, J., & Folds-Bennett, T. (1994). Metacognition and mathematics strategy use. *Applied Cognitive Psychology, 8*(6), 583-595. https://doi.org/10.1002/acp.2350080605

Cleary, T. J., & Zimmerman, B. J. (2004). Self-regulation empowerment program: A school-based program to enhance self-regulated and self-motivated cycles of student learning. *Psychology in the Schools*, *41*(5), 537-550. https://doi.org/10.1002/pits.10177

Cole, P. M., Dennis, T. A., Smith-Simon, K. E., & Cohen, L. H. (2009). Preschoolers' emotion regulation strategy understanding: Relations with emotion socialization and child self-regulation. *Social Development*, *18*(2), 324-352. https://doi.org/10.1111/j.1467-9507.2008.00503.x

Cole, P. M., Lougheed, J. P., & Ram, N. (2018). The development of emotion regulation in early childhood. In P. M. Cole & T. Hollenstein (Eds.), *Emotion Regulation: A matter of time*. (pp. 73–100). Routledge. https://doi.org/10.4324/9781351001328

Compagnoni, M., & Losenno, K. M. (2020). " I'm the Best! Or Am I?": Academic Self-Concepts and Self-Regulation in Kindergarten. *Frontline Learning Research*, *8*(2), 131-152.

Corno, L. (2001). Volitional aspects of self-regulated learning. In B. J. Zimmerman & D. H. Schunk (Eds.), *Self-regulated learning and academic achievement: Theoretical perspectives* (2 ed., pp. 191-225). Mahwah, NJ: Lawrence Erlbaum Associates Publishers.

Cragg, L., & Gilmore, C. (2014). Skills underlying mathematics: The role of executive function in the development of mathematics proficiency. *Trends in Neuroscience and Education*, *3*(2), 63–68. https://doi.org/10.1016/j.tine.2013.12.001

Davidson, M. C., Amso, D., Anderson, L. C., & Diamond, A. (2006). Development of cognitive control and executive functions from 4 to 13 years: Evidence from manipulations of memory, inhibition, and task switching. *Neuropsychologia*, *44*(11), 2037-2078. https://doi.org/10.1016/j.neuropsychologia.2006.02.006

Davis, E. L., & Levine, L. J. (2013). Emotion regulation strategies that promote learning: Reappraisal enhances children’s memory for educational information. *Child*

Development, *84*(1), 361–374. https://doi.org/10.1111/j.1467-8624.2012.01836.x

Davis, E., Levine, L., Lench, H.C., & Quas, J. (2010). Metacognitive emotion regulation: children's awareness that changing thoughts and goals can alleviate negative emotions. *Emotion, 10*(4), 498-510. https://doi.org/10.1037/a0018428

Deci, E. L., & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behavior*. New York, NY: Plenum.

Dennis, T., Hong, M., & Solomon, B. (2010). Do the association between exuberance and emotion regulation depend on effortful control? *International Journal of Behavioral Development*, *34*. https://doi.org/10.1177/0165025409355514

Dennis, T. A., & Kelemen, D. A. (2009). Preschool children's views on emotion regulation: Functional associations and implications for social-emotional adjustment. *International Journal of Behavioral Development*, *33*(3), 243-252. https://doi.org/10.1177/0165025408098024

Derryberry, D., & Rothbart, M. K. (1997). Reactive and effortful processes in the organization of temperament. *Development and Psychopathology*, *9*(4), 633-652. https://doi.org//10.1017/S0954579497001375

DeVellis, R. F. (2016). *Scale development: Theory and applications* (Vol. 26). Sage Publications.

Diamond, A. (2016). Why assessing and improving executive functions early in life is critical. In J. A. Griffin, P. McCardle, & L. S. Freund (Eds.), *Executive function in preschool-age children: Integrating measurement, neuro-development and translational research* (pp. 11–43). Washington, DC: American Psychological Association.

Diamond, A., Barnett, W. S., Thomas, J., & Munro, S. (2007). Preschool program improves cognitive control. *Science*, *318*(5855), 1387-1388. https://doi.org/10.1126/science.1151148

Diamond, A., & Lee, K. (2011). Interventions shown to aid executive function development in children 4 to 12 years old. *Science*, *333*(6045), 959-964. https://doi.org//10.1126/science.1204529

Di Leo, I., & Muis, K. R. (2020). Confused, now what? A Cognitive-Emotional Strategy Training (CEST) intervention for elementary students during mathematics problem solving. *Contemporary Educational Psychology*, *62*, 101879. https://doi.org/10.1016/j.cedpsych.2020.101879

Di Leo, I., Muis, K. R., Singh, C., & Psaradellis, C. (2019). Curiosity Confusion? Frustration! The role and sequencing of emotions during mathematics problem solving. *Contemporary Educational Psychology, 58,* 121–137. https://doi.org/10.1016/j.cedpsych.2019.03.001

Douglas, H. P., & LeFevre, J. A. (2018). Exploring the influence of basic cognitive skills on the relation between math performance and math anxiety. *Journal of Numerical Cognition*, *3*(3), 642-666. https://doi.org/10.5964/jnc.v3i3.113

Doyle, W. (1983). Academic work. *Review of Educational Research*, *53*(2), 159-199. https://doi.org/10.3102/00346543053002159

Dunn, K. E., Rakes, G. C., & Rakes, T. A. (2014). Influence of academic self-regulation, critical thinking, and age on online graduate students' academic help-seeking. *Distance Education*, *35*(1), 75–89. https://doi.org/10.1080/01587919.2014.891426

Dweck, C. S. (2002). The development of ability conceptions. In A. Wigfield & J. S. Eccles (Eds.), *Educational psychology*. *Development of Achievement Motivation*, (pp. 57-88).

Academic Press. https://doi.org/10.1016/B978-012750053-9/50005-X

Dweck, C. S. (2006). *Mindset: The new psychology of success*. Random house.

Efklides, A., Schwartz, B. L., & Brown, V. (2018). Motivation and affect in self-regulated learning: Does metacognition play a role? In D. H. Schunk & J. A. Greene (Eds.), *Educational psychology handbook series. Handbook of self-regulation of learning and performance* (pp. 64–82). Routledge/Taylor & Francis Group.

Eisenberg, N., Cumberland, A., & Spinrad, T. L. (1998). Parental socialization of emotion. *Psychological Inquiry*, *9*(4), 241-273. https://doi.org/10.1207/s15327965pli0904_1

Eisenberg, N., Fabes, R. A., Nyman, M., Bernzweig, J., & Pinuelas, A. (1994). The relations of emotionality and regulation to children's anger-related reactions. *Child Development*, *65*(1), 109–128. https://doi.org/10.1111/j.1467-8624.1994.tb00738.x

Eisenberg N., & Spinrad T.L. (2004). Emotion-related regulation: Sharpening the definition. *Child Development*, *75*(2), 334–39. https://doi.org/10.1111/j.1467-8624.2004.00674.x

Eisenberg, N., Spinrad, T. L., & Eggum, N. D. (2010). Emotion-related self-regulation and its relation to children's maladjustment. *Annual Review of Clinical Psychology*, *6*, 495–525. https://doi.org/10.1146/annurev.clinpsy.121208.131208

Eisenberg, N., Spinrad, T. L., Fabes, R. A., Reiser, M., Cumberland, A., Shepard, S. A., ... & Thompson, M. (2004). The relations of effortful control and impulsivity to children's resiliency and adjustment. *Child Development*, *75*(1), 25-46. https://doi.org/10.1111/j.1467-8624.2004.00652.x

Eshel, Y., & Kohavi, R. (2003). Perceived classroom control, self-regulated learning strategies, and academic achievement. *Educational Psychology 23*(3), 249-260.

https://doi.org/10.1080/0144341032000060093

Fabes, R. A., & Eisenberg, N. (1992). Young children's coping with interpersonal anger. *Child Development*, *63*(1), 116-128. https://doi.org/10.1111/j.1467-8624.1992.tb03600.x

Feldman R. (2015). Mutual influences between child emotion regulation and parent-child reciprocity support development across the first 10 years of life: Implications for developmental psychopathology. *Development and Psychopathology*, *27*(4), 1007–1023. https://doi.org/10.1017/S0954579415000656

Forslund, T., Brocki, K. C., Bohlin, G., Granqvist, P., & Eninger, L. (2016). The heterogeneity of attention-deficit/hyperactivity disorder symptoms and conduct problems: Cognitive inhibition, emotion regulation, emotionality, and disorganized attachment. *The British Journal of Developmental Psychology*, *34*(3), 371–387. https://doi.org/10.1111/bjdp.12136

Frenzel. A.C., Goetz, T., & Stockinger, K. (2024). Emotions and emotion regulation. In P. Schutz & K. R. Muis (Eds.), *Handbook of Educational Psychology.* Routledge.

Fuchs, L. S., & Fuchs, D. (2002). Mathematical problem-solving profiles of students with mathematics disabilities with and without comorbid reading disabilities. *Journal of Learning Disabilities*, *35*(6), 564-574. https://doi.org/10.1177/00222194020350060701

Gilmore, C. K., Göbel, S. M., & Inglis, M. (2018). An introduction to mathematical cognition. New York, NY: Routledge

Gilmore, C., Keeble, S., Richardson, S., & Cragg, L. (2017). The interaction of procedural skill, conceptual understanding and working memory in early mathematics achievement. *Journal of Numerical Cognition*, *3*(2). https://doi.org/10.5964/jnc.v3i2.51

Goetz, T., & Hall, N. C. (2020). Emotion and achievement in the classroom. In J. Hattie & E. M.

Anderman (Eds.), *Visible Learning Guide to Student Achievement* (pp. 145-152). Routledge.

Goetz, T., Frenzel, A. C., Pekrun, R., Hall, N. C., & Lüdtke, O. (2007). Between-and within-domain relations of students' academic emotions. *Journal of Educational Psychology*, *99*(4), 715-733. https://doi.org/10.1037/0022-0663.99.4.715

Grau, V., & Whitebread, D. (2012). Self and social regulation of learning during collaborative activities in the classroom: The interplay of individual and group cognition. *Learning and Instruction*, *22*(6), 401-412. https://doi.org/10.1016/j.learninstruc.2012.03.003

Graziano, P. A., Reavis, R. D., Keane, S. P., & Calkins, S. D. (2007). The role of emotion regulation in children’s early academic success. *Journal of School Psychology*, *45*(1), 3–19. https://doi.org/10.1016/j.jsp.2006.09.002

Graziano, P. A., Calkins, S. D., & Keane, S. P. (2011). Sustained attention development during the toddlerhood to preschool period: Associations with toddlers' emotion regulation strategies and maternal behavior. *Infant and Child Development*, *20*(6), 389-408. https://doi.org/10.1002/icd.731

Greene, J. A. (2017). *Self-regulation in education*. Routledge.

Greene, J. A., Plumley, R. D., Urban, C. J., Bernacki, M. L., Gates, K. M., Hogan, K. A., ... & Panter, A. T. (2021). Modeling temporal self-regulatory processing in a higher education biology course. *Learning and Instruction*, *72*, 101201. https://doi.org/10.1016/j.learninstruc.2019.04.002

Gross, J. J. (1998). The emerging field of emotion regulation: An integrative review. *Review of General Psychology*, *2*(3), 271-299. https://doi.org/10.1037/1089-2680.2.3.271

Gross, J. J. (2015). Emotion regulation: current status and future prospects.

Psychological Inquiry, *26*(1), 1-26. https://doi.org/10.1080/1047840X.2014.940781

Gross, J. J., & John, O. P. (2003). Individual differences in two emotion regulation processes: Implications for affect, relationships, and well-being. *Journal of Personality and Social Psychology*, *85*(2), 348. https://doi:10.1037/0022-3514.85.2.348

Gross, J. J., & Thompson, R. A. (2007). Emotion regulation: Conceptual foundations. In J. Gross (Ed.). *Handbook of emotion-regulation* (pp. 3–24). New York, NY: Guilford Publications.

Gunzenhauser, C., & Suchodoletz, A. V. (2014). Preschoolers' use of suppression influences subsequent self-control but does not interfere with verbal memory. *Learning and Individual Differences*, *32*, 219–224. https://doi.org/10.1016/j.lindif.2014.03.007

Hadwin, A., Järvelä, S., & Miller, M. (2018). Self-regulation, co-regulation, and shared regulation in collaborative learning environments. *Educational Psychologist, 50*(3), 204-219. https://doi:10.1080/00461520.2015.1075400

Hamre, B. K., & Pianta, R. C. (2001). Early teacher–child relationships and the trajectory of children's school outcomes through eighth grade. *Child Development*, *72*(2), 625–638. https://doi.org/10.1111/1467-8624.00301

Hamre, B. K, & Pianta, R. C., (2005). Can instructional and emotional support in the first-grade classroom make a difference for children at risk of school failure? *Child Development* *76*(5), 949–967. https://doi.org/10.1111/j.1467-8624.2005.00889.x

Harley, J. M., Jarrell, A., & Lajoie, S. P. (2019a). Emotion regulation tendencies, achievement emotions, and physiological arousal in a medical diagnostic reasoning simulation. *Instructional Science*, *47*, 151-180. https://10.1007/s11251-018-09480-z

Harley, J. M., Pekrun, R., Taxer, J. L., & Gross, J. J. (2019b). Emotion regulation in achievement situations: An integrated model. *Educational Psychologist*, *54*(2), 106–126. https://doi.org/10.1080/00461520.2019.1587297

Hillyer, J., & Ley, T. C. (1996). Portfolios and second graders' self-assessments of their development as writers. *Reading Improvement*, *133*(3), 148-159.

Howse, R. B., Calkins, S. D., Anastopoulos, A. D., Keane, S. P., & Shelton, T. L. (2003). Regulatory contributors to children's kindergarten achievement. *Early Education and Development*, *14*(1), 101-120. https://doi.org/10.1207/s15566935eed1401_7

Hoyle, R. H., & Dent, A. L. (2018). Developmental trajectories of skills and abilities relevant for self-regulation of learning and performance. In D. H. Schunk & J. A. Greene (Eds.), *Educational psychology handbook series. Handbook of self-regulation of learning and performance* (pp. 49–63). Routledge/Taylor & Francis Group.

Hudson, A., & Jacques, S. (2014). Put on a happy face! Inhibitory control and socioemotional knowledge predict emotion regulation in 5-to 7-year-olds. *Journal of Experimental Child Psychology*, *123*, 36-52. https://doi.org/10.1016/j.jecp.2014.01.012

Hutchinson, L. R. (2013). Young children's engagement in self-regulation at school (Unpublished doctoral dissertation). University of British Columbia, British Columbia. https://doi:10.14288/1.0073717

Hutchinson, L. R., Perry, N. E., & Shapka, J. D. (2021). Assessing young children's self-regulation in school contexts. *Assessment in Education: Principles, Policy & Practice*, *28*(5-6), 545-583. https://doi.org/10.1080/0969594X.2021.1951161

Hutchinson, L. R., Perry, N. E., Yee, N., Restrepo, Dantzer, B., & Lo (2015, August). Demographic variables in children's self-regulation. Poster session presented at the American Psychological Association Annual Conference, Toronto. ON

Jacobse, A. E., & Harskamp, E. G. (2012). Towards efficient measurement of metacognition in mathematical problem solving. *Metacognition and Learning*, *7*(2), 133-149. https://doi.org/10.1007/s11409-012-9088-x

Jang, H., Reeve, J., & Deci, E. L. (2010). Engaging students in learning activities: It is not autonomy support or structure, but autonomy support and structure. *Journal of Educational Psychology*, 102(3), 588–600. https://doi.org/10.1037/a0019682

Järvenoja, H., & Järvelä, S. (2009). Emotion control in collaborative learning situations: Do students regulate emotions evoked by social challenges. *British Journal of Educational Psychology, 79*, 463-481. https://doi.org/10.1348/000709909X402811

Kalokerinos, E. K., Résibois, M., Verduyn, P., & Kuppens, P. (2017). The temporal deployment of emotion regulation strategies during negative emotional episodes. *Emotion*, *17*(3), 450-458. https://doi.org/10.1037/emo0000248

Karabenick, S. A., & Sharma, R. (2012). Seeking academic assistance as a strategic learning resource. In *Student motivation, cognition, and learning* (pp. 205-228). Routledge.

Kashdan, T. B., & Rottenberg, J. (2010). Psychological flexibility as a fundamental aspect of health. *Clinical Psychology Review*, *30*(7), 865-878. https://doi.org/10.1016/j.cpr.2010.03.001

Koole, S. L., & Aldao, A. (2016). The self-regulation of emotion: Theoretical and empirical advances. In K. D. Vohs, & R. F. Baumeister (Eds.), *Handbook of self-regulation* (3rd ed., pp. 101-112). New York: Guilford.

Koole, S. L., & Veenstra, L. (2015). Does emotion regulation occur only inside people's heads? Toward a situated cognition analysis of emotion-regulatory dynamics. *Psychological Inquiry, 26*(1), 61-68. https://doi.org/10.1080/1047840X.2015.964657

Kopp, C. B. (1982). Antecedents of self-regulation: A developmental perspective. *Developmental Psychology*, *18*(2), 199–214. https://doi.org/10.1037/0012-1649.18.2.199

Kopp, C. B. (1989). Regulation of distress and negative emotions: A developmental view. *Developmental Psychology*, *25*(3), 343–354. https://doi.org/10.1037/0012-1649.25.3.343

Kuhn, D. (1999). *Metacognitive development*. In L. Balter & C. S. Tamis-Lemonda (Eds.), Child psychology. *A handbook of contemporary issues* (pp. 259–286). Philadelphia: Psychology Press.

Leerkes, E. M., Supple, A. J., O'Brien, M., Calkins, S. D., Haltigan, J. D., Wong, M. S., & Fortuna, K. (2015). Antecedents of maternal sensitivity during distressing tasks: Integrating attachment, social information processing, and psychobiological perspectives. *Child Development*, *86*(1), 94-111. https://doi.org/10.1111/cdev.12288

Lillard, A. S. (2005). *Montessori: The science behind the genius*. New York, NY: Oxford University Press.

Linnenbrink, E. A. (2005). The dilemma of performance-approach goals: The use of multiple goal contexts to promote students' motivation and learning. *Journal of Educational Psychology*, *97*(2), 197-213. https://doi.org/10.1037/0022-0663.97.2.197

Loderer, K., & Pekrun, R. (2019, August). Regulation of achievement emotions: Towards a theory-driven program of research. Presentation at the European Association for Research on Learning and Instruction Conference, Aachen, GR

Lodewyk, K. R., Winne, P. H., & Jamieson-Noel, D. L. (2009). Implications of task structure on self-regulated learning and achievement. *Educational Psychology*, *29*(1), 1-25.

https://doi.org/10.1080/01443410802447023

Lodewyk, K. R., & Winne, P. H. (2005). Relations among the structure of learning tasks, achievement, and changes in self-efficacy in secondary students. *Journal of Educational Psychology*, *97*(1), 3. https://doi.org/10.1037/0022-0663.97.1.3

Loe, I. M., & Feldman, H. M. (2007). Academic and educational outcomes of children with ADHD. *Journal of Pediatric Psychology*, *32*(6), 643-654. https://doi.org/10.1093/jpepsy/jsl054

Losenno, K. M., Muis, K. R., Munzar, B., Denton, C. A., & Perry, N. E. (2020). The dynamic roles of cognitive reappraisal and self-regulated learning during mathematics problem solving: A mixed methods investigation. *Contemporary Educational Psychology*, *62*. https://doi.org/10.1016/j.cedpsych.2020.101869

McCabe, L. A., Cunnington, M., & Brooks-Gunn, J. (2004). The development of self-regulation in young children: Individual characteristics and environmental contexts. In R. F. Baumeister & K. D. Vohs (Eds.), *Handbook of self-regulation: Research, theory, and applications* (p. 340–356). The Guilford Press.

McCardle, L., & Hadwin, A. F. (2015). Using multiple, contextualized data sources to measure learners' perceptions of their self-regulated learning. *Metacognition and Learning*, *10*(1), 43–75. https://doi.org/10.1007/s11409-014-9132-0

McClelland, M. & Cameron, C. (2011). Self-regulation and academic achievement in elementary school children. *New Directions for Child and Adolescent Development*, *2011*(133), 29-44. https://doi.org/10.1002/cd.302

McRae, K., & Gross, J. J. (2020). Emotion regulation. *Emotion*, *20*(1), 1–9. https://doi.org/http://dx.doi.org/10.1037/emo0000703

McWilliam, R. A., Scarborough, A. A., & Kim, H. (2003). Adult interactions and child engagement. *Early Education and Development*, *14*(1), 7-28. https://doi.org/10.1207/s15566935eed1401_2

Meinhardt, J., & Pekrun, R. (2003). Attentional resource allocation to emotional events: An ERP study. *Cognition and Emotion*, *17*(3), 477-500. https://doi.org/10.1080/02699930244000039

Michalsky, T. (2021). Preservice teachers' professional vision for and capacity to teach self-regulated learning: Effects of scaffolding level. *Teachers College Record*, *122*(3), 1-48. https://doi.org/10.1007/s11409-020-09251-7

Mikulincer, M., Shaver, P. R., & Pereg, D. (2003). Attachment theory and affect regulation: The dynamics, development, and cognitive consequences of attachment-related strategies. *Motivation and Emotion*, *27*(2), 77-102. https://doi.org/10.1023/A:1024515519160

Miyake, A., & Friedman, N. P. (2012). The nature and organization of individual differences in executive functions: Four general conclusions. *Current Directions in Psychological Science*, *21*(1), 8–14. https://doi.org/10.1177/0963721411429458

Montague, M. (2008). Self-regulation strategies to improve mathematical problem solving for students with learning disabilities. *Learning Disability Quarterly*, *31*(1), 37-44. https://doi.org/10.2307/30035524

Muis, K. R. (2007). The role of epistemic beliefs in self-regulated learning. *Educational Psychologist, 42*(3), 173–190. https://doi.org/10.1080/00461520701416306

Muis, K. R., Chevrier, M., & Singh, C. A. (2018). The role of epistemic emotions in personal epistemology and self-regulated learning. *Educational Psychologist, 53*(3), 165-184.

https://doi.org/10.1080/00461520.2017.1421465

Muis, K. R., & Franco, G. M. (2009). Epistemic beliefs: Setting the standards for self-regulated learning. *Contemporary Educational Psychology, 34*(4), 306-318. https://doi.org/10.1016/j.cedpsych.2009.06.005

Muis, K. R., Psaradellis, C., Lajoie, S. P., Di Leo, I., & Chevrier, M. (2015). The role of epistemic emotions in mathematics problem solving. *Contemporary Educational Psychology,* 42, 172–185. https://doi.org/10.1016/j.cedpsych.2015.06.003

Muis, K. R., Psaradellis, C., Chevrier, M., Di Leo, I., & Lajoie, S. P. (2016). Learning by preparing to teach: Fostering self-regulatory processes and achievement during complex mathematics problem solving. *Journal of Educational Psychology, 108,* 474–492. https://doi.org/10.1037/edu0000071.

Munzar, B., Muis, K. R., Denton, C. A., & Losenno, K. M. (2020). Elementary students' cognitive and affective responses to impasses during mathematics problem-solving. *Journal of Educational Psychology*. https://doi.org/10.1037/edu0000460

Nowacek, E. J., McKinney, J. D., & Hallahan, D. P. (1990). Instructional behaviors of more and less effective beginning regular and special educators. *Exceptional Children, 57*, 140–149.

Obergriesser, S., & Stoeger, H. (2020). Students' emotions of enjoyment and boredom and their use of cognitive learning strategies–How do they affect one another? *Learning and Instruction*, *66*, 101285. https://doi.org/10.1016/j.learninstruc.2019.101285

Pekrun, R. (2018). Control-value theory: A social-cognitive approach to achievement emotions. In G. A. D. Liem & D. M. McInerney (Eds.), *Big theories revisited 2: A volume of research on sociocultural influences on motivation and learning* (pp. 162-190).

Charlotte: Information Age Publishing. https://doi.org/10.4236/me.2018.9505

Pekrun, R., Goetz, T., Titz, W., & Perry, R. P. (2002). Academic emotions in students' self- regulated learning and achievement: A program of qualitative and quantitative research. *Educational Psychologist*, 37(2), 91–105. https://doi.org/10.1207/S15326985EP3702_4

Pekrun, R., Lichtenfeld, S., Marsh, H.W., Murayama, K., & Goetz, T. (2017). Achievement emotions and academic performance: longitudinal models of reciprocal effects. *Child Development*, *88*(5), 1653-1670. https://doi.org/10.1111/cdev.12704

Perry, N. B., & Calkins, S. D. (2018). A biopsychosocial perspective on the development of emotion regulation across childhood. In *Emotion regulation* (pp. 3-30). Routledge.

Perry, N. E. (1998). Young children's self-regulated learning and contexts that support it. *Journal of Educational Psychology*, *90*(4), 715. https://doi.org/10.1037/0022-0663.90.4.71

Perry, N. E. (2013). Understanding classroom processes that support children's self-regulation of learning [Monograph]. British Journal of Educational Psychology, Monograph Series II: Psychological Aspects of Education – Current Trends, 10, 45–68.

Perry, N. E., Brenner, C. A., & MacPherson, N. (2015). Using teacher learning teams as a framework for bridging theory and practice in self-regulated learning. In T. Cleary (Ed.), *Self-regulated learning interventions with at-risk youth: Enhancing adaptability, performance, and well-being* (pp. 229–250). American Psychological Association. https://doi.org/10.1037/14641-011

Perry, N. E., Hutchinson, L. R., Yee, N., & Määttä, E. (2018). Advances in understanding young children's self-regulation of learning. In D. Schunk, & J. Greene (Eds.). *Handbook of self-regulated learning and performance* (pp. 457–472). (2nd ed.). New York:

Routledge. https://doi.org/10.4324/9781315697048-29

Perry, N. E., Lisaingo, S., Yee, N., Parent, N., Wan, X., & Muis, K. (2020). Collaborating with teachers to design and implement assessments for self-regulated learning in the context of authentic classroom writing tasks. *Assessment in Education: Principles, Policy & Practice*, *27*(4), 416-443. https://doi.org/10.1080/0969594X.2020.1801576

Perry, N. E., Mazabel, S., Dantzer, B., & Winne, P. (2018). Supporting self-regulation and self-determination in the context of music education. In G. A. D. Liem & D. M. McInerney (Eds.), *Big theories revisited 2: A volume of research on sociocultural influences on motivation and learning* (pp. 295-318). (2nd ed.). Information Age Press.

Perry, N. E., Mazabel, S., & Yee, N. (2020b). Using self-regulated learning to support students with learning disabilities in classrooms. In *Handbook of educational psychology and students with special needs* (pp. 292-314). Routledge.

Perry, N. E., Phillips, L., & Dowler, J. (2004). Examining features of tasks and their potential to promote self-regulated learning. *Teachers College Record, 106*(9), 1854-1878.

Perry, N. E., Phillips, L., & Hutchinson, L. R. (2006). Mentoring student teachers to support self-regulated learning. *Elementary School Journal, 106*(3), 237-254.

Perry, N. E., & VandeKamp, K. O. (2000). Creating classroom contexts that support young children's development of self-regulated learning. *International Journal of Educational Research, 33*, 821-843. https://doi.org/10.1016/S0883-0355(00)00052-5

Pierro, A., Presaghi, F., Higgins, T. E., & Kruglanski, A. W. (2009). Regulatory mode preferences for autonomy supporting versus controlling instructional styles. *British Journal of Educational Psychology*, *79*(4), 599-615. https://doi.org/10.1348/978185409X412444

Raffaelli, M., Crockett, L. J., & Shen, Y. L. (2005). Developmental stability and change in self-regulation from childhood to adolescence. *The Journal of Genetic Psychology*, *166*(1), 54-76. https://doi.org/10.3200/GNTP.166.1.54-76

Reeve, J. (2006). Teachers as facilitators: What autonomy-supportive teachers do and why their students benefit. *Elementary School Journal*, 106(3), 225-236. https://doi.org/10.1086/501484

Reeve, J., Ryan, R. M., & Deci, E. L. (2018). Sociocultural influences on student motivation as viewed through the lens of self-determination theory. In G. A. D. Liem & D. M. McInerney (Eds.), *Big theories revisited 2: A volume of research on sociocultural influences on motivation and learning* (pp. 15–40). Information Age Press

Richards, J. M., & Gross, J. J. (2000). Emotion regulation and memory: The cognitive costs of keeping one's cool. *Journal of Personality and Social Psychology, 79*(3), 410. https://doi.org/10.1037/0022-3514.79.3.410

Richter, T., & Schmid, S. (2010). Epistemological beliefs and epistemic strategies in self-regulated learning. *Metacognition Learning*, 5, 47–65. https://doi.org/10.1007/s11409-009-9038-4

Rimm-Kaufman, S. E., Curby, T. W., Grimm, K. J., Nathanson, L., & Brock, L. L. (2009). The contribution of children's self-regulation and classroom quality to children's adaptive behaviors in the kindergarten classroom. *Developmental Psychology, 45*(4), 958–972. https://doi.org/10.1037/a0015861

Robinson, K. M., & Dubé, A. K. (2013). Children's additive concepts: promoting understanding and the role of inhibition. *Learning and Individual Differences*, 23, 101–107. https://doi.org/10.1016/j.lindif.2012.07.016

Rottweiler, A.-L., Taxer, J. L., & Nett, U. E. (2018). Context matters in the effectiveness of emotion regulation strategies. *American Education Research Association Open, 4(*2), 233285841877884. https://doi.org/10.1177/2332858418778849

Rudasill, K. M., & Rimm-Kaufman, S. E. (2009). Teacher–child relationship quality: The roles of child temperament and teacher–child interactions. *Early Childhood Research Quarterly, 24*(2), 107–120. https://doi.org/10.1016/j.ecresq.2008.12.003

Ryan, K. E., Ryan, A. M., Arbuthnot, K., & Samuels, M. (2007). Students' motivation for standardized math exams. *Educational Researcher*, *36*(1), 5-13. https://doi.org/10.3102/0013189X0629

Sameroff, A. (2010). A unified theory of development: A dialectic integration of nature and nurture. *Child Development*, *81*(1), 6-22. https://doi.org/10.1111/j.1467-8624.2009.01378.x

Scherer, K. R., & Moors, A. (2019). The emotion process: Event appraisal and component differentiation. *Annual Review of Psychology*, *70*, 719-745. https://doi.org/https://doi.org/10.1146/annurev-psych-122216011854

Schmeichel, B. J., Volokhov, R. N., & Demaree, H. A. (2008). Working memory capacity and the self-regulation of emotional expression and experience. *Journal of Personality and Social Psychology*, *95*(6), 1526-1540. https://doi.org/10.1037/a0013345

Schneider, W., & Artelt, C. (2010). Metacognition and mathematics education. *International Journal of Mathematics Education*, *42*(2), 149-161. https://doi.org/10.1007/s11858-010-0240-2

Schoenfeld, A. (1982). Some thoughts on problem-solving research and mathematics education. In F. K. Lester & J. Garofalo (Eds.), *Mathematical problem solving: Issues and research* (pp. 27-37). Philadelphia, PA: The Franklin Institute Press.

Schunk, D. H., & Zimmerman, B. J. (2007). Influencing children's self-efficacy and self-regulation of reading and writing through modeling. *Reading & Writing Quarterly: Overcoming Learning Difficulties*, *23*(1), 7-25. https://doi.org/10.1080/10573560600837578

Schutz, P. A., & Davis, H. A. (2000). Emotions and self-regulation during test taking. *Educational Psychologist*, *35*(4), 243-256. https://doi.org/10.1207/S15326985EP3504_03

Shafir, R., Schwartz, N., Blechert, J., & Sheppes, G. (2015). Emotional intensity influences pre-implementation and implementation of distraction and reappraisal. *Social Cognitive and Affective Neuroscience*, *10*, 1329–1337. https://doi.org/10.1093/scan/nsv022

Sheppes, G. (2020). Transcending the “good & bad” and “here & now” in emotion regulation: Costs and benefits of strategies across regulatory stages. In *Advances in experimental social psychology* (Vol. 61, pp. 185-236). Academic Press.

Sheppes, G., & Levin, Z. (2013). Emotion regulation choice: selecting between cognitive regulation strategies to control emotion. *Frontiers in Human Neuroscience*, *7*, 179. https://doi.org/10.3389/fnhum.2013.00179

Sheppes, G., & Meiran, N. (2007). Better late than never? On the dynamics of online regulation of sadness using distraction and cognitive reappraisal. *Personality and Social Psychology Bulletin*, *33*(11), 1518-1532. https://doi.org/10.1177/0146167207305537

Sheskin, D. J. (2004). *Handbook of parametric and nonparametric statistical procedures* (4th ed.). Boca Raton, FL: Chapman & Hall/ CRC.

Stefanou, C. R., Perencevich, K. C., DiCintio, M., & Turner, J. C. (2004). Supporting autonomy in the classroom: Ways teachers encourage student decision making and ownership.

Educational Psychologist, 39, 97-110. https://doi.org/10.1207/s15326985ep3902_2

Stipek, D. J. (1981). Children’s perceptions of their own and their classmates’ ability. *Journal of Educational Psychology, 73*(3), 404-410.

Strain, A. C., & D'Mello, S. K. (2015). Affect regulation during learning: The enhancing effect of cognitive reappraisal. *Applied Cognitive Psychology, 29*(1), 1–19. https://doi.org/10.1002/acp.3049

Suri, G., Whittaker, K., & Gross, J. J. (2015). Launching reappraisal: It’s less common than you might think. *Emotion*, *15*(1), 73–77. https://doi.org/10.1037/emo0000011

Throndsen, I. (2011). Self-regulated learning of basic arithmetic skills: A longitudinal study. *British Journal of Educational Psychology*, *81*(4), 558-578. https://doi.org/10.1348/2044-8279.002008

Tice, M. D., Baumeister, R. F., & Zhang, L. (2004). The role of emotion in self-regulation: Differing roles of positive and negative emotion. In P. Philippot & R. S. Feldman (Eds.), *The regulation of emotion* (pp. 213-226). Mahwah, NJ: Lawrence Erlbaum Associates.

Turner, J. C. (1995). The influence of classroom contexts on young children's motivation for literacy. *Reading Research Quarterly*, *30*(3), 410-441. https://doi.org/10.2307/747624

Usher, E. L., & Schunk, D. H. (2018). *Social cognitive theoretical perspective of self- regulation*. In D. H. Schunk, & J. A. Greene (Eds.). Educational psychology handbook series. Handbook of self-regulation of learning and performance (pp. 19–35). Routledge/ Taylor & Francis Group. https://doi.org/10.4324/9781315697048-2

van Grinsven, L., & Tillema, H. (2006). Learning opportunities to support student self-regulation: Comparing different instructional formats. *Educational Research*, *48*(1), 77-91. https://doi.org/10.1080/00131880500498495 van Loon, M. H., Bayard, N. S., Steiner, M., & Roebers, C. M. (2021). Connecting teachers' classroom instructions with children's metacognition and learning in elementary school. *Metacognition and Learning*, *16*, 623-650. https://doi.org/10.1007/s11409-020-09248-2

Vand der Stel, M., Veenman, M. V., Deelen, K., & Haenen, J. (2010). The increasing role of metacognitive skills in math: A cross-sectional study from a developmental perspective. *Mathematics Education*, *42*(2), 219- 229. https://doi.org/10.1007/s11858-009-0224-2

Veenman, M. V. J., & Spaans, M. A. (2005). Relation between intellectual and metacognitive skills: Age and task differences. *Learning and Individual Differences*, *15*(2), 159–176. https://doi.org/10.1016/j.lindif.2004.12.001

Vernon-Feagans, L., Willoughby, M., & Garrett-Peters, P. (2016). Predictors of behavioral regulation in kindergarten: Household chaos, parenting, and early executive functions. *Developmental Psychology*, *52*(3), 430. https://doi.org/10.1037/dev0000087

Verschaffel, L., Depaepe, F., & Van Dooren, W. (2015). Individual differences in word problem solving. In R. Cohen Kadosh & A. Dowker (Eds.), *The Oxford Handbook of Numerical Cognition* (pp. 953–976). Oxford: Oxford University Press.

Vilenius-Tuohimaa, P. M., Aunola, K., & Nurmi, J. E. (2008). The association between mathematical word problems and reading comprehension. *Educational Psychology*, *28*(4), 409-426. https://doi.org/10.1080/01443410701708228

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

Walker, J. M. T. (2008). Looking at teaching practices through the lens of parenting style. *The Journal of Experimental Education,76*(2), 218-240.

https://doi.org/10.3200/JEXE.76.2.218-240

Webb, T. L., Miles, E., & Sheeran, P. (2012). Dealing with feeling: A meta-analysis of the effectiveness of strategies derived from the process model of emotion regulation. *Psychological Bulletin*, *138*(4), 775–808. https://doi.org/10.1037/a0027600

Wentzel, K. R. (2002). Are effective teachers like good parents? Teaching styles and student adjustment in early adolescence. *Child Development*, *73,* 287-301. https://doi.org/10.1111/1467-8624.00406

Wentzel, K. R. (2004). Understanding classroom competence: The role of social-motivational and self-Processes. In R. V. Kail (Ed.), *Advances in child development and behavior, Vol. 32* (p. 213–241). Elsevier Academic Press.

Whitebread, D., Bingham, S., Grau, V., Pino-Pasternak, D., & Sangster, C. (2007). Development of metacognition and self-regulated learning in young children: Role of collaborative and peer-assisted learning. *Journal of Cognitive Education and Psychology, 6*, 433-455. https://doi.org/10.1891/194589507787382043

Whitebread, D., Coltman, P., Pasternak, D. P., Sangster, C., Grau, V., Bingham, S., ... & Demetriou, D. (2009). The development of two observational tools for assessing metacognition and self-regulated learning in young children. *Metacognition and Learning, 4*, 63-85. https://doi.org/10.1007/s11409-008-9033-1

Winne, P.H. (2017). Theorizing and researching levels of processing in self-regulated learning. *British Journal of Educational Psychology, 88*, 9-20. https://doi.org/10.1111/bjep.12173

Winne, P. H. (2018). Cognition and metacognition within self-regulated learning. In D. H. Schunk & J. A. Greene (Eds.), *Handbook of self-regulation of learning and performance* (2nd ed.). New York: Routledge.

Winne, P. H., & Hadwin, A. F. (1998). Studying as self-regulated learning. In D. J. Hacker, J. Dunlosky, & A. C. Graesser (Eds.), *Metacognition in educational theory and practice* (pp. 277–304). Hillsdale: Erlbaum.

Winne, P. H., & Perry, N. E. (2000). Measuring self-regulated learning. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 531–566). Academic Press. https://doi.org/10.1016/B978-012109890-2/50045-7

Yeniad, N., Malda, M., Mesman, J., van IJzendoorn, M. H., & Pieper, S. (2013). Shifting ability predicts math and reading performance in children: a meta-analytical study. *Learning and Individual Differences*, 23,1–9. https://doi.org/10.1016/j.lindif.2012.10.004

Zachariou, A., & Whitebread, D. (2019). Developmental differences in young children's self-regulation. *Journal of Applied Developmental Psychology*, *62*, 282-293. https://doi.org/10.1016/j.appdev.2019.02.002

Zimmerman, B. J. (2000). Attaining self-regulation: a social cognitive perspective. In M. Boekaerts, P. R. Pintrich & M. Zeidner (Eds), *Handbook of Self-regulation*. San Diego, CA: Academic Press.

Zimmerman, B. J. (2008). Investigating self-regulation and motivation: Historical background, methodological developments, and future prospects. *American Educational Research Journal*, *45*(1), 166–183. https://doi.org/10.3102/0002831207312909

Zimmerman, B. J. (2013). Theories of self-regulated learning and academic achievement: An overview and analysis. In B. J. Zimmerman & D. H. Shunk (Eds.) *Self-regulated learning and academic achievement*, (pp. 1-36). (2nd ed.) Routledge.

Zimmerman, B. J., & Schunk, D. H. (2011). Self-regulated learning and performance: An introduction and an overview. In D. H. Schunk & B. J. Zimmerman (Eds.) *Handbook of*

self-regulation of learning and performance, (pp. 15-26). Routledge.
https://doi.org/10.4324/9780203839010

Bridging Text

Chapter 2 reviewed literature and delineated the development of two targets of self-regulation, namely emotion regulation (ER) and self-regulated learning (SRL). The role of emotions during learning were highlighted and conclusions were drawn that students must effectively and adaptively regulate their emotions during learning to reach their goals and meet academic expectations. Accumulating evidence was presented that suggests expressive suppression, an ER strategy, may be more effective for modulating emotions during learning and supporting SRL processes than previously believed. Findings were also presented that SRL is a complex process that unfolds in a loosely linear manner during learning and predicts students' educational outcomes across learning domains and the life span. In all, relationships between ER and SRL were highlighted and called attention to a shared reliance and the same underlying self-regulatory processes that have developmental underpinnings and are highly contextualized. Yet, there is a paucity of SR research conducted with middle to upper elementary-aged students during classroom-based mathematics learning. Moreover, questions remain regarding which ER strategies may support students' SRL processes, and mathematics problem-solving outcomes.

Chapter 3 addresses these questions by examining the relationships between middle to upper elementary-aged students' use of two ER strategies (i.e., cognitive reappraisal, expressive suppression), their engagement in the four phases of SRL (i.e., task definition, planning and goal setting, enactment, monitoring and evaluation), and their mathematics problem-solving outcomes. Specifically, this study employed self-reports, think aloud data, and mathematics problem-solving activities that were selected from the local curriculum to replicate typical classroom-based learning. Findings may provide theoretical insight regarding the efficacy of distinct ER strategies, and practical implications for supporting students' SR in classrooms.

Chapter 3. Manuscript 1

Emotion Regulation and Self-Regulated Learning during Mathematics Problem-Solving

Author Note

Earlier versions of this manuscript were presented at the following conferences:

Losenno K. M., & Muis, K. R. (2023, April). Emotion regulation and self-regulated learning during mathematics problem-solving. Paper presented at the American Education Research Association Annual Conference, Chicago, Il.

This research was funded by a grant to Nancy E. Perry and Krista R. Muis from a grant for the Social Sciences and Humanities Research Council of Canada (435-2016-0374), and to Krista R. Muis from the Canada Research Chairs program.

Abstract

Emotion regulation (ER) and self-regulated learning (SRL) are important predictors of elementary-aged student's mathematics learning and achievement outcomes. To date, limited research has examined the roles of cognitive reappraisal and expressive suppression, two ER strategies, in relation to student's SRL and mathematic problem-solving outcomes. To address this gap, the current study examined the relationships between cognitive reappraisal, expressive suppression, the phases of SRL (task definition, planning/goal setting, enactment of learning strategies, monitoring/evaluation) and mathematics problem-solving in a sample of 152 grade 3 to grade 6 elementary school students. A path analysis demonstrated that suppression positively predicted task definition, and that task definition positively predicted enactment, and monitoring and evaluation. Task definition also mediated the relationship between suppression and enactment, and between suppression and monitoring and evaluation. Counter to hypotheses, reappraisal did not predict students' SRL or mathematics problem-solving outcomes. Implications for classroom-based research and interventions for self-regulation are discussed.

Keywords: emotion regulation, self-regulated learning, mathematics, elementary school

Introduction

Over the last three decades, research on self-regulation (SR) has demonstrated that students' self-regulatory skills are an important predictor of learning and achievement outcomes from kindergarten to university, and across various learning domains (Diamond et al., 2007; Hadwin et al., 2018; Kopp, 1982; McCabe et al., 2004; Zachariou & Whitebread, 2019). In general, self-regulation (SR) describes how individuals apply their cognition, affect, motivation, and behavior to effectively pursue goals and adapt to environmental demands (Usher & Schunk, 2018; Zimmerman, 2008). Previous and recent theorists indicate that SR consists of multiple components that are distinct in what they target (e.g., cognition, affect, motivation, learning, behavior; Bandura, 1989; Perry et al., 2018; Usher & Schunk, 2018). For example, emotion regulation (ER) refers to an individual's ability to engage effective strategies to modulate the physiological, cognitive, and behavioral response tendencies associated with affective experiences to pursue goals (Eisenberg & Spinrad, 2004; Frenzel et al., 2024; Gross, 2015). Self-regulated learning (SRL) refers to a learner's ability to select and apply strategies and engage in adaptive patterns of cognition, motivation and behaviors that support learning goals (Muis, 2007; Winne & Perry, 2000; Zimmerman, 2008). Though these targets of SR are distinct in what they aim to regulate, they are united by their reliance on the same underlying SR processes including executive functions, and higher order processes like metacognition, motivation, and strategic action (Diamond, 2016; Hoyle & Dent, 2018; Miyake & Friedman, 2012; Perry et al., 2018; Usher & Schunk, 2018).

This shared reliance on the same underlying processes leads theorists to posit that there may be interdependent relationships between distinct targets of SR (Usher & Schunk, 2018). However, limited empirical research has considered how two or more targets of SR (e.g., ER, SRL) operate in tandem (c.f., Di Leo & Muis, 2020; Losenno et al., 2020). Rather, research often examines the relationships between individual targets of SR and developmental and cognitive processes (Calkins & Marcovitch, 2010; Davis et al., 2010; Feldman, 2015; Graziano et al., 2011; Hoyle & Dent, 2018; Whitebread et al., 2007), or learning outcomes (Howse et al., 2003; McClelland & Cameron, 2011). Additionally, research on ER and SRL has prioritized the study of different measures that underlie both processes (e.g., executive functions, metacognition; Diamond, 2016; Graziano et al., 2007; Muis et al., 2015; Zimmerman, 2008). For example, ER and SRL research tends to measure executive functioning in younger populations (e.g., preschool, early elementary; Blair & Razza, 2007; Eisenberg et al., 2007), and metacognitive and motivational processes in older students (e.g., university; Winne & Perry, 2000). There is limited research that considers the higher order processes (e.g., metacognition, motivation, strategic action) involved in both ER and SRL for middle to upper elementary-aged students. To extend theoretical understandings of how multiple targets of SR operate in tandem to support learning outcomes for this population, the current study was designed to assess the relationships between ER and SRL in a sample of middle to upper elementary-aged students.

Additionally, theorists highlight the importance of context when measuring and assessing ER for learning and SRL (Harley et al., 2019a; Loderer & Pekrun, 2019; Perry et al., 2018). For example, findings demonstrate that mathematics problem-solving is an emotionally laden and strategically challenging learning activity for elementary-aged students (Di Let et al., 2019; Muis et al., 2015). Moreover, emotions are known to interact with students’ cognition, motivation, engagement, and learning outcomes (Efklides, 2018; Goetz & Hall, 2020; Pekrun, 2002), and influence the types of ER strategies one employs (Ben-Eliyahu & Linnenbrink-Garcia, 2015; McRae & Gross, 2020). Since diverse learning domains and contexts may elicit emotions differently (frequency, intensity), it is critical for researchers to consider context (i.e., learning domains) when examining how students' SR unfolds during classroom-based learning. As such, the primary objective of this study is to empirically examine the relationships between two ER strategies, students' SRL, and their outcomes during complex mathematics problem-solving. Specifically, path analyses were used to investigate the relationships between two ER strategies (cognitive reappraisal and expressive suppression), SRL, and problem-solving outcomes for a sample of grade 3 through grade 6 students. Moreover, the phases of SRL were assessed as possible mediators of the relationship between ER strategies and problem-solving outcomes. Specifically, investigating the of roles of cognitive reappraisal and expressive suppression in tandem with students' engagement in SRL may extend theoretical understandings about which ER strategies are important antecedents to students' SRL during mathematics problem-solving. Additionally, the consideration of multiple ER strategies may provide important theoretical insights regarding the effectiveness of these ER strategies for supporting students' mathematics problem-solving outcomes. Taken together, this holds important practical implications for the design and implementation of interventions that support ER and SRL for mathematics learning in classrooms and schools.

Emotion Regulation

Emotions are complex processes that unfold over time and serve important physiological, cognitive, and behavioral functions (Frenzel et al., 2024; Scherer & Moors, 2019). Emotions are important to consider in educational research, as they support students' decision making, and provide feedback about the match between one's abilities and goals and the demands they encounter in their environment (e.g., classrooms; Gross, 2015; Schutz & Davis, 2000). Additionally, findings demonstrate that emotions can facilitate or constrain learning processes including cognition, motivation, strategy selection, and learning outcomes (Efklides et al., 2018; Goetz & Hall, 2020; Pekrun et al., 2017). For example, students who experience enjoyment for learning also demonstrate better task focus, increased intrinsic motivation, more effective SRL skills and positive learning outcomes (Ahmed et al., 2013; Obergriesser & Stoeger, 2020; Pekrun, 2002). Alternatively, students' experience of confusion and frustration negatively predicts learning strategy use (Muis et al., 2015; Muis et al., 2016). This is particularly relevant during mathematics problem-solving as students frequently report experiencing confusion and frustration (Di Leo et al., 2019). However, in line with adult populations (D'Mello et al., 2014) findings demonstrate that confusion can promote young students' learning outcomes when it is successfully resolved (Di Leo et al., 2019; Munzar et al., 2020). It is also theoretically plausible that positive emotions (e.g., relaxation) may interrupt self-regulatory and learning processes (see Goetz & Hall, 2020), although findings indicate that negative emotions are assigned higher processing priorities compared to positive emotions (Meinhardt & Pekrun, 2003). Taken together, these findings suggest that both positive and negative emotions can facilitate or constrain self-regulatory and learning processes. As such, it is critical for students to effectively regulate their emotions in order participate in classroom learning and adapt to academic expectations.

A growing body of research has demonstrated that children can and do regulate their emotions during learning (Di Leo & Muis, 2020; Graziano et al., 2007; Zachariou & Whitebread, 2019). Recall that ER refers to an individual's ability to employ cognitive and behavioral processes to alter which emotions they experience, when they experience them, and how they are experienced (Gross, 2015). To engage in ER children must employ their executive functioning (e.g., a set of cognitive processes that direct behavior; Diamond, 2016; Miyake & Friedman, 2012), metacognition (e.g., label their emotions), motivation (e.g., persist when experiencing challenging emotions), and strategic action (e.g., engage strategies and monitor their effectiveness in addressing emotional states; Hutchinson et al., 2021; Perry et al., 2018). Research findings demonstrate that childrens' ER abilities become increasingly internalized and sophisticated over time, and that children begin developing a robust repertoire of strategies as they physiologically mature (Cole et al., 2018). Findings have also demonstrated that ER is an important predictor of educational outcomes (Blair & Razza, 2007; Eisenberg et al., 2010; Graziano et al., 2007; Rudasil & Rimm-Kaufman, 2009), and that individual differences in ER abilities are related to differences in internal (e.g., age, temperament; Dennis et al., 2010; Rudasil & Rimm-Kaufman, 2009) and environmental variables (e.g., family systems, classroom processes; Feldman, 2015; Perry, 2013). Ultimately these differences in childrens' ER abilities, and the interactions between these internal and environmental variables, lead to differences in learning outcomes (Hutchinson et al., 2015). For example, findings demonstrate that kindergarten students who exhibit effective patterns of ER display coordinated cognitive abilities (Calkins & Marcovitch, 2010; Graziano et al., 2011), experience better quality relationships with their teachers, are more productive in classrooms, and have better academic outcomes (Graziano et al., 2007). In comparison, students who exhibit ineffective patterns of ER display decreased levels of effortful control and increased externalizing problems (Eisenberg et al., 2010; Rudasil & Rimm-Kaufman, 2009), which can lead to difficulties participating in classrooms.

In sum, children who display effective patterns of ER may be better prepared to meet classroom expectations, which may lead to more opportunities to develop effective metacognition, motivation and strategic skills. Alternatively, children who engage in ineffective ER may exhaust their affective, cognitive, motivational and behavioral resources (Tice et al.,

2004) while attempting to meet classroom demands, which may ultimately disrupt their abilities to regulate different processes (e.g., learning, behavior). Therefore, an important goal for schools is to support students' development of effective and adaptive patters of ER so that they can engage in the cognitive and behavioral processes that support their classroom participation and academic outcomes (Perry & Calkins, 2018). However, there is a lack of research which provides theoretical and empirical insight into which ER strategies effectively support students' self-regulatory processes and learning outcomes during domain-specific classroom-based learning activities (e.g., math). As such, the current study aims to assess which ER strategies support students' mathematics problem-solving outcomes during regular classroom activities.

To better understand what reflects effective patterns of ER, researchers have examined how specific ER strategies relate to cognitive, regulatory and learning processes (Davis et al., 2013; McRae & Gross, 2020; Sheppes, 2020). Initial work, conducted primarily in laboratories, suggests that cognitive reappraisal is an effective ER strategy as it does not overly tax cognitive resources, and is related to desired affective changes and better memory recall (McRae & Gross, 2020; Richards & Gross, 2000; Shafir et al., 2015; Webb et al., 2012). In comparison, expressive suppression, a response focused strategy that involves modulating responses through a variety of tactics (e.g., distraction, venting, behavioral inhibition), predicts increased negative affect, ineffective affect modulation, poor memory recall, and decreased well-being (Gross, 1998; Gross & John, 2003; Kalokerinos et al., 2017; Webb et al., 2012). Taken together, suppression appears to be a less effective and adaptive strategy than reappraisal as it may deplete students' cognitive resources and interfere with their ability to engage in metacognition, motivation and strategic action as well as their learning processes.

However, a great deal of this ER research is situated in laboratory settings (Shafir et al., 2015; McRae et al., 2011, McRae & Gross, 2020), and are not ecologically valid representations of the processes that unfold during classroom learning (Harley et al., 2019a; Loderer & Pekrun, 2019; Whitebread et al., 2007). There is accumulating evidence from classroom-based research which suggests that cognitive reappraisal may be an important antecedent to students' SRL and their learning outcomes (Losenno et al., 2020; Strain & D'Mello, 2015). Specifically, students who employ reappraisal strategies during learning activities experience increased motivation for learning, engagement in SRL, and consequently better achievement outcomes (Davis & Levine, 2013; Folsbrom, 2022; Losenno et al., 2020; Strain & D'Mello, 2015). There are however, some findings which suggest that the use of suppression during learning activities may support affective, motivational and cognitive processes. For example, students' use of suppression strategies has been related to decreases in negative emotions like boredom and anxiety (Schutz & Davis, 2000), and increases in motivation for disliked courses (Rottweiler et al., 2018). Additionally, the use of suppression in a sample of preschool students was related to decreases in self-control but not in verbal memory (Gunzenhauser & von Suchodoletz, 2014). Therefore, under the right conditions suppression may offer certain adaptive advantages for students' learning and achievement. These findings highlight the importance of context when measuring the effectiveness of distinct strategies (Harley et al., 2019a) and warn against the unilateral classification of ER strategies (Butler, 2021; Sheppes, 2020).

Since ER is an important predictor of classroom processes, learning outcomes, and processes that underlie targets of SR (e.g., SRL; Graziano et al., 2007; Rudasil & Rimm-Kaufman, 2009; Losenno et al., 2020), it is critical for researchers to investigate how different ER strategies are related to SRL and learning outcomes for elementary-aged students. However, research which considers how suppression interacts with important classroom processes like

SRL is limited, and no research which considers the roles of both reappraisal and suppression on students has been identified. To fill this gap, the current study assessed cognitive reappraisal and expressive suppression in relation to elementary-aged students SRL and outcomes during complex mathematics problem-solving.

Self-Regulated Learning

Recall that SRL is a target of SR that unfolds during learning (Perry et al., 2018; Winne & Perry, 2000) and requires students to employ their executive functions, metacognition (e.g., identify their strengths and weaknesses), motivation (e.g., persist during challenges), and strategic action (e.g., apply and monitor strategies; Diamond, 2016; Hutchinson et al., 2021; Muis, 2007; Zimmerman & Schunk, 2011). Theorists posit that there are distinct phases of SRL and models traditionally include multiple areas of regulation (e.g., emotion, cognition, motivation). For example, Muis et al. (2018) suggest that there are four phases of learning: task definition, planning and goal setting, enactment, and evaluation and five targets of regulation: affect (e.g., activity emotions), cognition (e.g., knowledge activation), motivation (e.g., achievement goals, self-efficacy), behavior (e.g., effort, time on task), and context (e.g., resources, instructional cues). Research has demonstrated that students engage in these phases of SRL in a loosely linear fashion (Losenno et al., 2020). For example, elementary-aged students switched between task definition and planning and goal setting before enactment their learning strategies and monitoring and evaluating their products during complex mathematics problem-solving (Muis et al., 2015; Losenno et al., 2020). Additionally, as products from one phase become available they inform other phases, which generates a source of cyclical feedback for students to employ to adjust their SRL strategies to effectively pursue learning goals and adapt to environmental demands (Muis, 2007). However, there is limited empirical research that statistically models and assesses how SRL unfolds during students' mathematics problem-solving (c.f., Losenno et al., 2020). Moreover, though some research has considered how older students regulate learning and motivation in tandem (Wolters, 2003), limited research has considered the interactions between multiple targets of SR during learning for middle to upper-elementary aged students (c.f., Di Leo et al., 2020). As such, the current study aims to statistically model students' engagement in the four phases of SRL during mathematics problem-solving in a loosely linear fashion, and to gain insight into the relationships between multiple targets of regulation by testing for reciprocal paths between ER and SRL.

Research has demonstrated that like ER, SRL is a predictor of students' educational outcomes across the life span (e.g., kindergarten, university; McClelland & Cameron, 2011; Rudasill et al., 2010; Vernon-Feagans et al., 2016; Winne, 2017). For example, students who engage in effective patterns of SRL display better quality relationships with their teachers (Rimm-Kaufmann et al., 2009), engage in deeper levels of cognition and metacognition during learning (Winne, 2017), and have better academic outcomes (Muis et al., 2015). Additionally, findings demonstrate that students who enter school with more developed executive functions are more prepared to engage in SRL, and adapt to the academic expectations they encounter when learning in school (Bryce et al., 2015). Alternatively, students who display maladaptive patterns of SRL also display poor executive functioning, and cognitive and metacognitive abilities (Bryce et al., 2015; Graziano et al., 2007; Perry, 2013). Moreover, students who demonstrate these ineffective patterns express experiencing less secure teacher-child relationships (McKinnon & Blair, 2018), and have difficulty requesting support during learning (Dunn et al., 2014). Moreover, students with poor SRL experience more negative emotions during complex learning, which can interfere with their learning processes and ultimately lead to disengagement (Muis et al., 2015). As such, it is possible that SRL is an important antecedent to students' ER as better SRL skills may relate to decreased experiences of negative emotions and therefore require less regulation.

Taken together, students whose SRL is poorly developed may experience a host of outcomes that interrupt their ability to effectively participate in classroom-based learning and pursue positive academic outcomes. One means of supporting students' experience of negative affect that may arise because of poor SRL skills, or during emotionally laden learning activities that may elicit negative emotions which can constraint SRL, is by engaging in ER. As previously mentioned, students' engagement in cognitive reappraisal is related to less negative affect and produces desired affective changes without overly taxing ones' cognitive resources (Gross, 2015; Frenzel et al., 2024). Additionally, findings have demonstrated that reappraisal is an important predictor of the phases of SRL (Losenno et al., 2020; Strain & D'Mello, 2015). However, if suppression leads to decreased negative affect this may also be a good strategy for students to employ during complex mathematics problem-solving. This reinforces the notion that there are possible reciprocal relationships between ER and SRL. As such, the aim of the current study is to assess whether there are reciprocal relationships, and what the strength and direction might be, between both reappraisal and suppression with SRL.

Summary of ER and SRL

How are ER and SRL related within the context of students' classroom-based learning? Remember that ER and SRL are both targets of broader SR, and share a reliance on the same underlying processes (i.e., executive functions, metacognition, motivation, strategic action; Diamond, 2016; Miyake & Friedman, 2013; Perry et al., 2018; Usher & Schunk, 2018). Specifically, ER in learning supports students' application of various strategies to alter their behaviour in response to their affect so they can pursue learning goals (Gross, 2015), whereas SRL permits students to select and apply learning strategies to pursue learning goals (Perry et al., 2018). Since learning can be an emotionally laden activity (Di Leo et al., 2019; Pekrun, 2018), and affect interacts with metacognition and motivation (Efklides et al., 2018), it is important that students are able to regulate their emotions during learning. Additionally, evidence suggests that ER is an important antecedent to SRL (Losenno et al., 2020; Strain & D'Mello, 2015). Findings demonstrate that children with ineffective patterns of ER display poor executive functioning (e.g., attention, inhibition), and have trouble participating in classrooms (Calkins & Marcovitch, 2010; Eisenberg et al., 2010; Graziano et al., 2007). Together, this may constrain childrens' abilities to engage in and develop effective metacognitive, motivational, and strategic action skills that also underlie SRL (Tice et al., 2004) and support learning and achievement.

So, what is effective ER? Recall that previous research has suggested that when cognitive reappraisal is compared to expressive suppression it is considered an effective ER, as it is less cognitively demanding and is related to better affective modulation (Richards & Gross, 2000; Webb et al., 2012). As such, it is possible that students who employ reappraisal during learning have more resources available to engage in SRL processes and pursue their learning and problem-solving goals. However, research has also demonstrated that reappraisal is most effective in regulating moderate intensity emotions (McRae & Gross, 2020), and that individuals do not employ reappraisal as frequently as other strategies (Suri et al., 2015). As a result, researchers have begun to question if expressive suppression may be an effective ER strategy for students to employ during learning and achievement activities. Suppression has been associated with increases in cognitive demands (Gross & John, 2003; Richards & Gross, 2000), which may interfere with students' abilities to engage their learning and SRL processes. However, findings also demonstrate that suppression was not related to any decreases in memory recall (Gunzenhauser & von Suchodoletz, 2014), but was related to decreased negative affect (e.g., anxiety; Schutz & Davis, 2000) and increased motivation for disliked courses (Rottweiler et al., 2019). Although suppression has been characterized as cognitively demanding and ineffective for learning, accumulating evidence suggests that suppression can effectively reduce negative affective experiences. Since negative affect can negatively interact with SRL processes and learning outcomes (e.g., metacognition, motivation, decision making, strategy selection; Efklides, 2018; Goetz & Hall, 2020; Pekrun et al., 2017), it may be that suppression is also an important antecedent to SRL, and students' learning outcomes.

It should be noted that effective SRL may also play an important role in students' abilities to engage in effective ER strategies. That is because effective SRL is related to reduced negative affect and increases in learning and achievement outcomes (Muis et al., 2015; Vernon-Feagans et al., 2016). Therefore, students with strong SRL skills may experience less distraction from their goals and learning tasks, and do not need to engage in ER as often as students with weak SRL skills. Research has also demonstrated that SRL mediates the relationships between reappraisal and students' mathematics problem-solving outcomes (Losenno et al., 2020). Specifically, students' enactment of their learning strategies positively mediated the role of reappraisal on problem-solving outcomes. This work highlights that there is an important relationship between students' SRL and their engagement in reappraisal. However, there is a paucity of research which has considered reappraisal and suppression in relation to students' engagement in SRL, and their mathematics problem-solving outcomes.

Current Study

The current study extends previous research as it analysed the relationships between two ER strategies (cognitive reappraisal, expressive suppression), the four phases of SRL (task definition, planning/goal setting, enactment of learning strategies, monitoring/evaluation) and mathematics problem-solving outcomes. To examine the relationships between these processes, 152 students (72 girls) from grade 3 through grade 6 participated. Students provided a self-report of the ER strategies that they typically use during classroom-based learning, with a specific focus on mathematics problem-solving. A concurrent think-aloud protocol (Muis et al., 2015) was used to capture students SRL during a complex mathematics problem-solving activity. This activity was employed as a measure of students' mathematics problem-solving outcomes.

Given that elementary-aged students can regulate their emotions during learning (Di Leo & Muis, 2020; Graziano et al., 2007; Zachariou & Whitebread, 2019), and distinct ER strategies can influence cognitive, affective, and motivational processes that support students' SRL and learning outcomes (Davis & Levine, 2013; Graziano et al., 2007; Losenno et al., 2020; Rotteweiler et al., 2019; Strain & D'Mello, 2015), the relationships between multiple ER strategies and the phases of SRL should be statistically modeled. As such, the current study modeled paths between cognitive reappraisal and expressive suppression with the four phases of SRL to delineate the relationships between these distinct ER strategies and SRL during complex mathematics problem-solving. Specifically, cognitive reappraisal is less exhaustive of students' executive functioning (Diamond, 2016), and has been associated with decreased negative affect, and better achievement outcomes (Brady et al., 2018; Davis & Levine, 2013; Richards & Gross, 2000; Strain & D'Mello, 2015). Moreover, there is accumulating evidence that reappraisal is an important antecedent to SRL (Losenno et al., 2020; Strain & D'Mello, 2015). Accordingly, we hypothesized a positive relationship between cognitive reappraisal and the four phases of SRL and students' mathematics problem-solving outcomes.

Based on previous findings (Graziano et al., 2007; Gross, 2015; Tice et al., 2004) that expressive suppression is related to poor cognitive functioning and can tax the processes involved in SR, we hypothesized a negative relationship between expressive suppression and the four phases of SRL and students' mathematics problem-solving outcomes. However, given the accumulating evidence that suppression may be an effective ER strategy (e.g., reduces negative affect, increases motivation; Rottweiler et al., 2018; Schutz & Davis, 2000), it is theoretically possible that suppression may have a positive relationship with students' engagement in SRL and their outcomes during emotionally-laden learning activities like complex mathematics problem-solving (Di Leo et al., 2019). Moreover, effective SRL may predict decreased engagement in all forms of ER since these students may experience less negative emotions (Muis et al., 2015), and thereby have less need to regulate those emotions. Therefore, it is important to test the possible reciprocal relationships between ER strategies and the phases of SRL. Interestingly, Losenno et al. (2020) found that a reciprocal model of cognitive reappraisal and SRL was a better fit to their data than a unidirectional model but did not find any statistically significant reciprocal paths likely due to small sample size (i.e., under-powered).

Moreover, previous research has demonstrated that SRL can mediate the role of cognitive reappraisal on students' mathematics problem-solving outcomes (Losenno et al., 2020). Specifically, task definition, planning and goal setting, and enactment mediated the role of reappraisal on mathematics problem-solving outcomes. However, limited research has examined the relationships between students' use of suppression and SRL during complex mathematics problem-solving. As such, less is known about how suppression and SRL function in tandem during an emotionally laden learning activity. The current study extends this work as it considered the relationships between two distinct ER strategies (cognitive reappraisal, expressive suppression), and SRL during complex mathematics problem-solving. Findings may provide important insight into the role of suppression during strategically challenging and emotionally laden learning activities such as mathematics problem-solving.

Research Questions

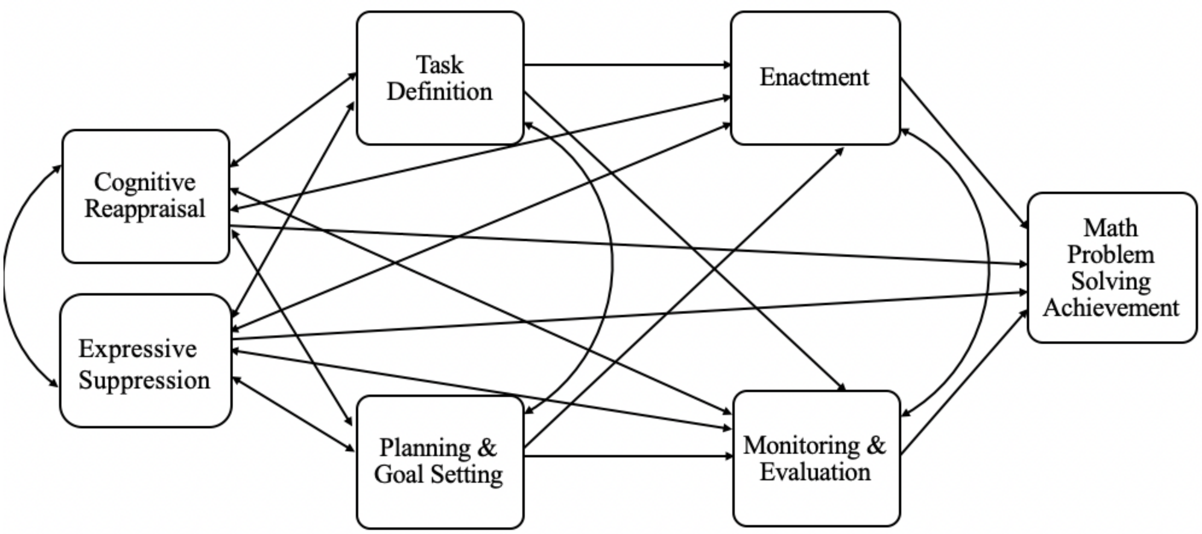
The research questions for the current study were as follows: (1) Do ER strategies have reciprocal relationships with the four phases of SRL? (2) Do ER strategies (reappraisal, suppression) predict the four phases of SRL (task definition, planning/goal setting, enactment of learning strategies, monitoring/evaluation) and mathematics problem-solving outcomes? (3) Do the four phases of SRL mediate the relationships between ER strategies and mathematics problem-solving outcomes?

Hypotheses

In line with previous theoretical and empirical findings (Di Leo et al., 2019; Losenno et al., 2020; Muis et al., 2016; Muis et al., 2018), it was hypothesized that a weakly-sequenced and reciprocal model of ER and SRL would be a statistically better fit to the data than a weakly sequenced unidirectional model (Hypothesis 1; for hypothesized model see Figure 1). Additionally, in line with previous research which suggests that reappraisal is an important antecedent to SRL and supports learning (Frenzel et al., 2024; Losenno et al., 2020, Muis et al., 2016; Perry et al., 2018; Strain & D’Mello, 2015), it was hypothesized that students use of reappraisal during complex mathematics problem-solving would positively predict the four phases of SRL: task definition, planning/goal setting, enactment of learning strategies, monitoring/evaluation; and positively predict their problem-solving outcomes while controlling for prior mathematics achievement (Hypothesis 2). As an extension to previous research (Losenno et al., 2020), and based on accumulating findings that suppression may be an effective ER strategy to use during emotionally challenging learning tasks (Frenzel et al., 2024) it was anticipated that students' use of suppression during problem-solving would positively predict the four phases of SRL, and their problem-solving outcomes while controlling for prior mathematics achievement (Hypothesis 3). Moreover, task definition and planning and goal setting phases of SRL should mediate the relationships between both ER strategies and enactment, monitoring and problem-solving outcomes (Hypothesis 4). Lastly, enactment and monitoring and evaluation should directly predict students' mathematics problem-solving outcomes (Hypothesis 5).

Figure 1

Hypothesized reciprocal model of ER, SRL and math problem-solving achievement



Note. For model clarity, the covariate prior achievement is not included in the figure but was included as a covariate for all variables.

Method

The data reported in this study is from Year 2 of a 3-year longitudinal study of middle- to upper-elementary-aged students' classroom-based self-regulation. During Year 1 (fall 2016), teachers and students from grades 3 to 6 from a single school in Montreal, Canada were recruited to participate in this study by the Principal Investigator (PI; Dr. Krista Muis). This school serves suburban neighbourhoods and the socio-economic status (SES) ranged from low to middle-high with students approximately evenly distributed across SES levels. Data collection commenced in the spring of Year 1 (2017) and the first cohort of grade 3 to 6 students were followed. At the beginning of each year (1, 2, 3), new grade 3 cohorts were recruited to participate and, prior to each data collection (e.g., Year 2 fall and spring) students from every grade were offered the opportunity to participate. Data from Year 2 (spring 2018) was selected for the present study as it is the first dataset that included a measure of two distinct ER strategies (i.e., cognitive reappraisal and expressive suppression). The larger project had two main goals: first, to gain insight into the roles and development of multiple facets of classroom-based SR (i.e., ER, SRL, and social SR) and, second, to examine how individual and environmental processes can facilitate and/or constrain the development of classroom-based SR (e.g., task-value, self-efficacy, instructional practices).

Participants

Participants include 152 students (72 girls) from all grade 3 to 6 classrooms from one public elementary school in Montreal, Canada. Parents consented to their children's participation, and students assented to their participation and could withdraw at any time without repercussions. At this school, the language of instruction was French and English wherein students spent equal amounts of time learning in both languages. In mathematics, the language of instruction was English. As such, students in different classrooms of the same grade had the same English/Mathematics teacher. Approximately 95% of participants were first-language English speaking, and the remaining students were first-language French speaking and were fluent in English. Participating students were Caucasian (87%), Black (2%), Hispanic (5%), Asian (4%) or Indigenous (2%). Teachers identified 21 students on Individualized Education Plans (IEP) who were provided adapted learning activates that supported their needs (i.e., simplified mathematics problem-solving activities).

Materials

Demographics. Students' sex (boy or girl) and age (date of birth) was obtained from parental consent forms (See Appendix A). See Table 1 for students' sex and age by grade level.

Emotion Regulation. The 10-item Emotion Regulation Questionnaire – Child and Adolescent (ERQ-CA; Gullone, & Taffe, 2012; See Appendix B) was used to measure students' employment of both cognitive reappraisals and expressive suppression. The original version, developed for research with young populations, was not developed in the context of classroom learning. As such, the PI Dr. Krista Muis adapted the language to situate ER during classroom-based mathematics problem-solving. That is, the PI instructed participants to think about their mathematics learning and problem-solving experiences as they completed the adapted ERQ-CA (e.g., "We would like to ask you some questions about how you control your emotions while at school, specifically during mathematics learning and problem-solving"). The cognitive reappraisal sub-scale consists of 6-items (e.g., "When I want to feel happier about something, I change the way I am thinking about it"), and the expressive suppression sub-scale consists of 4-items (e.g. "When I am feeling bad (e.g., sad, angry, or worried), I am careful not to show it"). A 5-point Likert scale was used to respond to each item where 1 = "Strongly Agree" and 5 = "Strongly Disagree". Responses were averaged across the reappraisal and suppression scales to generate a single score for each sub-scale. The reliability for the cognitive reappraisal scale was

α = .86, and the for the expressive suppression scale α = .76, which is consistent with previous research and standard of reliability for statistical application (DeVellis, 2016).

Table 1

Sex and age of students by grade

Grade	Boy	Girl	Total	Age	SD
Grade 3	22	22	44	8.66	0.48
Grade 4	20	8	28	9.74	.59
Grade 5	23	22	45	10.49	.51
Grade 6	15	20	35	11.56	.56
Total (152)	80	72		10.11	.54

Note. Age is represented as a mean value in years.

Self-Regulatory Processes. Following the recommendations of Muis et al. (2015), a concurrent think-aloud protocol was employed to capture students' use of self-regulated learning strategies as they solved a grade-appropriate mathematics problem. Each student was provided with Apple Ear Pods equipped with a microphone to record their voices on a remote recording device. Length of think-aloud recordings ranged from: minimum 3 minutes 41 seconds (grade 3 where the average duration was 10 minutes 9 seconds), and maximum 65 minutes 28 seconds (grade 6 where the average duration was 37 minutes 24 second; see Table 2 for means and standard deviations of think-aloud durations by grade level). Think-alouds were transcribed word for word and then segmented into meaningful units, which is a sentence or clause that consists of a thought or idea. The first author and third author then employed a coding scheme developed for elementary-aged students' mathematics problem-solving (Muis et al., 2015) to code segments. An iterative-coding process was used to code twenty-three micro-level SRL strategies (e.g., prior knowledge activation, goal setting, hypothesizing, calculating, evaluating; see Table 3 for a list of codes).

To ensure an acceptable inter-rater agreement, the first and third authors engaged in two phases of training over one month. The first phase of training consisted of coding four segmented transcripts together, two which were considered challenging to code and two which were straight forward. Coding of these transcripts continued until an acceptable level of inter-rater agreement was met. To establish inter-rater agreement, a two-way random intraclass correlation (ICC) coefficient was computed (ICC = .90). In the second phase, the two authors coded twelve transcripts (10% of the total transcripts) individually, six transcripts which were considered challenging to code and six transcripts which were considered straight forward. Inter-rater agreement was established at an acceptable level (ICC = .79). The remaining transcripts were then equally divided and coded by the first and third author.

Upon completion of coding, recommendations from Greene and Azevedo's (2009) protocol were followed and the twenty-three micro-level SRL codes were averaged into macro-level variables that represent the four phases of SRL: task definitions, planning/goal setting, enactment, monitoring/evaluation. To control for students' time on task and their verbosity, proportioned scores were calculated for each micro-level code wherein the raw frequency for each code was divided by the total frequency of codes (i.e., frequency of planning / total frequency of codes). As think-aloud protocols can yield zeros that represent meaningful values, a score of zero was substituted with the following formula to correct for skewness ($y = 1/4n$, where $y = 0$ and n = total frequency of codes; see Bohn-Gettler & Rapp, 2011; Tabachnick & Fidell, 2013).

Table 2

Descriptive information for think-aloud time by grade

Grade	Mean	SD
Grade 3	10.09	4.09
Grade 4	20.09	9.27
Grade 5	21.84	9.18
Grade 6	37.24	10.68

Note. Time is represented in minute

Table 3

Definitions and examples of micro- and macro-level learning strategies

Phase (macro)/ micro level	Code	Definition	Examples
Phase 1: Task definition		A learner generates a perception about the task, context, and the self in relation to the task. External and internal conditions play a major role.	Prior knowledge activation, beliefs, motivation, and knowledge of strategies are activated during this level.
Prior knowledge activation	PKA	Searching for or explicitly recalling relevant prior knowledge.	“Well I have to know percentages.” “So, I already know one fourth is equal to twenty-five in one hundred”.
Identifying important information	I3	Recognizing the usefulness of information.	“Ok, now I have to find, now I have to know that onions and herbs are one half of the area for the beets. “she needs to find the area that she will need to uh, to do her garden.” “So that’s what I need to figure out.”
Reading	R	Reading the problem, or its components, word for word.	“Sarah is planning her kitchen garden. She is planting many root vegetables to last her through the winter. This is the list of the vegetables and the amount of space Sarah has decided to give each one.”
Phase 2: Planning and goal setting		The learner begins to devise a plan to solve the problem and sets goals.	e.g., planning to use means-ends analysis, trying trial and error, identifying which part of the problem to solve first, solving it within a specific amount of time.
Making/restating a plan	P/RP	Stating what approach will be taken, what strategy will be used to solve the problem, or what part of the problem will be solved in some sequence. This includes restating plans.	“So, what we have to figure out is, is what 1 quarter of the garden is.” “So next, I have to do the uh beets.” “Now, how I found the area for each section.” “Let’s just test that out.”
Setting/restating a goal	G/RG	A goal is modeled as a multifaceted profile of information, and each standard in the profile is used as a basis to compare the products created when engaged in the activity. This includes restating goals.	“I’m looking for the space that she needs for her garden.” “we need to make the denominator all… we need to make the denominator… the equivalent. Every. Each denominator the same.” “I can’t spend too much time counting each vegetable”

Phase 3: Enactment		Enactment occurs when the learner begins to work on the task by applying tactics or strategies chosen for the task.	
Hypothesizing	HYP	Making predictions.	[learner is solving calculations] "It could be two. I think. It could be two." "It's either area [in reference to what the learner must calculate] or..." "It's probably the carrots, I did the carrots wrong I bet."
Summarizing	SUM	Summarizing what was just read in the problem statement.	[learner finishes reading] "So you know that potatoes will use one quarter of the garden. Cabbage is one fifth of the garden. Beets ten percent of the garden. Carrots 0.20 of the garden."
Help seeking	HS	Asking for help from a teacher, peer, or other source.	
-Information	-I	Help seeking for information	[calls on teacher] "Um, can I rip the pages apart please?" [referring to a component of the problem] "Do I have to fill it out?" "I have a question. Is this the garden? Just to make sure. Is that the garden?" "What do we do next?"
- Evaluation	- E	VERSUS help seeking for evaluation.	"I'm gonna ask [student], is that right?" [calls on teacher] "Am I doing this right?"
Coordinating informational sources	CIS	Using other sources of information to help solve the problem.	"I'm just going to go back to the thing [legend]"
Highlighting/labeling /coloring/ drawing/writing	HLC	Highlighting information, labeling information as part of the problem-solving process, or taking notes about the problem. Making a drawing to assist learning or as part of solving the problem	"I'm going to get a highlighter and highlight root." [highlighting] "I will write potatoes in that ¼ part of the garden." [labeling] [you can hear the learner's pencil] "I'm going to put the line right here" [drawing]
Calculating/measuring	CAL	Solving equations, measuring, or other similar features.	"So now, 10 divide by 5 is equal to 2. So, it's 5 by 2. Ok. 1, 2, 3, 4, 5" "So 100 divided by 4 is 25." [adding up the squares] "1, 2, 3, 4, 5, 6, 7, 8, 9, 10. 10 by 10. So that's 100 squares."

Re-reading	RR	Re-reading a section of the problem, word for word. Important that it is word for word, otherwise it is summarizing.	"I'm actually just going to reread it to make sure that I understand it completely."
Making inferences	MI	Making inferences based on information read or products created from solving the problem. (self-explanation) Explaining why something was done. Key word is *because*.	"I knew I made a mistake because they wouldn't give you a half there!" "If I end up with a small number like what I got last time, two, then that won't sound right." "Alright I did 100 divided by 4 because I wanted to find out the potatoes." [self-explanation]
Goal directed search	GDS	Intentionally searching for information related to the problem statement or the products created during problem-solving.	"I'm looking for how much the beets were so I can figure out the onions and herbs." [learner is looking for information regarding the problem] "Let's look at the other page." [learner gets stuck trying to solve the second component of the problem] "I'm going back to the first one [question] because I don't understand."
Phase 4: Monitoring and evaluation		Various types of reactions and reflections are carried out to evaluate the successes or failures of each level or products created for the task, or perceptions about the self or context. Reaction and reflection also includes judgments and evaluations of performance on a task as well as the attributions for success or failure.	Products created are compared to the standards set via metacognitive monitoring. Monitoring and evaluation can include any facet listed above (e.g., progress, motivation, plans, goals, strategies, products like answers or drawings made).
Self-questioning	SQ	Posing a question.	"So, what do I know right now?" "Why did I do this?" "What should I think about?" "Did I do this wrong?" "Is it cm, m or something else?"

Monitoring	MON	Monitoring something relative to goals.	[learner solves a component of the problem] “I wrote that down so I don’t forget.” [learner is calculating] “Okay, wait.” [referring to the worksheet] “I don’t have much space.” “Let me check if I went wrong somewhere.” “So, let me just count them just in case, I’m just going to count them.” “Someone’s going to come tell me your spending too much time on this.”
Judgement of learning	JOL	Learner is aware that something is unknown, not fully understood, or difficult to do.	“Uh, ok I’m stuck…I’m not sure what is essential to think about.” “I’m not sure how I’m gonna show that.” “I don’t understand this.” “I’m going to have a hard time doing this.” “I need help.” “This doesn’t make sense.”
Self- correcting	SC	Correcting one’s mistakes.	“No! not beets. Sorry. The carrots! I already did beets.” [learning is counting the problem space] “And then same with the onion - no, the onions and the herbs are only 5.” “I forgot to put an ‘a’ after the ‘c’ [referring to labels], so c-a, c-a, c-a, c-a.”
Evaluation	EVAL	Judging whether goals have been met, whether a strategy is working, whether the answer is correct, whether the work is neat, etc. Judgment of all facets that fall under monitoring.	“I don’t need to write that down.” [after counting the area of each vegetable] “Perfect! It fits completely in my garden!” “Uh oh, I did it wrong.” “Yah so 10, that’s the answer.” “So, we figured that [part of the problem] out.” “This is so messy.” “I’m not done.” “I made a mistake!”
Control	CON	Changing strategy when monitoring or evaluation results in a determination that goal has not been met.	[learner runs out of workspace] “I’ll have to do it really really small.” “This doesn’t seem very right so I’m going to erase it [after judging the garden was not correctly drawn] “I have to restart the puzzle piecing, at least I’ll know all the areas.”
Task Difficulty	TD	Statements reflecting the difficulty or easiness of a task.	“That was easy enough.” “Ok, this is not fun, this is hard!”

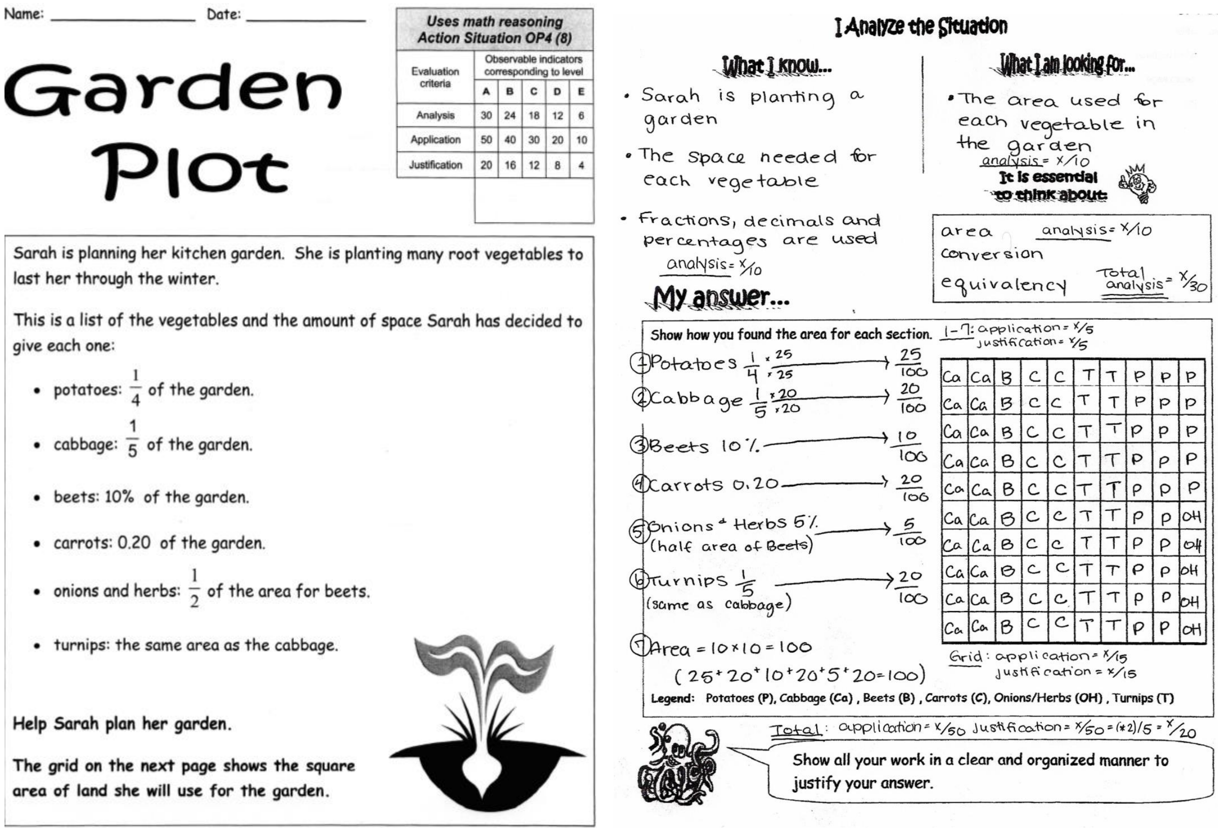
Mathematics Problem-solving Outcomes. Students completed one complex mathematics problem, which was chosen by their teacher from the regular curriculum and was grade levelappropriate. A total of four mathematics problems were used, such that students in the same grade level (e.g., grade 6) completed that same problem regardless of their classroom enrollment (see Figure 2 for grade 5 problem; see Appendices C to F). Each complex problem was made-up of three interrelated components that require students to preform several operations to interpret, represent, confirm, delineate and legitimate their solutions (Ministère de l'Éducation et Enseignement Supérieur, 2018; see Appendix G). The analysis component, worth 30%, required students to identify important information that was provided in the problem. This information included what they knew about the problem and what they had to figure out (i.e., the solution or end goal). The application component, worth 50%, included students' problem-solving steps (i.e., their calculations). Lastly, the justification component, worth 20%, required justification of students' answers (i.e., full sentence statements, final answers). Students who were identified as having an IEP were provided with an adapted problem that maintained the same structure but was simplified (i.e., less information to identify, fewer calculations required/aspects to solve). In all, these complex problems are considered challenging because the procedures required to successfully solve the problem are not obvious, and the provided instructions do not explicitly state which concepts and processes must be employed to reach a solution. Rather, these problems require students to rely on their repertoire of math concepts and processes, as well as their learning strategies, and to apply them in new ways (Ministère de l'Éducation, du Loisir et du Sport, 2009).

To grade students' solutions, the corresponding standardized provincial grading scheme was employed for each problem. Students were awarded full points for successful and accurate completion of each component (analysis, application, justification), half points were awarded for partial accuracy and completion, and zero points were awarded for inaccurate and/or incomplete components (see Figure 2 for grading scheme). Performance on one component of the mathematics problem (e.g., analysis) did not automatically influence grading on another component (e.g., application). For example, a student received full marks for completing their analysis and application components correctly even if they omitted or incorrectly answered aspects of the justification component. If a student omitted a step in the application component however, this would prevent them from completing the justification component and therefore their justification grade would be affected due to missing information. Students' grades were summed across each of the three problem-solving components for a total score out of 100. The PI and I graded 10% of the problems from each grade leveland obtained 100% inter-rater agreement. I graded the remaining mathematics problems.

Prior Mathematics Achievement. Teachers provided ratings of their students' mathematics achievement using two items (e.g., "What is this child's achievement level in terms of provincial expectations for Mathematics – solves a situational problem?") from the Self-Regulation in School Inventory (SRISI; Hutchinson, 2013; See Appendix H). Items were rated using a 7-point Likert scale anchored at four points, where Achievement Level 1 corresponds with failure to meet provincial standards and a score of 1; Achievement Level 2 corresponds with approaching provincial standards and a score of 3; Achievement Level 3 corresponds with meeting provincial standards and a score of 5, and Achievement Level 4 corresponds with surpassing provincial standards and a score of 7. This scale is like that which teachers employ when completing interim report cards for their students (e.g., each fall), and is correlated to their grades later in the year (i.e., r = .60, Muis et al., 2015). This scale was employed to standardize students' math achievement across grades and was used as a covariate for analyses. The reliability for this measure was α = .94, and teachers' ratings were correlated to students' problem-solving outcomes on the measures employed in this study (r = .31, p < .001). At the end of the questionnaire, teachers were provided space to report the IEP status of each student.

Figure 2

Grade 5 complex mathematics problem and grading scheme


Name: ______________ Date: ______________

Garden Plot

Uses math reasoning Action Situation OP4 (8)					
Evaluation criteria	Observable indicators corresponding to level				
	A	B	C	D	E
Analysis	30	24	18	12	6
Application	50	40	30	20	10
Justification	20	16	12	8	4

Sarah is planning her kitchen garden. She is planting many root vegetables to last her through the winter.

This is a list of the vegetables and the amount of space Sarah has decided to give each one:

- potatoes: $\frac{1}{4}$ of the garden.
- cabbage: $\frac{1}{5}$ of the garden.
- beets: 10% of the garden.
- carrots: 0.20 of the garden.
- onions and herbs: $\frac{1}{2}$ of the area for beets.
- turnips: the same area as the cabbage.

Help Sarah plan her garden.

The grid on the next page shows the square area of land she will use for the garden.

I Analyze the Situation

What I know...

- Sarah is planting a garden
- The space needed for each vegetable
- Fractions, decimals and percentages are used

analysis = x/10

What I am looking for...

- The area used for each vegetable in the garden

analysis = x/10

It is essential to think about:

area
conversion
equivalency

analysis = x/10
Total analysis = x/30

My answer...

Show how you found the area for each section.

1-7: application = x/5
justification = x/5

1. Potatoes $\frac{1 \times 25}{4 \times 25} \rightarrow \frac{25}{100}$
2. Cabbage $\frac{1 \times 20}{5 \times 20} \rightarrow \frac{20}{100}$
3. Beets 10% $\rightarrow \frac{10}{100}$
4. Carrots 0.20 $\rightarrow \frac{20}{100}$
5. Onions + Herbs 5% (half area of Beets) $\rightarrow \frac{5}{100}$
6. Turnips $\frac{1}{5}$ (same as cabbage) $\rightarrow \frac{20}{100}$
7. Area = 10 × 10 = 100 (25 + 20 + 10 + 20 + 5 + 20 = 100)

Ca	Ca	B	C	C	T	T	P	P	P
Ca	Ca	B	C	C	T	T	P	P	P
Ca	Ca	B	C	C	T	T	P	P	P
Ca	Ca	B	C	C	T	T	P	P	P
Ca	Ca	B	C	C	T	T	P	P	P
Ca	Ca	B	C	C	T	T	P	P	OH
Ca	Ca	B	C	C	T	T	P	P	OH
Ca	Ca	B	C	C	T	T	P	P	OH
Ca	Ca	B	C	C	T	T	P	P	OH
Ca	Ca	B	C	C	T	T	P	P	OH

Grid: application = x/15
justification = x/15

Legend: Potatoes (P), Cabbage (Ca), Beets (B), Carrots (C), Onions/Herbs (OH), Turnips (T)

Total: application = x/50 Justification = x/50 = (×2)/5 = x/20

Show all your work in a clear and organized manner to justify your answer.

Note. The first image represents the problem-solving question and the second image represents the grading scheme.

Procedure

Approximately one week prior to classroom-based data collection, in spring of 2018, teachers provided ratings of their students' prior mathematics achievement using the SRISI (Hutchinson, 2013). This timing ensured that teachers were acquainted with their students' skills and provides a calibration point between students' actual skills and teachers' perceptions of their students learning and self-regulatory skills in classrooms. The subsequent data collection took place over two days during regular classroom hours. On the first day, the PI instructed students to respond to items on the adapted ERQ-CA (Gullone & Taffe, 2012). Students then completed the ERQ-CA as the second author read each item aloud and provided students with specific examples related to classroom-based learning. As part of the larger project, students subsequently participated in a typical classroom-based review of mathematics problem-solving content that was led by their Mathematics teacher. The following day, the students were trained how to think out-loud. This included a step-by-step process (Di Leo et al., 2019; Muis et al., 2015, 2016; Losenno et al., 2020) in which students listened to an audio recording that provided an example of a poorly-executed think-aloud during a mathematics problem-solving situation, followed by a well-executed example. In line with think-aloud protocols for elementary-aged students (Muis et al., 2015, 2016; Losenno et al., 2020; Munzar et al., 2020), barriers were placed between students to ensure that they could not see each other's work.

Students were then provided with a grade appropriate complex mathematics problem that was selected by classroom teachers from the curriculum. In line with their classroom practices, each classroom teacher introduced the problem to their students and read the instructions aloud. The noise level in the classroom was monitored by six to eight research assistants who were circulating the classroom to ensure that students could not hear one another clearly. However, students who did find the noise distracting (n =18) were moved to a supervised learning space in the library. The research assistants ensured that students continued to think-aloud during the protocol and prompted students to continue talking after they had been quiet for five seconds. Teachers were also present in the classrooms, and in line with their typical classroom practices they answered students' questions during the mathematics problem-solving activity.

Results

Preliminary Analyses and Data Analytic Approach

First, skewness and kurtosis values were examined for ER strategies, the macro-phases of SRL, and mathematics problem-solving outcomes using Tabachnick and Fidell's (2013) criteria of < |3| for skewness and < |8| for kurtosis. Findings indicate that mathematics problem-solving outcomes (-3.54/ -0.48) was slightly skewed. Given that "0" has meaningful value for students' problem-solving outcomes, however, this score should not be transformed. To address this, the Maximum Likelihood Robust (MLR) estimator was employed in subsequent path analyses. Moreover, the think-aloud protocols yielded some zeros for micro-level strategies which were substituted with the following formula to correct for skewness (y = 1/4n, where y = 0 and n = total frequency of codes; see Bohn-Gettler & Rapp, 2011; Sheskin, 2004; Tabachnick & Fidell, 2013). The task definition phase had a single micro-level variable, reading, that demonstrated high skewness (10.54) and kurtosis values (9.78). The planning and goal setting phase also had a single variable, planning, that surpassed the cutoff for skewness (5.66). In the enactment phase, there were four micro-level variables that violated skewness: summarizing (-7.04), help seeking evaluation (-8.40), coordinating informational sources (-9.35), and highlighting/labeling/coloring (6.90). Lastly, for the monitoring and evaluation phase, three variables were past the cutoff value for skewness: goal directed search (-6.54), self-questioning (5.61), and self-correcting (7.21). However, the inclusion of these micro-level variables at the macro-level did not affect normality and therefore were included in analyses. See Table 4 for skewness and kurtosis values, as well as means and standard deviations for all variables.

Table 4

Descriptive information for study variables

	Mean	SD	Skew	Kurtosis
Cognitive reappraisal	3.25	0.97	-0.93	-1.62
Expressive suppression	2.77	0.89	0.42	-0.01
Task definition	0.09	0.06	1.81	-1.67
Planning and goal setting	0.10	0.07	2.11	-2.92
Enactment of learning strategies	0.16	0.04	1.87	-0.53
Monitoring and evaluation	0.14	0.05	2.59	-1.16
Math problem-solving outcome	72.71	20.43	-3.54	-0.48
Prior math achievement	4.64	1.30	-0.60	-1.38

Note. Means for the phases of SRL are reported as proportioned values. Math problem-solving outcome is reflected as a percentage.

Second, evidence that mathematics problems were challenging for students is demonstrated by their average scores, the time they spent on task and their verbalizations captured by the think-aloud protocol during problem-solving (see Table 5 for means and standard deviations of problem-solving outcomes). Third, given the nested nature of classroom-based data (students within classrooms), ICCs were computed for each variable to determine whether nested analyses were necessary. That is ER, SRL, and problem-solving outcomes were separately assessed as dependent variables to determine if the variance associated with the variable could be explained by students' grade level or classroom enrollment (e.g., teacher). All ICC values were less than 0.05 and indicate that nested analyses were not necessary (see Meyers et al., 2016). Therefore, students were grouped into a single sample. See Table 6 for correlations between variables.

Table 5

Descriptive information for math problem-solving outcomes by grade

Grade	Mean	SD
Grade 3	68.57	16.50
Grade 4	50.79	20.62
Grade 5	84.80	13.62
Grade 6	80.73	15.66

Note. Grade is represented in percentage.

Lastly, to test the fit of the data to a two-factor model of ER strategies (i.e., reappraisal, suppression) a Confirmatory Factor Analysis (CFA) was computed using Mplus 8.0 (Muthén & Muthén, 2017). Results demonstrated that a two-factor model of ER was a better fit to the data ($\chi 2$ (df = 34) = 63.73, $p < 0.01$, CFI = 0.93, RMSEA = 0.05), than a single factor model ($\chi 2$ (df = 35) = 173.75, $p < 0.01$, CFI = 0.74, RMSEA = 0.16).

Table 6

Pearson product-moment correlations for study variables

	2	3	4	5	6	7	8	9	10	11
1. Sex	-0.74	-0.12	-0.20*	0.20*	0.08	0.09	0.13	0.09	-0.19*	0.05
2. Grade		-0.13	-0.06	-0.08	-0.42**	-0.26**	-0.54**	-0.48**	0.36**	0.00
3. IEP			0.08	0.01	0.11	0.23**	0.02	0.04	-0.30**	-0.38**
4. Cognitive reappraisal				0.03	-0.04	0.04	0.11	0.08	-0.10	-0.09
5. Expressive suppression					0.15	-0.06	0.08	0.04	-0.06	-0.10
6. Task definition						0.36**	0.43**	0.37**	-0.19*	-0.25**
7. Planning and goal setting							0.21*	0.21**	-0.01	-0.01
8. Enactment								0.56**	-0.11	0.09
9. Monitoring and evaluation									-0.18*	0.06
10. Math problem-solving outcome										0.30**
11. Prior math achievement										

*p < 0.05, **p < 0.01.

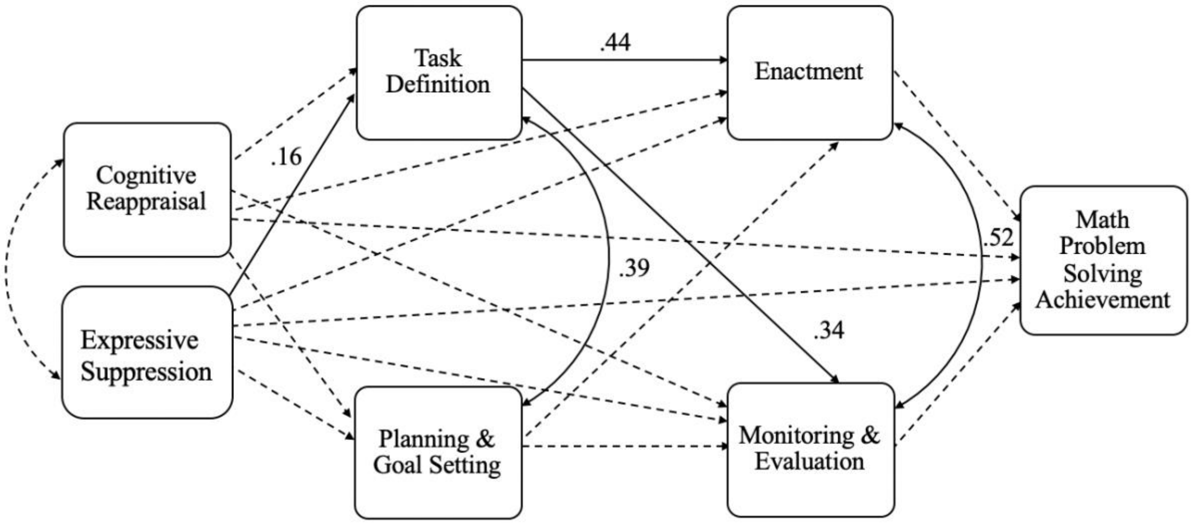
Path Analyses

To test the proposed mediation models, Mplus 8.0 (Muthén & Muthén, 2017) was used. The MLR estimator was employed, which precludes the use of bias-corrected bootstrapping (Muthén & Muthén, 2017). To assess the first research question, fit indices for a weakly sequenced reciprocal model of ER and SRL were compared to a weakly sequenced unidirectional model to determine which model better represented the relationships between ER and SRL processes during mathematics problem-solving. Cognitive reappraisal and expressive suppression were included as antecedents to the four phases of SRL, and mathematics problem-solving was a dependent variable with prior achievement included as a covariate.

Results from the weakly sequenced unidirectional model displayed a relatively good fit to the data, $\chi 2$ (df = 6) = 15.18 p = 0.02, CFI = 0.92, RMSEA = 0.10 CI [0.04, 0.17]. Though some research has indicated that RMSEA values falling between 0.08 – 0.10 represent a mediocre or poor fit of the model to the data, recent findings indicate that models with low *df* and small samples have increased rejection rates (e.g., RMSEA > 0.10; Kenny et al., 2015; Chen et al., 2008). Moreover, in line with findings from Curran et al. (2003), the CI coverage for small samples is considerably low (0.13), whereas the coverage should approach 0.95 (Kenny et al., 2015). Alternatively, the weakly sequenced reciprocal model displayed revealed a poor fit to the data, as the model could not reach convergence. These results support modeling the relationship between ER and SRL as unidirectional (see Figure 3 for final model).

Figure 3

Final model



Note. For model clarity, the covariate prior achievement is not included in the figure but was included as a covariate for all variables. Dashed lines represent non-significant paths.

To assess the second research question, the direct paths between ER, SRL and problem-solving were assessed. In support of the hypotheses, suppression positively and directly predicted task definition [β = 0.16, p = 0.03] when controlling for prior math achievement. Additionally, task definition positively and directly predicted enactment [β = 0.44, p < 0.001], and monitoring and evaluation [β = 0.34, p < 0.01]. Contrary to hypotheses, suppression did not directly predict planning and goal setting [β = -.080, p = 0.40], enactment [β = 0.01, p = 0.91], monitoring and evaluation [β = -0.04, p = 0.60], or problem-solving [β = 0.03, p = 0.98]. Moreover, cognitive reappraisal did not directly predict task definition [β = -0.03, p = 0.66], planning and goal setting [β = 0.06, p = 0.51], enactment [β = 0.10, p = 0.16], monitoring and evaluation [β = 0.11, p = 0.12], or problem-solving [β = -0.06, p = 0.51]. Furthermore, planning and goal setting did not directly predict enactment [β = 0.08, p = 0.35], or monitoring and evaluation [β = 0.06, p = 0.53]. Lastly, enactment [β = -0.06, p = 0.57] and monitoring and evaluation [β = -0.16, p = 0.12] did not directly predict problem-solving. Finally, prior achievement positively and directly predicted problem-solving [$\beta = 0.28$, $p < 0.01$], with approximately 54% of the variance in outcomes explained by the full model.

For the third research question, mediation analyses demonstrated that task definition mediated the relationship between suppression and enactment, indirect effect = 0.07, $p = 0.05$, and the relationship between suppression and monitoring and evaluation, indirect effect = 0.05, $p = 0.05$. These findings suggest that task definition mediated the relationship between expressive suppression and later phases of SRL.

Discussion

ER and SRL are two distinct targets of SR that support students' classroom abilities and outcomes across their educational careers (Di Leo et al., 2019; Muis et al., 2015; Perry & Calkins, 2018; Perry et al., 2018; Zachariou & Whitebread, 2019). Researchers have examined how single ER strategies interact with SRL (Di Leo & Muis, 2020; Losenno et al., 2020), or educational outcomes (Davis & Levine, 2013; Graziano et al., 2013) with younger (e.g., preschool, early-elementary school) and older students (e.g., middle school, university). However, there is limited research that considers how multiple ER strategies interact with students SRL and their learning outcomes in tandem, especially for middle to upper-elementary aged students. The current study addressed this gap as it examined the relationships between cognitive reappraisal and expressive suppression (ER strategies) with students' SRL and their complex mathematics problem-solving outcomes. Specifically, the phases of SRL were modeled in a loosely linear fashion, and reciprocal relationships were tested between both ER strategies and the phases of SRL. That is, task definition and planning and goal setting phases of SRL were modeled prior to the enactment of learning strategies and monitoring and evaluation to determine if students engage in SRL in sequence. Additionally, the current study examined whether the phases of SRL mediated the relationship between students' use of reappraisal and suppression, and their problem-solving outcomes.

The first research question asked, "Do ER strategies (reappraisal, suppression) have reciprocal relationships with the four phases of SRL (task definition, planning/goal setting, enactment of learning strategies, monitoring/evaluation?)". Given theoretical models of SRL indicate that the phases of SRL unfold in a loosely linear fashion (Muis, 2007; Muis et al., 2018), and empirical research has demonstrated that middle- to upper-elementary aged students employ SRL in weakly sequenced manner, the phases of SRL were modeled in sequence with prior achievement as a control. Fit indices demonstrated the unidirectional model was a better fit to the data. This is in line with previous empirical findings which demonstrate that although a reciprocal model of cognitive reappraisal and the four phases of SRL were a better fit to data in a similar population (upper- to middle-elementary aged students) in the same learning domain (mathematics problem-solving), the reciprocal paths were not statistically significant (Losenno et al., 2020). It is possible that the inclusion of multiple ER strategies (e.g., cognitive reappraisal, expressive suppression), paired with relatively low-power (i.e., small sample size) may account for the statistically non-significant findings for the reciprocal model in this study.

Moreover, it is possible that reciprocal relationships between students' use of ER strategies and their engagement in SRL exist but that the direction (i.e., positive or negative) of the paths from one variable to the other are not bi-directionally uniform. For example, if the path between suppression (ER) and planning and goal setting (SRL) is statistically significant and positive but the path from planning and goal setting to suppression is significant but negative, the overall statistical results may not suggest statistical significance (see Zhao et al., 2010).

However, the current study is limited in testing these claims, as models with one ER variable, or that phases of SRL held as predictors were not tested as part of the presented research questions. Given theoretical and empirical research support that ER and SRL can both be antecedents to one another (Davis & Levine, 2013; Frenzel et al., 2024; Losenno et al., 2020; Strain & D'Mello, 2015), future research should continue to assess which statistical models best represent these phenomena in classrooms. This is particularly important to consider as diverse populations of learners (e.g., kindergarten, elementary, university students) in distinct learning domains (e.g., literacy, mathematics, physics) may be related to differences in statistical models.

Additionally, it is possible that the design of the current study does not allow for the potential reciprocal relationships between ER and SRL to be captured. That is because this study was designed to assess how students engaged in ER and SRL during a complex mathematics problem-solving activity. As such, the relationships between these two targets of SR were captured during a single event as opposed to across multiple events that took place during classroom-based learning across the school year. Future longitudinal research which considers how ER and SRL interact and develop over time during classroom learning in domain specific achievement situations may provide insight into the possible reciprocal relationships between these two targets of SR. This research may support researchers understanding of how best to support students' development of SR and thereby inform the design of interventions and classroom practices for supporting SR at a global classroom level.

The second research question assessed if cognitive reappraisal and expressive suppression predict the four phases of SRL, and problem-solving outcomes. Findings indicate that when controlling for prior mathematics achievement, students' use of expressive suppression positively and directly predicted their engagement in task definition. However, suppression did not predict any other phases of SRL, nor did cognitive reappraisal predict any phases of SRL. Although previous research has indicated that suppression may be ineffective for learning as it may tax one's cognitive resources and ultimately impair learning and self-regulatory processes (e.g., metacognition, motivation, strategic action; Gross & John, 2003; Tice et al., 2004; Webb et al., 2012), the findings in this study challenge this notion. Specficially, findings suggest that suppression is a positive antecedent to early SRL and therefore may be an effective ER strategy for students to employ during learning. This is in line with some accumulating evidence that suppression is effective for increasing students' motivation for disliked courses (Rottweiler et al., 2019), and effectively reduces students' negative affective (Schutz & Davis, 2000). Since negative emotions are related to the use of shallow learning strategies and are known to diminish students' cognitive resources, and hinder learning processes and outcomes (Goetz & Hall, 2020; Meinhardt & Pekrun, 2003; Pekrun et al., 2017), suppression may be an effective strategy to use to regulate negative emotions, particularly more intense ones (Shafir et al., 2015). It should be noted that, while negative emotions are understood to be assigned a higher processing priority compared to positive emotions, that positive emotions may also drain task-related processing resources (Meinhardt & Pekrun, 2003). However, there is no known research to date which assesses how suppression may be effective for students' regulation of positive emotions.

Additionally, given the important role of motivation in all targets of SR such that it supports students to persist in the face of challenges (Hutchinson, 2013; Perry et al., 2018), and that negative emotions can decrease students' motivation for learning (Efklides et al., 2018; Pekrun et al., 2002), suppression may be an effective ER strategy for increasing motivation. This is especially likely in a strategically challenging and emotionally laden activity such as mathematics problem-solving wherein students' frequently report experiencing confusion and frustration (Di Leo et al., 2019). For example, students who experience negative emotions at the start of a mathematics problem-solving activity (e.g., confusion, anxiety) may benefit from employing suppression such that they are better able to channel their cognitive resources towards defining the parameters of the task which includes considering instructional cues, activating prior knowledge and experience, and the emotions they experience about the task (Muis, 2007; Muis et al., 2018). As such, under these conditions the use of suppression may free up the cognitive, affective, motivational, and strategic resources that students require to engage in SRL effectively and adaptively. Future research which includes assessments of students' emotions and motivations may provide important insight into the relationships between suppression and SRL during complex mathematics problem-solving.

Regarding the statistically non-significant findings of expressive suppression on the remaining phases of SRL and mathematics problem-solving, it is possible that engaging this ER strategy in tandem with other SRL and mathematics problem-solving processes may overly burden underlying cognitive, metacognitive, motivational, and behavioral processes involved in SRL and problem-solving. For example, suppression may be an effective strategy for supporting engagement in an early phase of SRL such as task definition, since this phase is not as cognitively demanding when compared to a later phase of SRL like the enactment of learning strategies. That is, the procedural work one must do during the mathematics problem-solving activity may deplete the cognitive resources required to engage in suppression as children attempt to calculate, hypothesize, and solve components of the mathematics problem while monitoring and evaluating their goals, plans and products of their work in tandem. As such the timing in which students employ ER strategies in relation to SRL strategies is an important line of future research which may provide insight into how ER strategies effectively support learning processes and outcomes (Scheppes, 2020).

Complementary to the findings from the current study regarding the positive and significant relationship between suppression and SRL, students' emotional experiences and motivational mindsets may also be related to the statistically non-significant findings between cognitive reappraisal and SRL. Previous findings have demonstrated that the effectiveness of reappraisal as an ER strategy is decreased when it is being used to regulate intense as opposed to mild or moderate emotions (McRae & Gross, 2020). In consideration of the research findings that indicate mathematics problem-solving is an emotionally laden and strategically challenging activity for middle to upper-elementary aged students (Di Leo et al., 2019; Muis et al., 2015) it is possible that students' experience emotions more intensely than they might during a less challenging task. As such, if students experience intense positive emotions, or any negative emotions at the onset of problem-solving it may be easier for students to employ suppression to engage in their SRL processes. That is, if a student reframes the emotions they experience early in problem-solving, the associated cognitive demands may interfere with their ability to engage in SRL, procedural problem-solving processes and ultimately hinders their problem-solving outcomes. This possibility reinforces that it is important for researchers to investigate how discrete emotions may influence students' engagement in and development of effective and adaptive regulation strategies during diverse learning activities.

It is also possible that the value students place on the mathematics problem-solving activity and their appraisals about their task-specific abilities may underlie the statistically non-significant findings between reappraisal and the phases of SRL. That is, theorists posit that a key antecedent to students' use of reappraisals are students' judgements about their domain-specific abilities (e.g., control) and their task-value (Frenzel et al., 2024; Harley et al., 2019; Schutz & Davis, 2000). However, this study is limited in that it did not assess students' beliefs about their task specific abilities and values. As such, continued research which considers the role of students' beliefs about their abilities (i.e., control) and the value of mathematics problem-solving (i.e., task value), as well as the emotions they experience while engaging in the problem-solving activity is necessary. Such research designs would support aims to gain insight into the important antecedents of ER and SRL in the context of classroom-based mathematics problem-solving, and ultimately serve to inform educational design in this domain.

Taken together, these findings of the current study reinforce that it is an important goal of schools to support students' ER skills (Perry & Calkins, 2018), as this may also support their SRL skills. However, given mixed findings in the current study as well as the current literature regarding the effectiveness of reappraisal and suppression for supporting students' SRL, it is critical that researchers continue to examine the relationships between multiple ER strategies and educational outcomes. Moreover, future research which considers emotions and motivation as antecedents to students' ER may support theoretical understandings about why students select specific ER strategies, and when a strategy might be most effective and adaptive for SRL and learning outcomes. This may support researchers and educators in designing and integrating interventions at a classroom-level that support students' emotional understanding (e.g., metacognition), and developing a repertoire of strategies that supports their ER, SRL and ultimately their academic outcomes.

The final question asked whether the phases of SRL mediate the relationship between ER strategies and mathematics problem-solving outcomes. Findings from the current study partially support the hypotheses by demonstrating that task definition mediated the relationship between expressive suppression and the later phases of SRL: enactment and monitoring and evaluation. These findings provide additional support for theoretical models of SRL which suggest that students engage in SRL in a weakly sequenced fashion (Muis, 2007; Muis et al., 2018). Moreover, these findings are in line with previous findings which indicate that ER is an important antecedent to SRL, and learning outcomes (Gross, 2015; Hutchinson, 2013; Losenno et al., 2020). However, previous research has implicated cognitive reappraisal as an effective ER strategy that supports SRL and learning outcomes and has either not considered the role of suppression or has characterized it as an ineffective ER strategy. By considering both ER strategies in tandem, the current study challenges the notion that suppression may be an ineffective ER strategy and provides evidence that students' use of suppression during mathematics problem-solving can be effective in that it supports their use of learning strategies. Results from this study extend researchers understanding of the relationships between students' use of ER strategies and their engagement in the different phases of SRL, and reinforce that ER strategies should not be unilaterally classified when contextual factors (e.g., learning domain) are not considered (Butler, 2021).

Although findings from the current study indicate that suppression is an effective ER strategy for supporting SRL during a particularly challenging and emotionally laden learning activity (i.e., complex mathematics problem-solving), additional research is needed to assess how students' SR develops at a global level in classrooms. To date, research which examines whether differences in pedagogical practices may promote or curtail individuals' development of ER is limited (Hamre & Pianta, 2005). However, available findings suggest that differences between classroom instructional practices are related to differences in students' development and application of SRL (Perry & VandeKamp, 2000; Perry et al., 2018). Given that ER is an important antecedent to SRL and learning outcomes (Davis & Levine, 2013; Frenzel et al., 2024; Losenno et al., 2020), and that targets of SR (e.g., ER, SRL) share a reliance on the same underlying processes (e.g., executive functions, metacognition; Diamond, 2016; Perry et al., 2018; Usher & Schunk, 2018), it is critical for researchers to gain insight as to whether pedagogical practices support students' development of their ER and SRL skills in tandem.

Furthermore, findings from the current study indicated that prior mathematics achievement was a statistically significant direct predictor of students' mathematics problem-solving outcomes. This is supported by previous findings which indicate that teachers' ratings of their students' mathematics abilities are reliable predictors of their mathematics outcomes (Hutchinson et al., 2021; Whitebread et al., 2009). However, findings that the phases of SRL did not predict students problem-solving outcomes diverge from previous research which has demonstrated that SRL is a reliable predictor of learning and achievement outcomes in mathematics, even when controlling IQ and age (Blair & Razza, 2007; Losenno et al., 2020). Given that students' mathematics problem-solving activities were challenging, based on the average scores per grade level, it is possible that students struggled to effectively engage in SRL, which could result in statistically non-significant findings. That is, even though the problem-solving activities employed in the current study reflects typical classroom practices, students may have struggled to enact learning strategies in concert with their mathematical (e.g., adding, subtracting) and problem-solving procedures. On the other hand, students who displayed strong mathematics problem-solving abilities may not have intentionally engaged in certain phases of SRL like planning and goal setting. Rather, their problem-solving processes may be well-developed and allow them to behave in automated ways (e.g., inherently knowing the steps to take to solve the problem without having to make plans). Future research which qualitatively examines how students approach problem-solving may provide important insight regarding how SRL strategies unfold during and relate to students' mathematics problem-solving outcomes.

Finally, it is also possible that some students may have relied on ER and SRL strategies that were most accessible to them as they require less effort than applying less practiced or more sophisticated strategies. That is, some students may employ suppression over reappraisal due to inability, or difficulty with managing problem-solving information in concert with the cognitive processes required to employ reappraisal. Moreover, students may have sought out help as opposed to monitoring the correctness of their final products (e.g., answers to individual aspects or entire problem) or hypothesizing about different approaches to problem-solving (e.g., trying new mathematics procedures). Though findings from the current study did not reveal statistically significant paths from students' ER and SRL to their mathematics problem-solving outcomes, findings reinforce previous research which indicates that young learners vary in their development and application of ER and SRL (Hutchinson et al., 2015; Perry, 2013; Zachariou & Whitebread, 2019). Since variance in students' SR abilities are typically related to related to differences in their learning and achievement outcomes (Hutchinson et al., 2021; Muis et al., 2016), researchers should continue to examine interactions between ER and SRL during learning. Specifically, future research which examines how ER and SRL develop in tandem during the school year, or across academic cycles (e.g., year to year) may provide important insight regarding how to support students SR in schools.

Limitations

There a several limitations to this research that should be addressed. First, the ERQ-CA (Gullone, & Taffe, 2012) was adapted to be situated within classroom-based learning, specifically for mathematics problem-solving. Reliability for the expressive suppression sub-scale was acceptable for research and analyses (DeVellis, 2016), but was lower than the reliability for the cognitive reappraisal sub-scale. This finding reinforces the calls placed by researchers for the development of tools that measure ER and ER strategies within authentic learning settings (Harley et al., 2019a; Loderer & Pekrun, 2019). Additionally, the use of a measure that assesses what students think they do to regulate emotions, versus what they do in real time during problem-solving activities may differ. Some research has employed measures that capture students' emotional experiences and their use of ER strategies in real time, however a bulk of this research has been conducted in online settings (Azevedo et al., 2013; Harley et al., 2019b). Continued research is needed to gain insight into how students engage their ER skills during classroom-based learning.

Second, concurrent think-aloud protocols may interfere with students' cognitive processes, and ultimately result in non-representative mathematics problem-solving outcomes. Although these think-aloud protocols have been employed successfully in research (Di Leo et al., 2019; Muis et al., 2015), the skills required to verbalize and participate in problem-solving may be cognitively taxing. This is especially true for those children who struggle with mathematics or regulating their emotions and learning. Research should consider how this methodology may influence findings and consider diverse approaches to measuring SRL during problem-solving activities (e.g., video recordings).

Lastly, a small sample size precludes the use of some statistical analyses (e.g., multi-level modeling, latent growth curve modeling). Specifically, developmental trends cannot be captured. Since students' grade level (e.g., grade 3 through 6) was significantly correlated to all phases of SRL, it is important for future researchers to consider how ER and SRL are related to developmental differences. Moreover, contextual variables were not fully accounted for in the present study. Although the measures employed were situated in classroom-based mathematics problem-solving, the roles of instruction and assessment were not examined. To gain insight into the roles of classroom context on self-regulatory development, future research should include measures of classroom instruction and assessment.

Conclusion

The findings of this study reinforce that it is an important goal of schools to support students' development of ER and SRL skills. Researchers should continue to explore which ER strategies may be an important antecedent to SRL, whether reciprocal relationships exist between these two constructs, and how SRL unfolds during learning activities. Additionally, research should examine ER and SRL in diverse learning settings (classrooms, online, group-based), in diverse domains (e.g., mathematics, science) and diverse populations (e.g., SES, ethnicity, cognitive abilities). Together, this research may provide important insight into how ER and SRL work in tandem and inform interventions, and pedagogical design to better support the development of these targets of SR in school.

References

Ahmed, W., van der Werf, G., Kuyper, H., & Minnaert, A. (2013). Emotions, self-regulated learning, and achievement in mathematics: A growth curve analysis. *Journal of Educational Psychology*, *105*, 150-161. https://doi.org/10.1037/a0030160

Azevedo, R., Harley, J., Trevors, G., Duffy, M., Feyzi-Behnagh, R., Bouchet, F., & Landis, R. (2013). Using trace data to examine the complex roles of cognitive, metacognitive, and emotional self-regulatory processes during learning with multi-agent systems. In *International handbook of metacognition and learning technologies* (pp. 427-449). Springer, New York, NY.

Bandura, A. (1989). Regulation of cognitive processes through perceived self-efficacy. *Developmental Psychology*, 25, 725– 739. https://doi.org/10.1037/0012-1649.25.5.729

Ben-Eliyahu, A., & Linnenbrink-Garcia, L. (2015). Integrating the regulation of affect, behavior, and cognition into self-regulated learning paradigms among secondary and post-secondary students. *Metacognition and Learning*, *10*(1), 15–42. https://doi.org/10.1007/s11409-014-9129-8

Blair, C., & Razza, R. P. (2007). Relating effortful control, executive function, and false belief understanding to emerging math and literacy ability in kindergarten. *Child development*, *78*(2), 647-663. https://10.1111/j.1467-8624.2007.01019.x

Bohn-Gettler, C. M., & Rapp, D. N. (2011). Depending on my mood: Mood-driven influences on text comprehension. *Journal of Educational Psychology, 103*(3), 562–577. https://doi.org/10.1037/a0023458

Brady, S. T., Hard, B. M., & Gross, J. J. (2018). Reappraising test anxiety increases academic performance of first-year college students. *Journal of Educational Psychology*, *110*(3), 395–406. https://doi.org/10.1037/edu0000219

Bryce, D., Whitebread, D. & Szűcs, D. (2015). The relationships among executive functions, metacognitive skills and educational achievement in 5 and 7-year-old children. *Metacognition Learning 10*, 181–198. https://doi.org/10.1007/s11409-014-9120-4

Butler, D. L. (2021). Enabling educators to become more effective supporters of SRL: Commentary on a special issue. *Metacognition and Learning*, *16*(3), 667-684. https://doi.org//10.1007/s11409-021-09282-8

Calkins, S. D., & Marcovitch, S. (2010). Emotion regulation and executive functioning in early development: Integrated mechanisms of control supporting adaptive functioning. In S. D. Calkins & M. A. Bell (Eds.), *Human brain development: Child development at the intersection of emotion and cognition* (p. 37–57). American Psychological Association. https://doi.org/10.1037/12059-003

Chen, F., Curran, P. J., Bollen, K. A., Kirby, J., & Paxton, P. (2008). An empirical evaluation of the use of fixed cutoff points in RMSEA test statistic in structural equation models. *Sociological Methods & Research*, *36*(4), 462-494. https://doi.org/10.1177/0049124108314720

Cole, P. M., Lougheed, J. P., & Ram, N. (2018). The development of emotion regulation in early childhood. In P. M. Cole & T. Hollenstein (Eds.), *Emotion Regulation: A matter of time*. (pp. 73–100). Routledge. https://doi.org/10.4324/9781351001328

Davis, E. L., & Levine, L. J. (2013). Emotion regulation strategies that promote learning: Reappraisal enhances children’s memory for educational information. *Child Development*, *84*(1), 361–374. https://://doi.org/10.1111/j.1467-8624.2012.01836.x

Davis, E., Levine, L., Lench, H.C., & Quas, J. (2010). Metacognitive emotion regulation: children's awareness that changing thoughts and goals can alleviate negative emotions. *Emotion, 10*(4), 498-510. https://doi.org/10.1037/a0018428

Dennis, T., Hong, M., & Solomon, B. (2010). Do the association between exuberance and emotion regulation depend on effortful control? *International Journal of Behavioral Development*, *34*. https://doi.org/10.1177/0165025409355514

Diamond, A. (2016). Why assessing and improving executive functions early in life is critical. In J. A. Griffin, P. McCardle, & L. S. Freund (Eds.), *Executive function in preschool-age children: Integrating measurement, neuro-development and translational research* (pp. 11–43). Washington, DC: American Psychological Association.

DeVellis, R. F. (2016). *Scale development: Theory and applications* (Vol. 26). Sage Publications.

Diamond, A., Barnett, W. S., Thomas, J., & Munro, S. (2007). Preschool program improves cognitive control. *Science, 318*(5855), 1387-1388. https://doi.org/10.1126/science.1151148

Di Leo, I., & Muis, K. R. (2020). Confused, now what? A Cognitive-Emotional Strategy Training (CEST) intervention for elementary students during mathematics problem solving. *Contemporary Educational Psychology*, *62*, 101879. https://doi.org/10.1016/j.cedpsych.2020.101879

Di Leo, I., Muis, K. R., Singh, C., & Psaradellis, C. (2019). Curiosity Confusion? Frustration! The role and sequencing of emotions during mathematics problem-solving. *Contemporary Educational Psychology, 58,* 121–137. https://doi.org/10.1016/j.cedpsych.2019.03.001

Dunn, K. E., Rakes, G. C., & Rakes, T. A. (2014). Influence of academic self-regulation, critical thinking, and age on online graduate students' academic help-seeking. *Distance Education*, *35*(1), 75–89. https://doi.org/10.1080/01587919.2014.891426

Efklides, A., Schwartz, B. L., & Brown, V. (2018). *Motivation and affect in self-regulated learning: Does metacognition play a role?* In D. H. Schunk & J. A. Greene (Eds.), *Educational psychology handbook series. Handbook of self-regulation of learning and performance* (p. 64–82). Routledge/Taylor & Francis Group.

Eisenberg N., & Spinrad T.L. (2004). Emotion-related regulation: Sharpening the definition. *Child Development*, *75*(2), 334–39. https://doi.org/10.1111/j.1467-8624.2004.00674.x

Eisenberg, N., Spinrad, T. L., & Eggum, N. D. (2010). Emotion-related self-regulation and its relation to children's maladjustment. *Annual Review of Clinical Psychology*, *6*, 495–525. https://doi.org/10.1146/annurev.clinpsy.121208.131208

Feldman R. (2015). Mutual influences between child emotion regulation and parent-child reciprocity support development across the first 10 years of life: Implications for developmental psychopathology. *Development and Psychopathology*, *27*(4), 1007–1023. https://doi.org/10.1017/S0954579415000656

Frenzel. A.C., Goetz, T., & Stockinger, K. (2024). Emotions and emotion regulation. In P. Schutz & K. R. Muis (Eds.), *Handbook of Educational Psychology.* Routledge.

Goetz, T., & Hall, N. C. (2020). Emotion and achievement in the classroom. In J. Hattie & E. M. Anderman (Eds.), *Visible Learning Guide to Student Achievement* (pp. 145-152). Routledge.

Graziano, P. A., Reavis, R. D., Keane, S. P., & Calkins, S. D. (2007). The role of emotion regulation in children's early academic success. *Journal of School Psychology*, *45*(1), 3–

19. https://doi.org/10.1016/j.jsp.2006.09.002

Graziano, P. A., Calkins, S. D., & Keane, S. P. (2011). Sustained attention development during the toddlerhood to preschool period: Associations with toddlers' emotion regulation strategies and maternal behavior. *Infant Child Development, 20*(6), 389-408. https://doi.org/10.1002/icd.731

Greene, J. A., & Azevedo, R. (2009). A macro-level analysis of SRL processes and their relations to the acquisition of a sophisticated mental model of a complex system. *Contemporary Educational Psychology, 34*, 18–29. https://doi.org/10.1016/j.cedpsych.2008.05.006

Gross, J. J. (1998). The emerging field of emotion regulation: An integrative review. *Review of general psychology*, *2*(3), 271-299. https://doi.org/10.1037/1089-2680.2.3.271

Gross, J. J. (2015). Emotion regulation: current status and future prospects. *Psychological inquiry*, *26*(1), 1-26. https://doi.org/10.1080/1047840X.2014.940781

Gross, J. J., & John, O. P. (2003). Individual differences in two emotion regulation processes: Implications for affect, relationships, and well-being. *Journal of Personality and Social Psychology, 85*(2), 348. https://doi:10.1037/0022-3514.85.2.348

Gullone, E., & Taffe, J. (2012). The emotion regulation questionnaire for children and adolescents (ERQ–CA): A psychometric evaluation. *Psychological Assessment*, *24*(2), 409–417. https://doi:10.1037/a0025777

Gunzenhauser, C., & Suchodoletz, A. v. (2014). Preschoolers' use of suppression influences subsequent self-control but does not interfere with verbal memory. *Learning and Individual Differences*, *32*, 219–224. https://doi.org/10.1016/j.lindif.2014.03.007

Hadwin, A., Järvelä, S., & Miller, M. (2018). Self-regulation, co-regulation, and shared regulation in collaborative learning environments. *Educational Psychologist, 50*(3), 204-219. https://doi:10.1080/00461520.2015.1075400

Harley, J.M., Jarrell, A., & Lajoie, S.P. (2019a). Emotion regulation tendencies, achievement emotions, and physiological arousal in a medical diagnostic reasoning simulation. *Instructional Science*. https://10.1007/s11251-018-09480-z

Harley, J. M., Pekrun, R., Taxer, J. L., & Gross, J. J. (2019b). Emotion regulation in achievement situations: An integrated model. *Educational Psychologist*, *54*(2), 106–126. https://doi.org/10.1080/00461520.2019.1587297

Howse, R. B., Calkins, S. D., Anastopoulos, A. D., Keane, S. P., & Shelton, T. L. (2003). Regulatory contributors to children's kindergarten achievement. *Early Education and Development*, *14*(1), 101-120. https://doi.org/10.1207/s15566935eed1401_7

Huang, C. (2011). Achievement goals and achievement emotions: A meta-analysis. *Educational Psychology Review*, *23*, 359-388. https://doi.org/10.1007/s10648-011-9155-x

Hutchinson, L. R. (2013). Young children's engagement in self-regulation at school (Unpublished doctoral dissertation). University of British Columbia, British Columbia. https://doi:10.14288/1.0073717

Hutchinson, L. R., Perry, N. E., & Shapka, J. D. (2021). Assessing young children's self-regulation in school contexts. *Assessment in Education: Principles, Policy & Practice*, *28*(5-6), 545-583. https://doi.org/10.1080/0969594X.2021.1951161

Hutchinson, L. R., Perry, N. E., Yee, N., Restrepo, Dantzer, B., & Lo (2015, August). Demographic variables in children's self-regulation. Poster session presented at the American Psychological Association Annual Conference, Toronto. ON

Kalokerinos, E. K., Résibois, M., Verduyn, P., & Kuppens, P. (2017). The temporal deployment of emotion regulation strategies during negative emotional episodes. *Emotion*, *17*(3), 450-458. https://doi.org/10.1037/emo0000248

Kenny, D. A., Kaniskan, B., & McCoach, D. B. (2015). The performance of RMSEA in models with small degrees of freedom. *Sociological Methods & Research*, *44*(3), 486-507. https://doi.org/10.1177/0049124114543236

Kopp, C. B. (1982). Antecedents of self-regulation: A developmental perspective. *Developmental Psychology*, *18*(2), 199–214. https://doi.org/10.1037/0012-1649.18.2.199

Loderer, K., & Pekrun, R. (2019, August). Regulation of achievement emotions: Towards a theory-driven program of research. Presentation at the European Association for Research on Learning and Instruction Conference, Aachen, GR

Losenno, K. M., Muis, K. R., Munzar, B., Denton, C. A., & Perry, N. E. (2020). The dynamic roles of cognitive reappraisal and self-regulated learning during mathematics problem solving: A mixed methods investigation. *Contemporary Educational Psychology, 62*. https://doi.org/10.1016/j.cedpsych.2020.101869

McCabe, L. A., Cunnington, M., & Brooks-Gunn, J. (2004). The development of self-regulation in young children: Individual characteristics and environmental contexts. In R. F. Baumeister & K. D. Vohs (Eds.), *Handbook of self-regulation: Research, theory, and applications* (p. 340–356). The Guilford Press.

McClelland, M. & Cameron, C. (2011). Self-regulation and academic achievement in elementary school children. *New Directions for Child and Adolescent Development*, *2011*(133), 29-44. https://doi.org/10.1002/cd.302

McKinnon, R. D., & Blair, C. (2018). Does early executive function predict teacher–child relationships from kindergarten to second grade? *Developmental psychology*, *54*(11), 2053. https://doi.org/10.1037/dev0000584

McRae, K., & Gross, J. J. (2020). Emotion regulation. *Emotion*, *20*(1), 1–9. https://doi.org/http://dx.doi.org/10.1037/emo0000703

McRae, K., Misra, S., Prasad, A. K., Pereira, S. C., & Gross, J. J. (2011). Bottom-up and top-down emotion generation: Implications for emotion regulation. *Social Cognitive and Affective Neuroscience*, *7*, 253–262. https://doi.org/10.1093/scan/nsq103

Meinhardt, J., & Pekrun, R. (2003). Attentional resource allocation to emotional events: An ERP study. *Cognition and Emotion*, *17*(3), 477-500. https://doi.org/10.1080/02699930244000039

Meyers, L. S., Gamst, G., & Guarino, A. J. (2016). Applied multivariate research: Design and interpretation (3rd ed.). Thousand Oaks, CA: Sage.

Ministère de l'éducation, du loisir et du sport. (2009). Start your engines! Situational problem for Elementary Cycle Three—Year One [Reference document and teacher's guide]. Quebec, Canada: Author.

Ministère de l'Éducation et Enseignement Supérieur. (2018). The Quebec curriculum Grades 1–6: Mathematics, science, and technology [Program of studies]. Retrieved from http://www.education.gouv.qc.ca/fileadmin/site_web/documents/education/jeunes/pfeq/PFEQ_mathematique-primaire_EN.pdf.

Miyake, A., & Friedman, N. P. (2012). The nature and organization of individual differences in executive functions: Four general conclusions. *Current Directions in Psychological Science*, *21*(1), 8–14. https://doi.org/10.1177/0963721411429458

Muis, K. R. (2007). The role of epistemic beliefs in self-regulated learning. *Educational Psychologist, 42*(3), 173–190. https://doi.org/10.1080/00461520701416306

Muis, K. R., Chevrier, M., & Singh, C. A. (2018). The role of epistemic emotions in personal epistemology and self-regulated learning. *Educational Psychologist*, *53*(3), 165-184. https://doi.org/10.1080/00461520.2017.1421465

Muis, K. R., Psaradellis, C., Lajoie, S. P., Di Leo, I., & Chevrier, M. (2015). The role of epistemic emotions in mathematics problem-solving. *Contemporary Educational Psychology*, 42, 172–185. https://doi.org/10.1016/j.cedpsych.2015.06.003

Muis, K. R., Psaradellis, C., Chevrier, M., Di Leo, I., & Lajoie, S. P. (2016). Learning by preparing to teach: Fostering self-regulatory processes and achievement during complex mathematics problem-solving. *Journal of Educational Psychology*, *108*, 474–492. https://doi.org/10.1037/edu0000071.

Munzar, B., Muis, K. R., Denton, C. A., & Losenno, K. M. (2020). Elementary students' cognitive and affective responses to impasses during mathematics problem-solving. *Journal of Educational Psychology*. https://doi.org/10.1037/edu0000460.

Muthén, L. K., & Muthén, B. O. (2017). *Mplus User's Guide* (8th ed.). Los Angeles, CA: Muthén & Muthén.

Obergriesser, S., & Stoeger, H. (2020). Students' emotions of enjoyment and boredom and their use of cognitive learning strategies–How do they affect one another? *Learning and Instruction*, *66*, 101285. https://doi.org/10.1016/j.learninstruc.2019.101285

Pekrun, R. (2018). Control-value theory: A social-cognitive approach to achievement emotions. In G. A. D. Liem & D. M. McInerney (Eds.), *Big theories revisited 2: A volume of* *research on sociocultural influences on motivation and learning* (pp. 162-190). Charlotte: Information Age Publishing. https://doi.org/10.4236/me.2018.9505

Pekrun, R., Goetz, T., Titz, W., & Perry, R. P. (2002). Academic emotions in students' self-regulated learning and achievement: A program of qualitative and quantitative research. *Educational Psychologist*, 37(2), 91–105. https://doi.org/10.1207/S15326985EP3702_4

Pekrun, R., Lichtenfeld, S., Marsh, H.W., Murayama, K., & Goetz, T. (2017). Achievement emotions and academic performance: longitudinal models of reciprocal effects. *Child Development*, *88*(5), 1653-1670. https://doi.org/10.1111/cdev.12704

Perry, N. B., & Calkins, S. D. (2018). A biopsychosocial perspective on the development of emotion regulation across childhood. In *Emotion regulation* (pp. 3-30). Routledge.

Perry, N. E. (2013). Understanding classroom processes that support children's self-regulation of learning [Monograph]. British Journal of Educational Psychology, Monograph Series II: Psychological Aspects of Education – Current Trends, 10, 45–68.

Perry, N. E., Brenner, C. A., & MacPherson, N. (2015). Using teacher learning teams as a framework for bridging theory and practice in self-regulated learning. In T. Cleary (Ed.), *Self-regulated learning interventions with at-risk youth: Enhancing adaptability, performance, and well-being* (pp. 229–250). American Psychological Association. https://doi.org/10.1037/14641-011

Perry, N. E., Hutchinson, L. R., Yee, N., & Määttä, E. (2018). *Advances in understanding young children's self-regulation of learning*. In D. Schunk, & J. Greene (Eds.). Handbook of self- regulated learning and performance (pp. 457–472). (2nd ed.). New York: Routledge. https://doi.org/10.4324/9781315697048-29

Richards, J. M., & Gross, J. J. (2000). Emotion regulation and memory: The cognitive costs of keeping one's cool. *Journal of Personality and Social Psychology, 79*(3), 410. https://doi.org/10.1037/0022-3514.79.3.410

Rimm-Kaufman, S. E., Curby, T. W., Grimm, K. J., Nathanson, L., & Brock, L. L. (2009). The contribution of children’s self-regulation and classroom quality to children’s adaptive behaviors in the kindergarten classroom. *Developmental Psychology, 45*(4), 958–972. https://doi.org/10.1037/a0015861

Rottweiler, A.-L., Taxer, J. L., & Nett, U. E. (2018). Context matters in the effectiveness of emotion regulation strategies. *American Education Research Association Open*, *4*(2), 233285841877884. https://doi.org/10.1177/2332858418778849

Rudasill, K. M., & Rimm-Kaufman, S. E. (2009). Teacher–child relationship quality: The roles of child temperament and teacher–child interactions. *Early Childhood Research Quarterly*, *24*(2), 107–120. https://doi.org/10.1016/j.ecresq.2008.12.003

Sameroff, A. (2010). A unified theory of development: A dialectic integration of nature and nurture. *Child Development*, *81*(1), 6-22. https://doi.org/10.1111/j.1467-8624.2009.01378.x

Scherer, K. R., & Moors, A. (2019). The emotion process: Event appraisal and component differentiation. *Annual Review of Psychology*, *70*, 719-745. https://doi.org/https://doi.org/10.1146/annurev-psych-122216011854

Schutz, P. A., & Davis, H. A. (2000). Emotions and self-regulation during test taking. *Educational Psychologist*, *35*(4), 243-256. https://doi.org/10.1207/S15326985EP3504_03

Shafir, R., Schwartz, N., Blechert, J., & Sheppes, G. (2015). Emotional intensity influences pre-implementation and implementation of distraction and reappraisal. *Social Cognitive and*

Affective Neuroscience, *10*, 1329–1337. https://doi.org/10.1093/scan/nsv022

Sheppes, G. (2020). Transcending the "good & bad" and "here & now" in emotion regulation: Costs and benefits of strategies across regulatory stages. In *Advances in experimental social psychology* (Vol. 61, pp. 185-236). Academic Press.

Sheskin, D. J. (2004). *Handbook of parametric and nonparametric statistical procedures* (4th ed.). Boca Raton, FL: Chapman & Hall/ CRC.

Strain, A. C., & D'Mello, S. K. (2015). Affect regulation during learning: The enhancing effect of cognitive reappraisal. *Applied Cognitive Psychology*, *29*(1), 1–19. https://doi.org/10.1002/acp.3049

Suri, G., Whittaker, K., & Gross, J. J. (2015). Launching reappraisal: It's less common than you might think. *Emotion*, *15*(1), 73–77. https://doi.org/10.1037/emo0000011

Tabachnick, B. G., & Fidell, L. S. (2013). *Using multivariate statistics* (6th ed.). Boston, MA: Allyn Bacon.

Tice, M. D., Baumeister, R. F., & Zhang, L. (2004). The role of emotion in self-regulation: Differing roles of positive and negative emotion. In P. Philippot & R. S. Feldman (Eds.), *The regulation of emotion* (pp. 213-226). Mahwah, NJ: Lawrence Erlbaum Associates.

Usher, E. L., & Schunk, D. H. (2018). *Social cognitive theoretical perspective of self- regulation*. In D. H. Schunk, & J. A. Greene (Eds.). Educational psychology handbook series. Handbook of self-regulation of learning and performance (pp. 19–35). Routledge/ Taylor & Francis Group. https://doi.org/10.4324/9781315697048-2

Vernon-Feagans, L., Willoughby, M., & Garrett-Peters, P. (2016). Predictors of behavioral regulation in kindergarten: Household chaos, parenting, and early executive functions. *Developmental Psychology*, *52*(3), 430. https://doi.org/10.1037/dev0000087

Webb, T. L., Miles, E., & Sheeran, P. (2012). Dealing with feeling: A meta-analysis of the effectiveness of strategies derived from the process model of emotion regulation. *Psychological Bulletin*, *138*(4), 775–808. https://doi.org/10.1037/a0027600

Whitebread, D., Bingham, S., Grau, V., Pino-Pasternak, D., & Sangster, C. (2007). Development of metacognition and self-regulated learning in young children: Role of collaborative and peer-assisted learning. *Journal of Cognitive Education and Psychology*, *6*, 433-455. https://doi.org/10.1891/194589507787382043

Whitebread, D., Coltman, P., Pasternak, D. P., Sangster, C., Grau, V., Bingham, S., ... & Demetriou, D. (2009). The development of two observational tools for assessing metacognition and self-regulated learning in young children. *Metacognition and Learning*, *4*, 63-85. https://doi.org/10.1007/s11409-008-9033-1

Winne, P.H. (2017). Theorizing and researching levels of processing in self-regulated learning. *British Journal of Educational Psychology*, *88*, 9-20. https://doi.org/10.1111/bjep.12173

Winne, P. H., & Perry, N. E. (2000). Measuring self-regulated learning. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (p. 531–566). Academic Press. https://doi.org/10.1016/B978-012109890-2/50045-7

Wolters, C. A. (2003). Regulation of motivation: Evaluating an underemphasized aspect of self-regulated learning. *Educational Psychologist*, *38*(4), 189–205. https://doi.org/10.1207/s15326985ep3804_1

Zachariou, A., & Whitebread, D. (2019). Developmental differences in young children's self-regulation. *Journal of Applied Developmental Psychology*, *62*, 282-293. https://doi.org/10.1016/j.appdev.2019.02.002

Zhao, X., Lynch, J. G., & Chen, Q. (2010). Reconsidering Baron and Kenny: Myths and Truths about Mediation Analysis. *Journal of Consumer Research*, *37*(2), 197–206. https://doi.org/10.1086/651257

Zimmerman, B. J. (2008). Investigating self-regulation and motivation: Historical background, methodological developments, and future prospects. *American Educational Research Journal*, *45*(1), 166–183. https://doi.org/10.3102/0002831207312909

Zimmerman, B. J., & Schunk, D. H. (2011). Self-regulated learning and performance: An introduction and an overview. In D. H. Schunk & B. J. Zimmerman (Eds.) *Handbook of self-regulation of learning and performance*, (pp. 15-26). Routledge. https://doi.org/10.4324/978020383901

Bridging Text

Chapter 3 employed self-reports, think-alouds, and authentic educational activities to assess middle to upper elementary-aged students' ER and SRL skills during complex mathematics problem-solving. Findings demonstrated that expressive suppression, an ER strategy often characterized as detrimental for cognitive, emotional, and learning processes, was a positive antecedent to students' engagement in early SRL. Additionally, early SRL mediated the role of suppression on later phases of SRL. In the context of this dissertation, these findings extend theoretical knowledge regarding the efficacy of ER strategies, and the relationships between ER and SRL during mathematics problem-solving. Findings also provide practical insight regarding how to support students SR skills at a global level in classrooms. However, the developmental nature of classroom-based ER and SRL, the roles of teachers' instruction, and the possible interdependent relationships between these targets of SR remains under investigated.

To address these lines of inquiry, Chapter 4 presents an empirical study that examines change in middle to upper elementary-aged students' ER and SRL skills across the school year, and whether teachers' approaches to classroom instruction influence that change. The relationships between ER and SRL across the school year were also explored. A teacher report tool was employed to capture students' ER and SRL skills at the level of their shared underlying SR processes (i.e., metacognition, motivation, strategic action). Finally, teacher reports of their instructional behaviors were paired with observations of their instructional practices during a mathematics lesson to assess whether features of classroom instruction support students' ER and SRL. In sum, Chapter 4 addresses themes of the current dissertation concerning elementary-aged students' development of ER and SRL skills in classrooms, the role of teachers in that development, and whether distinct targets of SR are related to one another across the school year.

Chapter 4. Manuscript 2

The Development of Emotion Regulation and Self-Regulated Learning in Classrooms: A Mixed Methods Study

Author Note

A version of this manuscript will be submitted for publication purposes:

Losenno, K. M. & Muis, K. R. (in preparation). The development of emotion regulation and self-regulated learning in classrooms: a mixed methods study. *Learning and Instruction.*

This research was funded by a grant to Nancy E. Perry and Krista R. Muis from a grant for the Social Sciences and Humanities Research Council of Canada (435-2016-0374), and to Krista R. Muis from the Canada Research Chairs program.

Abstract

Emotion regulation (ER) and self-regulated learning (SRL) are targets of self-regulation that develop due to maturation and environmental variables like differences in instructional practices and learning domains. The current study employed mixed-methods to examine change in 145 grade 3 to grade 6 students' ER and SRL skills across a school year. Classroom teachers reported on their students' self-regulatory skills, and their own classroom practices. Observations of mathematics lesson were conducted to assess whether features of instruction support students' ER and SRL in diverse learning domains. Repeated measures ANOVAs demonstrated that students' self-regulatory skills changed across the school year, in part as a function of their teachers' classroom instructional practices. Teachers' self-reports were paired with classroom observations to delineate instructional practices that foster students' ER and SRL during mathematics. A cross-lagged path analysis highlighted possible interdependent relationships between students' ER and SRL across time. Theoretical and practical implications are discussed.

Keywords: emotion regulation, self-regulated learning, classroom instruction, mixed methods

Introduction

Research in self-regulation (SR) has considered how students' self-regulatory skills are acquired and develop within classrooms (Hutchinson et al., 2021; Perry et al., 2018; Whitebread et al, 2007; Zachariou & Whitebread, 2019). SR is a broad term that refers to an individual's ability to effectively guide and control cognitive, affective, motivational, behavioral, and social processes towards goals while adapting to changing environmental demands (Zimmerman, 2008; Perry et al., 2020). To engage in SR, one must employ basic executive functions like attention inhibition, and working memory in co-ordination with higher order cognitive processes like metacognition, motivation, and strategic action (Diamond, 2016; Hutchinson, 2013; Miyake & Friedman, 2012; Perry et al., 2018). Theorists have posited that there are multiple distinct targets of SR which regulate specific processes (e.g., affect, learning), yet rely on the same underlying processes (e.g., executive functioning, metacognition, motivation, action; Bandura, 1982; Hoyle & Dent, 2018; Perry et al., 2018; Usher & Schunk, 2018). That is, one's attempts to regulate their emotions by applying strategies to modulate which emotions they experience and when (i.e., emotion regulation; Gross, 2015), or to support their learning and academic goal pursuits (i.e., self-regulated learning; Zimmerman, 2013) rely on the same processes that are shared between all targets of SR. Though research findings have empirically demonstrated that emotion regulation (ER) and self-regulated learning (SRL) are distinct yet related constructs (Hutchinson et al., 2021), there is a paucity of research which considers how interdependent relationships between these phenomena may influence students' development of skills for either target.

Previous research has demonstrated that SR is a developmental process such that students' SR skills develop overtime because of physiological maturation that supports the coordination and development of increasingly effortful and sophisticated SR strategies (Hoyle &

Dent, 2018; Kopp, 1982; Perry & Calkins, 2018). Individual differences in maturation have been linked to the on-set and coordination of SR skills, which in turn influence children's school readiness, and academic outcomes (Davidson et al., 2006; Diamond, 2016; Schaul & Schwartz, 2014). Specifically, differences in students' ER and SRL skills are related to differences in their learning and achievement (Blair & Razza, 2007; Muis et al., 2015). For example, middle to upper-elementary-aged students' ER and SRL are important independent predictors of their complex mathematics problem-solving outcomes (Di Leo & Muis, 2020; Losenno et al., 2019; Muis et al., 2015, 2016). Accumulating research also suggests that ER serves as an important antecedent to SRL, as different emotions and strategies for regulating those emotions influence the quality and quantity of SRL strategies that students employ (Frenzel et al., 2024; Pekrun, 2018). Theorists have also implicated SRL as an important antecedent to successful ER since effective SRL skills may reduce one's experience of negative emotions during learning and negate or reduce the need for ER (Di Leo et al., 2019; Muis et al., 2015). These findings suggest that one's ER skills may provide important opportunities to engage in SRL, and vice-versa. Though researchers continue to explore the roles of ER and SRL in learning and achievement situations, there is scarce research that has examined how elementary-aged students' ER and SRL skills develop in tandem during the school year.

Finally, research on SR has highlighted that individual differences in young children's SR skills are related to differences in environmental variables (Cole et al., 2018; Graziano et al., 2011; Perry, 2013). That is, differences in families and school systems (e.g., parenting practices, classroom practices) influence the types and frequencies of experiences one accumulates practicing and refining their SR skills (Cole et al., 2018; Kopp, 1982; Perry et al., 2020; Wentzel, 2002). Developmental research in SR has demonstrated that children who are exposed to sensitive and well-aligned parenting practices, as opposed to punitive or misaligned, develop positive beliefs about their abilities to cope with affect, express better markers of physiological regulation (e.g., heart rate recovery; Calkins et al., 2008; Mikulincer et al., 2003), and ultimately their ER abilities (Eisenberg et al., 2004; Graziano et al., 2011). Educational research has also demonstrated that elementary-aged students' exposure to instructional practices are related to differences in SRL outcomes (Perry et al., 2018). That is, students who are enrolled in classrooms wherein teachers emphasize instructional practices that promote student autonomy (e.g., provide well-aligned teacher support, foster a community of learners) are provided meaningful opportunities to practice and refine their SRL skills (Hamre & Pianta, 2005; Perry et al., 2020). In contrast, students who are exposed to directive instructional practices which lack opportunities to make meaningful choices and exert control over their learning may experience decreased motivation for learning and miss important opportunities to practice SR skills in classrooms (Hutchinson, 2013; Perry et al., 2018; Wentzel, 2002). However, much of this research has examined instruction in relation to students' SR processes during literacy or play-based learning and less is known about whether different features of instruction in mathematics may facilitate students' SR.

Together, these findings highlight that individual differences in children's ER and SRL skills are related to their exposure to different practices (e.g., instructional) that are implemented by critical reference points (e.g., teachers). However, there is little research that examines how different instructional practices across classrooms may influence students' development of ER and SRL in tandem (Hamre & Pianta, 2001; Koole & Veenstra, 2015). As such, the objective of the current study was to address this gap by examining how middle to upper elementary-aged students' ER and SRL skills develop during the school year and exploring whether features of classroom-based instruction provide students opportunities to engage in SR. In doing so, the current study aims to advance theoretical knowledge regarding the relationships between different targets of SR, and how to practically support students' SR skills in classrooms. Moreover, examining students' ER and SRL skills using items that assess underlying SR processes (i.e., metacognition, motivation, strategic action) may support future methodological approaches to SR research. Finally, pairing teacher reports of their instructional behaviors with observations of their classrooms processes during a mathematics lesson may provide rich information that informs educational practice, policy, and the development of classroom-based interventions for SR.

Emotion Regulation

Emotions are multi-componential processes that serve important personal and social functions like facilitating decision making, scripting social behaviors, and providing ongoing feedback about the match between the environment and the individual (Gross, 1998; Gross & Thompson, 2007; Scherer & Moors, 2019). Given that emotions are related to students' engagement in learning processes and predict differences in achievement outcomes (Pekrun, 2018), being able to regulate emotions is an important goal of childhood (Perry & Calkins, 2018). Situated in learning, ER involves modulating affective, psychological, and behavioral response tendencies to pursue learning goals and adapt to changing environmental demands (e.g., classroom) and academic expectations (Cole et al., 2018; Eisenberg & Sulik, 2012; Gross, 2015). Engagement in ER requires the coordination of basic executive functions in tandem with metacognition (e.g., labeling emotions), motivation (e.g., persisting in the face of distracting or uncomfortable emotions), and strategic action (e.g., applying strategies that support functioning and goal pursuits; Hutchinson et al., 2021; Perry et al., 2018).

Findings have demonstrated that ER is present during early infancy in the form of automated behavioral responses (e.g., thumb sucking, gaze aversion; Grolnick et al., 2006) and as children physiologically mature their brains become increasingly interconnected which supports the development of increasingly effortful and complex regulatory skills (Davidson et al., 2006). For example, as children grow, their anterior cingulate cortex (ACC) and prefrontal cortex (PFC) continue to develop, both of which are associated with increased coordination and sophistication of the cognitive, affective, and behavioral processes that support regulation through deliberate and effortful strategy use (Ochsner & Gross, 2004; Perry & Calkins, 2018; Raffaelli et al., 2005). Furthermore, children's executive functioning and temperamental effortful control – both of which emphasize attentional and inhibitory control – continue to mature (Diamond, 2016; Eisenberg et al., 2004; Miyake & Friedman, 2012). Together, this physiological maturation supports children's development of a robust repertoire of ER skills that become more effortful and cognitively based as opposed to automated and behaviorally overt over time (Calkins & Dedmon, 2010; Cole et al., 2018).

These developmental shifts from automated to effortful, and overt to covert highlight that behavioral measures of children's ER development alone may not be reliable indicators of the underlying processes involved in SR (e.g., metacognition, motivation, strategic action). For example, findings demonstrate that children 3 to 5 years old can identify strategies that effectively regulate negative affect on par with university students, but that they demonstrate a preference for less effective strategies like rumination and venting (Dennis & Kelemen, 2009). Moreover, children 5 to 7 years old who perform well on inhibitory control tasks, an aspect of executive functioning, can effectively mask their emotions compared to children who demonstrated low measures on inhibitory control tasks (Hudson & Jacques, 2014). Together these findings demonstrate that cognitive ER strategies can be difficult to observe and meaningfully attach to behaviors, even with young children (Calkins & Dedmon, 2010; Cole et al., 2018; McCabe et al., 2004). However, measures of behavior and executive functioning have often been employed in ER research with school children (Cole et al., 2018; Dennis et al., 2010; Hudson & Jacques, 2014) and limited ER research measures the higher order cognitive processes that underlie all targets of SR (Hutchinson et al., 2021; Perry et al., 2020). The current study addresses this methodological gap as it was designed to measure the metacognitive, motivational, and behavioral processes involved in middle to upper elementary-aged students' development of classroom-based ER.

In sum, children's individual differences in their abilities to engage in the SR processes that underlie ER have been related to differences in physiological maturation such that some children display more co-ordinated abilities early in life (e.g., preschool) whereas others display more sophisticated abilities later in life (e.g., elementary school; Diamond, 2016; Eisenberg & Sulik, 2012; Hutchinson et al., 2015). Additionally, individual differences in students' ER abilities are associated with differences in their academic outcomes in school (Eisenberg et al., 2004; Davis & Levine, 2013; Graziano et al., 2007). A study of kindergarteners demonstrated that ER – measured as effortful control, an aspect of executive functioning – predicted differences in mathematics outcomes independently of their intelligence (Blair & Razza, 2007). Although evidence suggests that young students' executive functioning and ER are related (Ursache, et al., 2013), findings also reinforce that they are independent processes (Leerkes et al., 2008) that uniquely contribute to early school adaption and academic achievement (Blair & Razza, 2007; Howse et al., 2003). Furthermore, findings have demonstrated that ER directly predicts elementary-aged children's mathematics problem-solving outcomes, as well as their engagement in different phases of SRL during mathematics problem-solving (Di Leo et al., 2019; Losenno et al., 2020). These findings suggest that one of the ways in which ER skills may support students' learning outcomes is because of the relationship between ER and SRL. Though these findings highlight that ER is an important skill for children to develop as it supports a host of educational outcomes, limited research assesses how elementary-aged students' ER skills develop in relation to SRL within classrooms.

Self-Regulated Learning

Self-regulated learning (SRL) refers to the patterns of metacognitive, motivational, and strategic action that one employs during learning to support their academic goal pursuits and adapt to the demands present within the classroom (Muis, 2007; Winne, 2018; Zimmerman & Schunk, 2011). To effectively engage in SRL one must employ their executive functioning (e.g., working memory, attention inhibition), in concert with their metacognition (e.g., identify their strengths and weaknesses as a learner), motivation (e.g., persist in the face of challenging learning activities), and strategic action (e.g., select and apply strategies; Hoyle & Dent, 2018; Hutchinson et al., 2021; Perry et al., 2018; Winne, 2018). Findings demonstrate that students with strong executive functioning are better able to adapt to the demands of school-based learning and engage in SRL more readily than those students with poorer executive functioning (Bryce et al., 2015). On the other hand, students who demonstrate difficulty with executive functioning (e.g., struggle to inhibit behavior and focus attention; Bryce et al., 2015), may have trouble forming high-quality relationships with their teachers and peers and be afforded less opportunities to engage in classroom activities that support SRL (McKinnon & Blair, 2018; Rudasill & Rimm-Kaufman, 2009). Fortunately, executive functioning becomes increasingly coordinated and effective as children physiologically mature (Diamond, 2016; Hoyle & Dent, 2018; Miyake & Friedman, 2012), which in turn supports the continued development of SRL processes and skills over time.

Given that SRL relies on multiple complex cognitive and metacognitive processes, previous research has underestimated young learners' developmental preparedness to meaningfully engage in processes like metacognition (Kuhn, 1999; Veenman & Spaans, 2005). However, evidence demonstrates that young children can and do engage in metacognitive processes and SRL (Hoyle & Dent, 2018; Hutchinson et al., 2021; Perry et al., 2020; Whitebread et al., 2007). For example, a classroom-based study demonstrated that 3 to 5-year-old children engage in metacognitive processes including monitoring and control, especially when participating in child initiated play-based learning (Whitebread et al., 2007). Additionally, findings demonstrated that 6- to 8-year-old students participating in musical play display increases in their use of planning, metacognitive monitoring, and emotional and motivational monitoring with age (Zachariou & Whitebread, 2019). This also holds true in teenage populations (Veenman, & Spaans, 2005), as 13- to 15-year-old students demonstrate increasing use of metacognitive skills especially as they pertain to planning and evaluation during mathematics problem-solving (Vand der Stel et al., 2010). Interestingly, findings have demonstrated that metacognitive skills shift from being domain specific (e.g., music, math) to domain general, and develop in tandem with but somewhat independently from intelligence (Kuhn, 1999; Vand der Stel, 2010; Veenman, & Spaans, 2005; Zachariou & Whitebread, 2019). Together these findings indicate that children can and do engage in SRL, and that SRL tends to develop overtime. However, a bulk of this research has focused on young children (e.g., preschool, kindergarten), or older students (e.g., middle school, university; Veenman & Spaans, 2005; Vand der Stel, 2010; Zachariou & Whitebread, 2019). As such, questions remain regarding middle to upper elementary-aged childrens' development of SRL skills in classrooms. The current study addresses this gap by assessing how grade 3 to 6 students' classroom-based SRL developed from the fall to the spring of a school year.

Moreover, differences in students' SRL abilities are related to differences in learning outcomes across learning domains (Hutchinson et al., 2021; Muis et al., 2015, 2016). Students who display strong SRL skills display deeper levels of engagement in metacognitive and learning processes (Winne, 2018), and have better academic outcomes (Muis et al., 2015; Rudasill et al., 2010). These students also adopt more positive beliefs about their learning abilities (i.e., self-efficacy; Compagnoni & Losenno, 2020; Schunk & Usher, 2011), and experience higher quality relationships with their teachers and peers (Rudasill & Rimm-Kaufman, 2009), which ultimately support their classroom participation, goal pursuits, and academic success. Taken together, it is clear that young students can develop effective or ineffective patterns of SRL, which are related to differences in their cognitive processes, motivational beliefs, and differences in learning and achievement outcomes. Although research findings indicate that students' SRL skills tend to develop to become more coordinated and robust over time (Hoyle & Dent, 2018; Raffaelli et al., 2005), research which considers how differences in students' SRL skills may influence their development of ER skills is limited. To date, research indicates that students who engage in effective forms of SRL may experience better learning outcomes or hold more positive beliefs about their abilities which may result in the experience of less negative affect (Tice et al., 2004). Therefore, these students may have the benefit of expending less cognitive effort in their attempts to regulate negative affect, which in turn can free up the cognitive resources needed to engage in all forms of SR and learning. Since ER and SRL share the same underlying SR processes, and research findings demonstrate that there are important relationships between these two targets of SR, it is important for researchers to gain insight into the possible interdependent relationships between students' development of ER and SRL skills within classrooms.

Interdependent Relationships

How does the development of ER and SRL interact? Recall that all targets of SR have a shared reliance on the same underlying processes including executive functioning, metacognition, motivation, and strategic action (Bandura, 1982; Hoyle & Dent, 2018; Hutchinson et al., 2021; Perry et al., 2018). Previous research suggests that these regulatory skills evolve because of developmental maturation that takes place in infancy and childhood (e.g., ACC, PFC; Davidson et al., 2006; Dennis et al., 2010). That is, by the time an infant reaches childhood, the typical physiological maturation that has occurred (e.g., ACC, PFC) supports the increased coordination and stability of their cognitive processes and the behavioral application of these processes in more nuanced manners (e.g., deliberate and effortful strategy use; Ochsner & Gross, 2004; Perry & Calkins, 2018; Raffaelli et al., 2005). It follows that research findings indicate that the SR processes that underlie ER and SRL skills (e.g., executive functions, metacognition) increase across time for young (e.g., 3 to 9-years-old) to middle-aged students (e.g., 13 to 15-years-old; Cole et al., 2018; Hoyle & Dent, 2018; Van der Stel et al., 2010; Veenman, & Spaans, 2005; Whitebread et al., 2007; Zachariou & Whitebread, 2019). However, limited research has assessed if middle to upper-elementary-aged students' (e.g., 8 to 12-years old) self-regulatory skills change during the school year using measures that capture underlying processes (e.g., metacognition, motivation, strategic action) yet reflect distinct targets of SR (i.e., ER, SRL; Hutchinson et al., 2021).

To gain insight into the relationships between multiple targets of SR, empirical research has examined whether ER and SRL are statistically distinct phenomena or whether a single global factor of SR is a better statistical representation of these processes. Findings support theoretical contributions and demonstrate that although ER and SRL are correlated and share variance, they remain statistically unique targets of SR (Hutchinson et al., 2021). However, this research was conducted with kindergarten students and less is known about how ER and SRL skills develop in tandem for middle to upper-elementary-aged students. Moreover, accumulating research highlights the possibility that one's skills and abilities in a target of SR (e.g., ER) may influence their skills and abilities in another target (e.g., SRL), since they rely on the same underlying processes. Specifically, empirical findings indicate that ER is an important antecedent to SRL (Frenzel et al., 2024). Recall that findings have demonstrated that emotions influence students' engagement in SRL and their achievement such that negative emotions tend to negatively predict SRL and achievement, whereas positive emotions tend to positively predict SRL and achievement (Pekrun, 2018, Tice et al., 2004). Research indicates that one's ability to effectively regulate the emotions they experience during learning can mediate the role of emotions on learning processes (Frenzel et al., 2024; Munzar et al., 2020). For example, findings demonstrate that grade 3 to 6 students' use of cognitive reappraisal, an ER strategy considered cognitively effective, positively predicts students' engagement in the four phases of SRL, and their complex mathematics problem-solving outcomes (Losenno et al., 2020).

Accumulating research also suggests that students' use of expressive suppression may support their motivation for learning and SRL processes (Frenzel et al., 2024). Although suppression has been identified as an ER strategy which can heavily tax the processes involved in SR and interfere with learning processes (Gross, 2015; Gross & John, 2003), findings suggests that suppression effectively reduces students' experience of negative affect like anxiety and boredom during test taking, and supports their motivation in courses they dislike (Rottweiler et al., 2018; Schutz & Davis, 2000). Theorists posit that suppression may support students' learning efforts as it provides a protective factor for one's beliefs about their abilities and preserves cognitive resources as it does not require engagement with the emotional stimuli (Gross, 2015; Sheppes & Meiran, 2007). Moreover, students' use of suppression during complex mathematics problem-solving positively predicted their engagement in an early phase of SRL (i.e., task definition; see Manuscript 1). Together, these findings demonstrate that there are relationships between students' use of different ER strategies and their emotional experiences, motivation for learning, and SRL processes. As such, it is an important goal for students to develop a range of ER skills that they can flexibly apply (Aldao et al., 2015; Bonano & Burton, 2013) as a means of directly supporting their SRL as well as several other processes that are related to broad SR.

Additionally, theorists posit that effective SRL may support ER skills over time. Given that students who demonstrate effective SRL skills have more positive learning outcomes (Losenno et al., 2019; Muis et al., 2016), one's SRL skills may reduce the need for ER. That is, students whose SRL skills are well developed (e.g., engage in metacognitive monitoring) are likely to be successful during learning, which in turn reduces one's experience of negative emotions (e.g., confusion) and ultimately the frequency with which one needs to regulate emotions during learning. For example, grade 3 to 6 students who demonstrate effective SRL skills also report experiencing less difficulty and less confusion during mathematics problem-solving (Di Leo et al., 2019). Research has demonstrated that confusion, when too intense or left unresolved, may disrupt learning processes and outcomes for young students (Munzar et al., 2020). Though research findings demonstrate a tendency for ER and SRL to be positively related to one another (Losenno et al., 2019; Hutchinson et al., 2020), it is also the case that students who demonstrate positive patterns of classroom-based SRL may demonstrate difficulty with regulating their emotions given a lack of experience applying and refining their ER skills.

Taken together, it is theoretically possible that students' skills for one target of SR may facilitate or constrain development of skills in another target. However, there is limited empirical research which investigates the possible interdependent relationships between the students' ER and SRL skills. Therefore, an aim of the current study is to assess how middle- to upper-elementary-aged students' ER and SRL skills develop in tandem during the school year. In doing so, findings may provide theoretical insight that supports future research on SR, and the development and implementation of interventions for SR at a global level in classrooms.

Classroom Instruction

From developmental and educational research on SR, positive relationships with critical reference points are also recognized as a foundation for SR development early in life (Blair et al., 2010; Sameroff, 2010). Developmental researchers point to primary caregivers as critical reference points as they model behaviors that the child observes, practices and eventually internalizes (Cole et al., 2018; Kopp, 1989; Leerkes & Parade, 2015). Recall that young children who experience sensitive caregiver practices (e.g., well-aligned for child needs) display increasingly developed regulatory skills (e.g., physiological regulation, sustained attention), early in life (Calkins et al., 2008; Eisenberg et al., 2004; Graziano et al., 2011; Perry & Calkins, 2018). These relationships reflect co-regulatory efforts, wherein a more knowledgeable or capable other (e.g., parent, teacher) supports and facilitates another's (e.g., child, student) self-regulatory processes (Vygotsky, 1978; Hadwin et al., 2018; Sameroff, 2010). That is, more knowledgeable others are integral in supporting the individual in reaching their goals and adapting to the demands of their environment by explaining and modeling effective processes (e.g., strategies, procedures) and offering well-timed and attuned support.

In educational psychology, the critical reference point is typically considered the classroom teacher, and findings demonstrate that students' exposure to different instructional practices in classrooms relate to individual differences in their development of SRL skills (Hamre & Pianta, 2001, 2005; Perry, 2013; Perry et al., 2020; Walker, 2008; Wentzel, 2002). Specifically, classroom teachers who emphasize students' SRL tends to incorporate complex tasks that appropriately challenge students' learning abilities, provide instrumental support and autonomy-supportive instruction that is reflected in practices that emphasize student choice and control and create safe learning spaces (Eshel & Kohavi, 2003; Lodewyk et al., 2009; Perry et al., 2018; Reeve, 2006; Stefanou et al., 2004). For example, findings indicate that students who are exposed to complex tasks that include multiple learning components (e.g., writing, problem-solving), are appropriately challenging, and embedded with opportunities for self-assessment are related to a host of positive learning outcomes (Perry et al., 2018). Specifically, students' who complete complex tasks tend to hold positive beliefs about their learning abilities, display increased motivation for learning, and request appropriate teacher and peer support (Hutchinson, 2013; Linnenbrink, 2005; Perry et al., 2004; Stefanou et al. 2004), all which support students' SR skills. Additionally, students who are enrolled in classrooms where in teachers employ instructional practices that emphasize students' autonomy by centralizing student responsibility in their own learning (e.g., choice, control) find meaning in their learning and display increases to their SRL skills (e.g., metacognition; Eshel & Kohavi, 2003; Lodeyk et al., 2009; Perry et al., 2006; Perry et al., 2020). Classrooms that emphasize student autonomy tend to reflect safe learning spaces, a hallmark of which is positive teacher and peer relationships and non-threatening evaluation practices (Hutchinson, 2013; Perry, 2013, Zimmerman, 2008). These learning environments tend to frame mistakes as learning opportunities and are understood to reduce students' experience of negative affect, support their motivation and engagement in learning, their metacognitive abilities, and ultimately their engagement in SRL (Linnenbrink et al., 2005; Perry et al., 2020; Perry & VandeKamp, 2000; Stefanou et al., 2004). Since ER and SRL share the same underlying processes (e.g., executive functions, metacognition) it is likely that the practices of classrooms teachers also play important roles for both targets of students' ER (Hamre & Pianta, 2005; Koole & Veenstra, 2015; Wentzel, 2002). However, there is limited research which has examined whether instructional practices support students' ER.

In contrast, research findings demonstrate that students' exposure to instructional practices that emphasize teacher direction may experience less positive SRL and learning outcomes than their counterparts (Eshel & Kohavi, 2003; Pierro et al., 2009; Perry et al., 2020). Directive instruction is reflected in teaching practices wherein learning tasks are highly structured, expectations are clear-cut, and individual learning is promoted as opposed to fostering a community of learners (Cameron & Morrison, 2011; Perry, 1998; Stefanou et al., 2004). Research suggests that students who are enrolled in classrooms that emphasize teacher direction may miss opportunities to engage metacognitive processes that take place when making meaningful choices, and exerting control over their own learning (e.g., selecting learning materials, how to approach solving a problem), and in turn may experience less engagement and satisfaction in learning (Stefanou et al., 2004; Perry & VandeKamp, 2000; Pierro et al., 2009). Additionally, if directive practices emphasize teacher feedback and assessment, then this may limit opportunities for self-evaluation or non-threatening feedback (e.g., cooperative assessment, peer-revision), which support metacognitive processes like monitoring and evaluation (Hillyer &

Ley, 1996; Linnenbrink, 2005; Zimmerman, 2008). Moreover, classrooms practices that emphasize directive instruction may promote individual learning and limit important peer-interactions that support problem-solving, resilience towards negative emotions (e.g., less fear of judgement during help seeking), and perspective taking – a social form of metacognition (Eisenberg et al., 2004; Paris & Newman, 1990; Perry et al., 2018; Whitebread et al., 2007). For example, research findings with a sample grade 6 students demonstrated that students whose perceptions of control over their learning were on-par with their teacher, as opposed to student centralized, demonstrated decreased motivation for learning, limited beliefs in their abilities, and applied a limited repertoire of SRL strategies (Eshel & Kohavi, 2003).

However, some research with young students suggests (e.g., preschool, elementary) that directive instruction can be beneficial for their self-regulatory and learning processes (Bohn et al., 2004; Camron & Morrison, 2011; Lillard, 2005; Nowacek et al., 1990). Directive instruction is reflected in teacher behaviors like explaining (e.g., procedural processes, expectations), directing (e.g., which procedures or strategies to use), and assessment (e.g., monitoring and evaluating students' products, outcomes, or successful strategy use; Cameron & Morrison, 2011; Lillard, 2005; Pierro et al., 2009; Cameron et al., 20009). Theoretically, directive instruction does not inherently hinder students' learning or self-regulatory processes. Rather, it is likely that directive instruction supports young students in their endeavors to be academically successful. That is, since children are physiologically still developing while attempting to employ processes like planning, monitoring, and evaluation in concert with procedural and strategical processes related to learning activities, directive instruction may reduce cognitive load and free up resources needed to engage in learning and SR (Cameron et al., 2009; Lillard, 2005). Empirically, research findings have demonstrated that students who are enrolled in classrooms wherein their teachers engage in directive instructional practices is positively related to engagement in learning, and academic outcomes (Bohn et al., 2006; Cameron & Morrison, 2011; McWilliam et al., 2003). In turn, teachers' use of directive instruction may support their students' abilities to initiate, remain engaged in, and effectively execute independent learning activities and ultimately provide meaningful opportunities to engage in SR processes. To date, much of the extant literature on pedagogical approaches and features of instruction that emphasize opportunities for students to engage in SR have been conducted in play-based learning, literacy, and music (Perry et al., 2004; Perry & VandeKamp, 2000; Whitebread et al., 2007; Zachariou & Whitebread, 2019). Therefore, there is a gap in researcher knowledge concerning the role of directive instruction on students SR in procedurally and strategically challenging learning domains like mathematics.

Indeed, research findings indicate that, beyond individual differences in physiological maturation and cognitive abilities, features of classroom instruction play an important role in students' SRL and possibly their ER. Therefore, it is critical for researchers to consider contextual factors when assessing the development of students' classroom-based ER and SRL skills. To date, elementary-level teachers' instructional practices are not often examined during mathematics instruction. Rather, classroom-based research has examined whether different features of instruction support students' self-regulatory skills during literacy and play-based learning. Moreover, previous research has tended to employ self-reports of instruction that dichotomize autonomy-supportive and directive instruction, as opposed to including observational protocols that capture the nature of teachers' practices. As a result, questions remain regarding whether pedagogical approaches to mathematics instruction provide students with meaningful opportunities to develop their ER and SRL skills. The current study extends the literature on classroom-based SR by employing teacher reports of their own typical pedagogical practices with an observational protocol to assess whether instructional practices may support student's development of ER and SRL skills during mathematics instruction.

Current Study

The current study was designed to assess if middle- to upper-elementary-aged students' ER and SRL skills developed during the school year, and the possible dynamic relationships between the development of each target of SR. Additionally, quantitative and qualitative measures were used to examine whether classroom instruction supported students' SR skills during mathematics learning. Specifically, 145 students from grade 3 to grade 6 participated in a larger 3-year study on SR during classroom-based mathematics learning. In the fall and spring of each year, teachers provided reports of their typical classroom instructional practices, and their students' ER and SRL skills. Indeed, previous research has shown that SR is a developmental process, and that children (e.g., 3 to 8-year-olds) and teenagers' (e.g., 13 – 15-year-olds) SR skills (e.g., metacognition, motivation) increase overtime and shift from being domain specific to domain general (Hoyle & Dent, 2018; Raffaelli et al., 2005; Zachariou & Whitebread, 2019). Therefore, it is important to assess how middle to upper elementary-aged students' classroom-based ER and SRL skills develop during the school year. To meet this aim, a repeated measures ANOVA was employed to assess if students' ER and SRL skills improved by the end of the school year (spring). Teachers (i.e., specifically, their classroom practices) were also included as a factor to determine if changes in students' SR were different between classrooms as a function of their teacher's instructional practices.

To gain insight into whether teachers' pedagogical practices support students' development of SR skills, teachers' self-reports of their typical instructional practices (i.e., autonomy-supportive and directive instruction) were assessed using a split-median analysis. To provide additional insight into the role of classroom instruction on students' SR, teacher reports were examined in tandem with observational information that was collected during teachers' mathematics instruction as part of the larger study. Though autonomy-supportive instruction is understood to emphasize opportunities for students' SR in classrooms (Eshel & Kohavi, 2004 Perry et al., 2021; Whitebread et al., 2007), less is known about whether directive instructional practices may facilitate or hinder students' opportunities to develop SR skills during mathematics learning. Previous research on teachers' classroom practices with elementary-aged students tend to assess practices at a global level, or during literacy or play-based learning (Hutchinson, 2013; Perry et al., 2018; Perry et al., 2020; Whitebread et all, 2007). As such, less is known about the role of teachers' classrooms practices on students' SR development during particularly emotionally laden and strategically challenging learning domains like mathematics (Di Leo et al., 2019). Moreover, mixed methods assessments of classroom instruction are not often implemented during mathematics instruction (Perry & VandeKamp, 2000; Van de Stal et al., 2010). Therefore, the current study employed a supplemental qualitative analysis to integrate findings from quantitative results regarding changes in students SR skills, and to support researcher understanding of instructional processes in relation to students' development of ER and SRL during mathematics learning.

Finally, based on previous research which suggests that all targets of SR (e.g., ER, SRL) are distinct in what they target but rely on the same underlying processes (i.e., executive functions, metacognition, motivation, strategic action; Bandura, 1982; Hutchinson et al., 2021; Perry et al., 2018), it is possible that there are interdependent relationships between distinct targets of SR. For example, research findings have indicated that students' ER skills serve as an important antecedent to their SRL during learning, and that students' SRL skills mediate the relationship between ER and academic outcomes (Frenzel et al., 20204; Losenno et al., 2019). Moreover, SRL is believed to support students' ER skills as students who display positive patterns of engagement in SRL hold positive beliefs about their abilities, experience positive learning outcomes (Compagnioni & Losenno, 2020; Muis et al., 2016; Schunk & Usher, 2011), and likely experience less negative affect as a result (Tice et al., 2004). Therefore, a cross-lagged path analysis was conducted to assess the interdependent relationships between students' ER skills in the fall and their SRL skills in the spring, and vice-versa.

Research Questions

The following research questions were addressed: (1) Do elementary students' classroom-based ER and SRL skills change from the fall to spring, and does change differ across classrooms as function of teacher practices? (2) Do observed instructional practices during mathematics learning support students' SR development in this domain? (3) Are there interdependent relationships between students' classroom-based ER and SRL such that ER skills in the fall predict SRL skills in the spring, and vice-versa?

Hypotheses

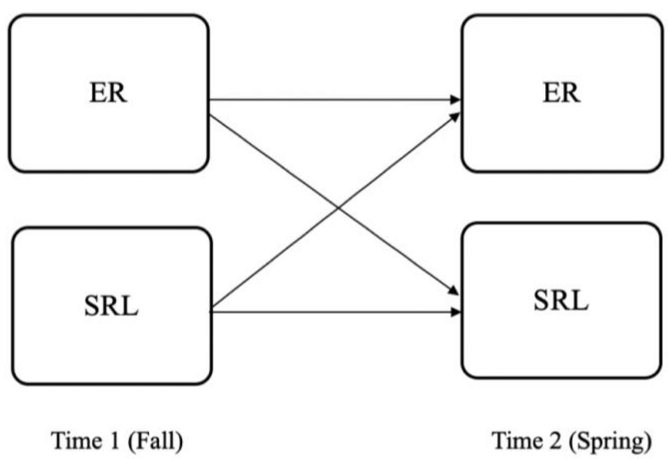
Based on previous theoretical and empirical findings that children's ER and SRL develop over time (Perry & Calkins, 2018; Van de Stal et al., 2010; Zachariou & Whitebread, 2019), I hypothesize that students' ER and SRL skills in the spring will be significantly different from their ER and SRL in the fall (Hypothesis 1). Specifically, students' ER and SRL skills should significantly improve from the fall to the spring. Therefore, I anticipate that change in students' ER and SRL skills across the school year will be significantly different across classrooms as a function of their classroom teacher's practices (Hypothesis 2). Based on previous research that has indicated that pedagogical practices may facilitate or curtail students' self-regulatory processes (e.g., metacognition, monitoring, evaluation, strategy use; Hamre & Pianta, 2005; Cameron & Morrison, 2011; Perry et al., 2021), I predict that teacher identity (e.g., classroom membership) will significantly interact with students' ER and SRL skills and that there may be differences in students' SR change between classrooms given varying instructional practices.

Additionally, previous research (Eshel & Kohavi, 2004; Hamre & Pianta, 2005; Hutchinson, 2013; Perry, 2013; Perry et al., 2020; Whitebread et al., 2007) has shown students require a mix of autonomy-supportive and directive instructional practices to be successful in their learning endeavours and to support the development of their SR skills. Therefore, I anticipate that teachers will report engaging in both instructional practices (Hypothesis 3). Moreover, I hypothesize that observational records of teachers' instructional practices during a mathematics lesson will reveal differences in classroom practices and thereby opportunities for students to engage in and develop their ER and SRL skills. Specifically, I hypothesize that teachers who reported emphasizing autonomy-supportive practices will also be observed implementing instructional practices (e.g., complex tasks, instrumental support) in ways that meaningfully support their students' ER and SRL processes during mathematics learning (Hypothesis 4). However, previous research findings have demonstrated that directive instruction is positively related to students' independent work activities, engagement in learning, and learning outcomes (Bohn et al., 2004; Cameron et al., 2009; Lillard, 2005; McWilliam et al., 2003), which may be especially helpful for students' learning endeavours in a strategically and procedurally challenging and emotionally laden learning domain like mathematics. Therefore, I hypothesize that observations of teachers' instructional practices may reveal that directive instructional practices like well-structured tasks, explicit procedures for learning activities, and unsolicited teacher support may afford students' meaningful opportunities to foster their SR skills during mathematics learning (Hypothesis 5).

Finally, since ER and SRL share underlying self-regulatory processes (e.g., executive functioning, metacognition, motivation, strategic action; Cole et al., 2018; Diamond, 2016), and are considered interdependent (Usher & Schunk, 2018; Perry et al., 2018), I predict that there will be significant relationships between these two targets of SR over time (Hypothesis 6; see Figure 4 for hypothesized model). That is, not only will students' ER skills in the fall predict their ER skills in the spring but their early ER skills will also predict their later SRL skills. The same hypothesis holds true for SRL skills such that students' SRL skills in the fall will predict their SRL and ER skills in the spring.

Figure 4

Hypothesized cross-lagged path model



Note. Students' age in the fall was included as a covariate.

Method

The data reported in this study comes from Year 2 of a 3-year longitudinal study of students' classroom-based self-regulation. In the fall of 2017 (Year 1), teachers and their students were recruited by the Principal Investigator (PI; Dr. Krista Muis) to participate. In the spring of 2018, (Year 1), data collection commenced and a cohort of students from grade 3 (age 8) through to grade 6 (age 11) were followed. At the beginning of each school year, new grade 3 cohorts were offered the opportunity to participate in this study (fall 2018, fall 2019) and all new and current students in each grade were offered the opportunity to participate at the start of each new data collection period (e.g., fall and spring). The second year of data was selected for the present research as it was the first set of data that represented an entire academic year (fall 2018 and spring 2019). The larger project had two main goals: (1) to understand how multiple facets of students' SR (ER, SRL, and social components of SR) develop over time, and (2) to gain insight into the individual and environmental factors that support or curtail SR development (e.g., task value, self-efficacy, academic skills, features of classroom instruction).

Design

The present study employed an explanatory sequential multilevel mixed method design (McCrudden & Marchand, 2020; McCrudden et al., 2019) to assess how students' SR skills (i.e., ER, SRL) develop during the school year and to gain insight into teachers' instructional practices that support students' SR skills during classroom-based mathematics learning. That is, complementary quantitative and qualitative data sources were employed across the student and teacher levels of analysis. Specifically, quantitative data were collected to examine how students' ER and SRL develop during the school year, whereas teachers' instructional practices where quantitatively and qualitatively captured to enhance researchers' understanding of how teachers' instructional practices may support classroom SR. To date, there is a paucity of research that has employed mixed methods across levels of study (e.g., students in classrooms, teachers) and assesses how different emphases on instructional practices may support or curtail students' ER and SRL skills during classroom-based learning. Theorists have suggested that employing multiple diverse measures of teachers' instructional practices (e.g., teacher reports, observations) may more fully account for how instructional practices in classrooms support or hinder students' SR processes (SRL, ER; Ben-Eliyahu & Bernacki, 2015; Winne, 2010). As such, teachers' reports of their typical instructional practices at a global level (quantitative) paired with the observational analysis (qualitative) of a classroom-based mathematics lesson offered an opportunity to gain insight into teachers' instructional practices in classrooms with varying degrees of emphasis on practices (i.e., autonomy-supportive and directive instruction) that theoretically support SR. Moreover, following calls from Ben-Eliyahu and Bernacki (2015), this study employed measures with appropriate time scales for assessing how students' SR changes over time. That is, students' SR was assessed via teacher reports of their students' skills within the context of classroom-based mathematics learning, and across the school year. These measures corresponded with the quantitative assessments and observational analyses of teachers' mathematics classroom instructional practices across the school year, which are relatively enduring processes that evolve slowly (weeks, months). Such a design should provide a natural setting to enhance researchers' understanding of which classroom instructional practices may facilitate students' SR.

Participants

Participants were 145 students (71 girls) and four teachers (all women) from one public elementary school in Montréal, Canada. Student participants were from all classrooms from grades 3, 4, 5 and 6 with two classrooms per grade. Teacher participants were also from grades 3 through 6, and taught both classes at one grade level (i.e., Teacher 1 taught both grade 6 classes). Parents provided consent for their child/children and students assented to participate. Teachers also provided their consent to participate in this study. At this school, students in grades 3 through 6 are instructed in both French and English. Students spend 50% of their time learning in French with their French teacher, and 50% of their time learning in English with their English teacher. In mathematics, the language of instruction was English, and students in different classrooms of the same grade level (i.e., grade 6: classroom 1, classroom 2) were taught mathematics by the same English teacher. Most student participants were first-language English speaking (95%) and the remainder were first-language French speaking (5%) but spoke English fluently. Participating teachers were all first-language English speaking. The socio-economic status at this school ranged from low to middle-high and students were approximately evenly distributed across SES levels. Approximately 87% of participating students and 100% of participating teachers were Caucasian. The remaining students were Black (2%), Hispanic (5%), Asian (4%) or Indigenous (2%). Teachers identified 21 students as having individualized education plans (IEP) and were provided learning activities and instructional support that was adapted to their individualized learning needs.

Materials

Demographics. Students' date of birth (age) and sex (boy or girl) was obtained from parental consent forms (see Appendix A). Teacher information including their name was collected from teacher consent forms. See Table 7 for students' age and sex by grade level.

Table 7

Sex and age of students by grade.

Grade	Boy	Girl	Total	Age	SD
Grade 3	21	23	44	8.02	.27
Grade 4	19	8	27	9.15	.46
Grade 5	20	19	39	10.08	.27
Grade 6	14	21	35	10.97	.62
Total (145)	74	71		9.55	0.41

Note. Age is represented as a mean value at time 1 (fall).

Self-regulatory processes. The Self-Regulation In School Inventory (SRISI; Hutchinson, 2013; Hutchinson et al., 2021) is a validated teacher-report tool that has been employed to measure multiple facets of students' classroom SR skills (SRL, ER, social SR) using items that assess underlying processes involved in self-regulation (i.e., metacognition, motivation, strategic action; see Appendix I). An adapted 16-item version of the SRISI was employed to capture teacher reports of their students SR in the fall and spring, using a 7-point Likert scale where 1 corresponds to "never true" and 7 corresponds to "always true". This tool was employed to assess teachers' perceptions of two dimensions of their students' classroom self-regulation: SRL (9-items; e.g., Is aware of how much time it takes him/her to complete academic tasks) and ER (7-items; e.g., Has something positive to say about his/her learning progress even when he/she is disappointed because he/she does not do well on an assignment). Though teachers' judgements of their students' classroom SRL have been questioned, evidence indicates that teachers can provide reliable and valid judgments of students' SR during everyday classroom activities (Hutchinson et al., 2021; Kaufmann, 2020; Whitebread et al., 2009).

Each item pertaining to the ER and SRL subscales from the fall and the spring were assessed for skewness and kurtosis using a z-score cut off set at < |3| for skewness and < |8|, which corresponds with the sample size (Tabachnick & Fidell, 2013). Results demonstrated that two ER items in the fall were non-normal: (1) Has something positive to say about her/his learning, even when s/he is disappointed because s/he does not do well on an assignment, underlying processes: motivation (-3.38/0.50); (2) Engages in positive self-talk or other productive strategies when faced with challenging or upsetting situations, rather than letting negative emotions get in the way, underlying processes: action (-3.37/0.17). Additionally, four SRL items in the fall and the same four SRL items in the spring were negatively skewed: (1)

Enjoys and/or values learning new things, underlying process: motivation (fall = -5.40/ 2.22, spring = -5.82/ 2.83); (2) Is willing to try challenging tasks, underlying process: motivation, (fall = -4.35/ 0.06, spring = -4.23/ -0.47); (3) Takes responsibility for learning successes and failures by attributing them to factors s/he can control, underlying process: motivation, (fall = -3.67/ 0.93, spring = -3.88/ 1.66); Can manage a set of directions to complete tasks independently, underlying process: action (fall = -3.75/ -0.64, spring = -3.60/ -1.21). However, when these items were averaged together to create composite scores for the ER and SRL sub-scales in the fall and spring, the assumptions of normality and skewness were not violated. Therefore, reliability was assessed for each sub-scale (ER, SRL) at each time-point (fall, spring). Findings demonstrated that reliability for the ER measure in the fall ($\alpha = 0.94$) and the spring ($\alpha = 0.94$), and the SRL sub-scale measure in the fall ($\alpha = .93$) and in the spring ($\alpha = .89$), were consistent with previous research (see Table 8 for descriptive information regarding ER and SRL in the fall and the spring; Hutchinson, 2021).

Table 8

Descriptive information for ER and SRL skills for all students

	Mean	SD	Skew	Kurtosis
ER fall	4.95	1.13	-1.80	-1.66
ER spring	5.03	1.18	-2.02	-0.89
SRL fall	5.18	1.08	-2.29	-1.02
SRL spring	5.34	1.14	-2.59	-0.43

Note. Means for ER and SRL reflect latent variable means provided by mPlus.

Instructional Practices. Teachers completed the 14-item Classroom Context Questionnaire (CCQ; Perry, 1998 adapted by Muis, 2017; see Appendix J) which measures how often they employ instructional/assessment practices known to support SR in their classrooms. These practices include: teacher and peer support, complex tasks, choice, accommodation, control over challenge, embedded assessment, and self-evaluation. Each item consists of two counter-balanced options A or B which corresponded to autonomy-supportive or directive instructional practices, both of which are critical for SR (Butler, 2021). For example, an item states "When students worked on tasks," option A stated, "I encouraged them to work together (e.g., collaborate on a project)" whereas option B stated, "I encouraged them to work independently". This tool was adapted by the PI, Dr. Krista R. Muis, to include a 5-point Likert scale where 1 indicated "never' and 5 indicated "always" to allow teachers to provide more exact ratings of how often they engaged in these classroom practices, specifically during mathematics instruction. At the end of the questionnaire, there was space for teachers to elaborate on practices they reported that did not reflect a typical week (i.e., For any of the items that do not reflect a typical week for you (i.e., you selected "No" for a typical week), please indicate the number (#2, etc) and briefly describe why is not a typical week). However, teachers rated that each of the practices represented in the CCQ were present to some degree during a typical week of teaching, and thereby did not need to complete this section.

Given that features of classroom instruction are relatively consistent across time (Ben-Eliyahu & Bernacki, 2015), and the aim of this study was to examine which classrooms practices might foster students' development of SR skills during the school year, the CCQ data from the fall was employed. Composite scores for each sub-scale were created by averaging the corresponding items. Due to small sample size (n = 4 teachers), normality and reliability measures could not be assessed for the autonomy-supportive and directive instruction sub-scales. To assess teachers' emphases on autonomy-supportive and directive instruction practices, and for sake of comparison between teachers, a split-median score was used for each of the sub-scales from the CCQ. First, composite scores were created for the autonomy-supportive and directive instruction sub-scales using average scores. Since the items for each sub-scale are rated on a Likert-scale ranging from 1 to 5 the median score was set at a value of 2.50. Teachers' reports of their autonomy-supportive and directive instruction practices were then assigned a value of "0" or "1" depending on their average score (i.e., < = 2.49 average score > = 2.50). For the autonomy-supportive sub-scale, teachers' whose average score was on or below the median were assigned a value of "0" (i.e., 0 = low emphasis on autonomy-supportive instruction), whereas teachers whose score was on or above the median were assigned as value of 1 (e.g., 1 = high emphasis on autonomy-supportive instruction). For the directive instruction sub-scale, teachers whose score was on or below the median were assigned a value of 0 (e.g., 0 = low emphasis on directive instruction), whereas teachers whose average score was above the median were assigned a value of "1" (i.e., 1 = high emphasis on directive instruction). Therefore, teachers could be assigned one of four possible codes to represent combinations of instructional behaviours: (1) high autonomy-supportive and low directive instruction (2) high autonomy-supportive and high directive instruction (3) low autonomy-supportive and high control instruction, and (4) low autonomy-supportive and low directive instruction.

Classroom Observations. To capture instructional practices during classroom-based mathematics learning, myself, the PI and a trained researcher engaged in classroom observations during the fall and spring, using the Classroom Observation Instrument (Perry, 1998; Perry et al., 2000; see Appendix K). This tool has three sections, the first of which provided general information about the classroom being observed which includes the date, the name of the observer, the name of the teacher, the grade level of the students, and the learning domain and duration of the lesson. The second section provided space for researchers to produce detailed descriptions of the activities taking place within the classroom, including verbatim speech between teacher and student, peer to peer, the physical landscape of the room, and the type of learning activities that unfold. The last section provided examples of how classroom practices manifest to support students' self-regulation. The table, created by Hutchinson (2013), consists of two columns where the first column provided a list of the classroom features of instruction that may support SR including: complex tasks, choices, control over challenge, self-evaluation, teacher support, peer support, non-threatening/non-competitive evaluations, and communities of learners. The second column described how these concepts may manifest during classroom learning. For example, the column for complex tasks stated, "Classroom activities and tasks provide opportunities for children to showcase their learning in different ways". This also exemplifies that each feature and their characteristics are not mutually exclusive. Rather these categories may overlap (e.g., complex tasks may provide opportunities for choice), and provide support for more than one target of SR (i.e., SRL, ER). As researchers have demonstrated, the dimensions on this protocol (e.g., choice, challenge, peer/teacher support) have been associated with the development of elementary-aged students' SRL (Perry & VandeKamp, 2000; Perry et al., 2018), and possibly their ER (Hamre & Pianta, 2005). Additionally, these observational reports corresponded with practices reported in the CCQ (Perry, 1998 adapted by Muis) and were employed as an additional measure of teachers' practices during mathematics instruction.

Following Perry's (1998) recommendations for use of the observation protocol, after each period of observation researchers reviewed their notes and discussed the presence and quality of each feature of instruction that they observed within the classroom. That is, instances and examples of opportunities for students to employ and practice their SRL were identified from the detailed descriptions. Then, a score was assigned for the quality and presence of each feature of instruction where 0 corresponds with "no evidence", 1 corresponds with "somewhat evident but not in ways that support SR”, and 3 corresponds with “evident in ways that support SR”. For example, when discussing the feature “choice,” a teacher may allow students to choose what to write with (e.g., pen, pencil). This is not recognized as meaningful for SR and would receive a score 1, but not a score of 0 because the practice is not absent. If a teacher provided meaningful choices such as allowing students to choose with whom to work, or where to work in the classroom, this would receive a score of 3 as it provides meaningful opportunities for students to engage in SR. To establish inter-rater reliability for the assigned scores, all three researchers engaged in consensus coding (Bradley et al., 2007**)**. This entails all three researchers independently applying the coding scheme from section 3 to the data and subsequently comparing findings. Any differences were resolved through discussion until an inter-rate agreement of 100% was obtained for all the observations. Finally, scores were averaged across each dimension of instructional practice to produce a single score that represents the presence and quality of classroom instructional practices that were observed by researchers.

Procedure

In the fall of 2018 and spring of 2019, approximately one week before in-class data collection, participating teachers provided ratings of their instructional practices during mathematics sessions using the CCQ (Perry, 1998; adapted by Muis, 2017). Teachers also completed an SRISI for each of their participating students. This ensured that teachers had time to become acquainted with their students and to implement their approaches to classroom instruction. This also ensured that teacher reports of their students’ classroom skills (i.e., self-regulatory, academic) were calibrated with students’ actual skills. In the following week, classroom-based observations were carried out by myself, the PI and a trained research assistant. Following the protocols set out by Perry (1998), these observations took place during regular classroom hours of mathematics instruction for approximately one hour. Myself and my colleagues positioned ourselves in different corners of the classroom where we could clearly see the teacher, the students, and any learning materials (e.g., the black board, activity handouts) that were employed. Each teacher's name, the date, time and subject matter were recorded before beginning the observations. Following each observation period, myself and my colleagues would discuss our ratings. As part of the larger project, students then completed a complex mathematics problem, which is not reported here as mathematics problem-solving performance was not included as a variable of interest.

Results

Preliminary Analyses and Data Analytic Approach

Given the nested nature of classroom data wherein students are nested within grade levels (e.g., grade 4, grade 6) and with teachers/classrooms, Intraclass Correlation Coefficients (ICC) were computed for each variable to determine if nested analyses were necessary. As such, each variable in the model was independently assessed as a dependent variable to determine if the variance in each dependent variable could be accounted for by grade level/classroom. Results (ICC = < 0.05) suggested that variance in the data was not statistically significantly explained by grade level or classroom enrollment (see Meyers et al., 2016). Therefore, the students were grouped into a single sample and correlations were computed for students' sex, age, grade level, IEP status, and the fall and spring ER and SRL sub-scales (see Table 9).

Next, a repeated measures ANOVA was conducted for each target of SR to assess if students' ER and SRL developed across the school year. Each analysis included teachers, specifically their instructional practices, as a factor to see if there was an interaction between classroom practices and students' SR development. Given that only two time points were included in this analysis, an analysis of sphericity was not necessary. To assess if different features of instruction during classroom-based learning supported students' SR, teachers' reports of their instructional practices were examined in relation to the classroom observations that were conducted for each teacher during a typical classroom-based mathematics lesson. Finally, a cross-lagged path analysis was conducted using Mplus 8.0 (Muthén & Muthén, 2017) to assess the possible interdependent relationships between students' development of ER and SRL during the school year.

Table 9

Pearson product-moment correlations for study variables

	1	2	3	4	5	6	7	8
1. Sex	1.00							
2. Age	-0.03	1.00						
3. Grade level	-0.07	0.94**	1.00					
4. IEP status	0.10	-0.12	-0.15	1.00				
5. ER fall	-0.13	-0.07	-0.01	-0.41**	1.00			
6. ER spring	-0.12	-0.14	-0.04	-0.35**	0.76**	1.00		
7. SRL fall	-0.07	-0.24**	-0.19*	-0.34**	0.86**	0.74**	1.00	
8. SRL spring	-0.15	-0.33**	-0.24**	-0.35**	0.66**	0.87**	0.76**	1.00

Note. Age is represented by students age in the fall.

* $p < .05$, ** $p < .01$.

Repeated Measures ANOVA

To address the first question, "Do elementary students' classroom-based ER and SRL skills change from the fall to spring, and does change differ across classrooms as function of teacher practices?" SPSS 21 (IBM Corp., 2021) was used to conduct two repeated measures ANOVAs, one for each target of SR. Teacher identity was included as a factor and simple comparisons were conducted to examine if there were significant differences in students' ER and SRL across the year, and whether the change in their SR skills significantly differed as a function of their teachers' classroom practices (see Table 10 for means and standard errors of students' SR scores across classrooms). Results from the first repeated measures ANOVA demonstrated that there was a significant interaction between teachers and students' ER skills from the fall to the spring, F (3,142) = 7.51, $p < 0.001$, $n^2 = 0.14$. However, the main effect for ER was non-significant, F (1,144) = 0.16, $p < 0.067$, $n^2 = 0.001$ (see Figure 5). Simple comparisons indicated that grade 3 students' ER significantly increased across the school year, (1,44) = 7.48, $p = 0.01$, $n^2 = 0.15$, whereas grade 4 students' ER significantly decreased, (1,26) = 21.53, $p < 0.001$, $n^2 = 0.45$. Findings demonstrated that grade 5 students did not display changes to their ER skills, (1,29) = 0.48, $p = 0.49$, $n^2 = 0.16$, nor did grade 6 students (1,44) = 1.27, $p = 0.26$, $n^2 = 0.03$.

Table 10

Mean scores and standard errors for students' ER and SRL in the fall and spring by grade level

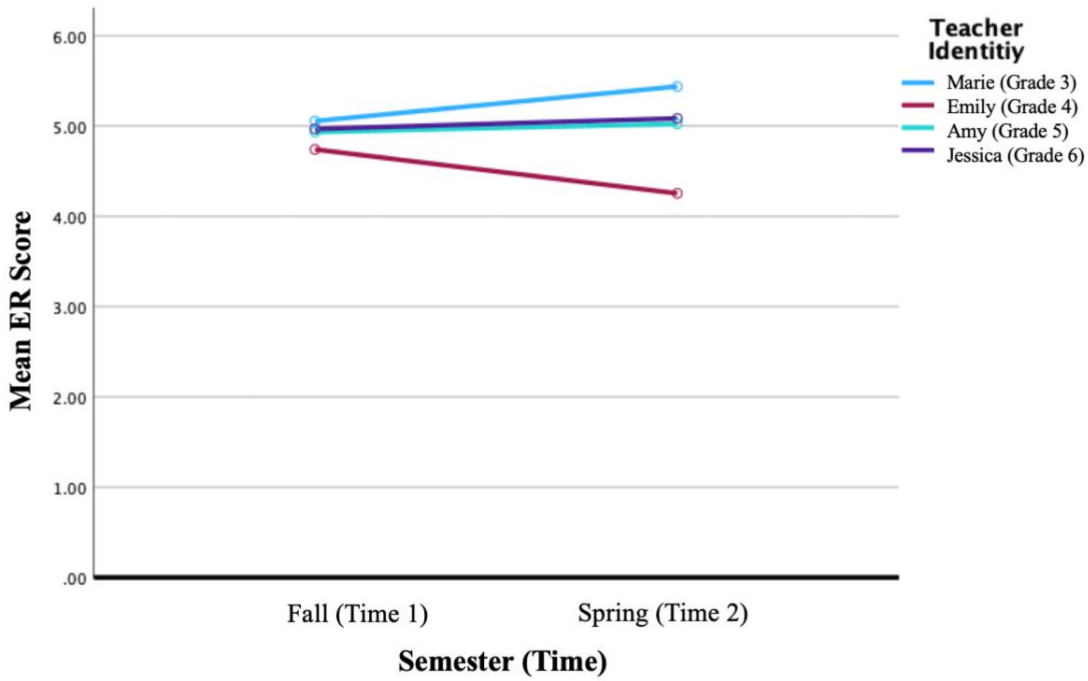
Grade	Measure	Mean	SE	95% CI
Grade 3	ER fall	5.06	0.17	4.72, 5.39
	ER spring*	5.44	0.17	5.10, 5.77
	SRL fall	5.581	0.16	5.26, 5.90
	SRL spring*	6.025	0.16	5.71, 6.34
Grade 4	ER fall	4.741	0.22	4.31, 5.17
	ER spring*	4.254	0.22	3.83, 4.68
	SRL fall	4.97	0.21	4.56, 5.38
	SRL spring*	4.69	0.20	4.29, 5.10
Grade 5	ER fall	4.93	0.21	4.52, 5.34
	ER spring	5.02	0.21	4.62, 5.43
	SRL fall	5.13	0.19	4.76, 5.51
	SRL spring	5.28	0.19	4.91, 5.66
Grade 6	ER fall	4.97	0.17	4.63, 5.31
	ER spring	5.08	0.17	4.75, 5.42
	SRL fall	4.94	0.17	4.61, 5.27
	SRL spring*	5.11	0.16	4.79, 5.44

Note. (*) denotes a mean score in the spring that was significantly different from the fall.

* $p < 0.05$.

Figure 5

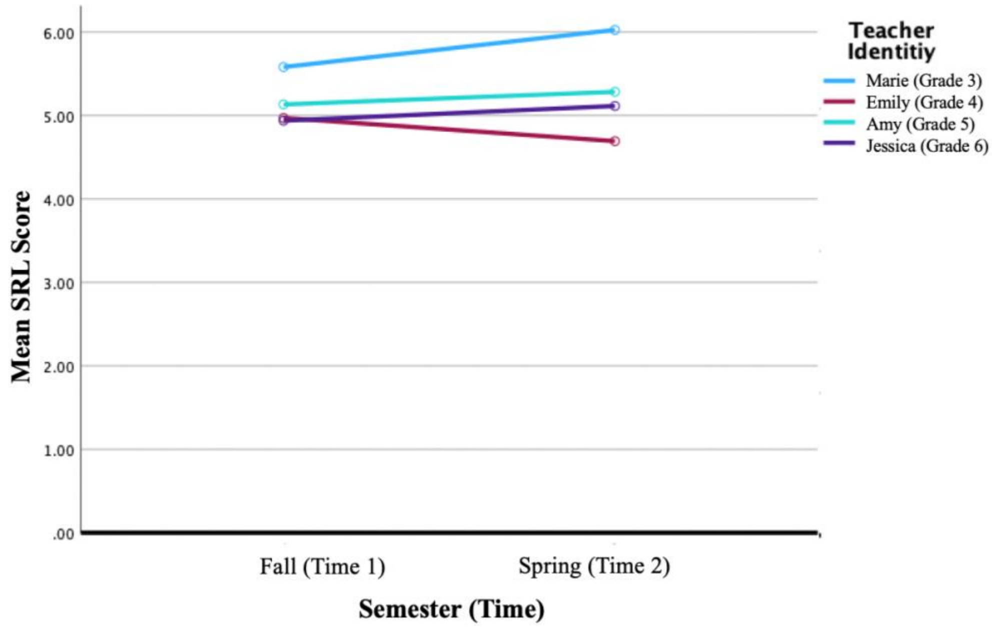
Estimated mean scores for students' ER from fall to spring between grade levels



Findings from a second repeated measures ANOVA demonstrated that there was a significant main effect for SRL, F (1,144) = 3.68, p = 0.05, n^2 = 0.03, and a significant interaction between teachers and students' SRL such that change in students' SRL was in part a function of their teachers' practices, F (3,142) = 6.87, p < 0.001, n^2 = 0.13 (see Figure 6). Simple comparisons demonstrated that grade 3 students' SRL skills significantly increased across the school year, F (1,44) = 10.19, p = 0.003, n^2 = 0.19, as did grade 6 students' SRL skills, F (1,44) = 5.54, p = 0.02, n^2 = 0.12. In line with findings regarding ER, simple comparisons indicated that grade 4 students' SRL skills significantly decreased over time, F (1,26) = 6.93, p = 0.01, n^2 = 0.22, and that grade 5 students' SRL skills did not significantly change, F (1,29) = 0.87, p = 0.34, n^2 = 0.03.

Figure 6

Estimated mean scores for students' SRL from fall to spring between grade levels



Split-median Analysis and Observations of Classroom Instruction

To address the second question, "Do observed instructional practices during mathematics learning support students' SR development?", teachers' self-reported instructional practices were examined in concert with records of their classroom observations. Each teacher taught two classrooms at the same grade level and reported the same instructional practices across their classrooms. Results from the split-median analysis of teachers' self-reported instructional behaviors displayed a single trend, relatively high mean scores for autonomy-supportive (2.86 > $\bar{x}$ < 4.57) and directive instructional practices (2.86 > $\bar{x}$ < 3.79). Teachers also received the same observational ratings across their classrooms. As such, the self-reported and observational scores were aggregated across their classrooms to represent their instructional practices at a broad level for each teacher (see Table 11). The most robust observation of each teacher's instructional practices during a mathematics lesson was reviewed and findings from the split-median analysis are discussed in relation to the instructional practices that may support students' SR.

Table 11

Mean scores of self-reported instructional practices and observational ratings during mathematics lessons

Feature of instruction	Complex Task	Embedded assessment	Self-evaluation	Teacher support	Peer support	Choice	Control	Accommodation
Teacher								
Marie Autonomy ($\bar{x}$ = 4.57) Direction ($\bar{x}$ =3.79)	2	2	2	2	2	1	1	2
Emily Autonomy ($\bar{x}$ = 3.57) Direction ($\bar{x}$ =3.43)	1.5	1	1	2	0.5	1.5	1	2
Amy Autonomy ($\bar{x}$ = 3.71) Direction ($\bar{x}$ =2.86)	2	2	2	2	1.5	2	2	2
Jessica Autonomy ($\bar{x}$ = 2.86) Direction ($\bar{x}$ =3.57)	2	2	2	2	2	2	2	2

Note. List of teachers descends from grade 3 to grade 6. Autonomy and direction refers to teachers' mean score on the CCQ subscales.

Grade 3 Classrooms

Marie was the teacher for the grade 3 classrooms, and like her peers she reported emphasizing autonomy-supportive ($\bar{x} = 4.57$) and directive instruction ($\bar{x} = 3.79$) during a typical week of teaching. Marie's score on the autonomy-supportive and directive instruction sub-scales from the CCQ were the highest amongst her peers. Marie's observational records provide perspective regarding her instructional practices during a mathematics lesson and whether these features of instruction may support students SR. Specifically, she received high (i.e., 2) observational ratings from complex task, embedded assessment, self-evaluation, teacher support, peer support, and accommodation. These ratings indicate that Marie was observed implementing these instructional practices in ways that meaningfully support SR. However, Marie received a score of 1 for choice, and 1 for control. Notably, these were the lowest scores that were assigned for these instructional practices across all the participating teachers. These ratings suggest that Marie was not observed implementing these practices in manners that support her students' SR. However, a review of her observed mathematics lesson provides important insight regarding her instructional practices and how they may emphasize students' SR at a global classroom level.

Marie's Observed Mathematics Lesson. Marie started her class with her students sitting on the carpet at the front of the classroom, so that they were looking at an interactive whiteboard. She explained to the class that they were going to work in groups, and that they were expected to talk out loud as they work on their problems. When a student was concerned that there were only three people at her table instead of four, Marie explained that they would figure that problem out later. She explained that before their group task, they were going to review their work on units, "so, let's review this page here, so here there is 10 digits, why is there 10 digits and not 9?" She called on a student with their hand raised, and when the student had difficulty explaining correctly, Marie said “so that’s what’s throwing some of you off is the 0, when you see this [write value 1003 on board] you think it’s 13 instead of 1003. You have to remember the position of the numbers”. Marie asked a student to quiet down when they were being distracting, she then displayed a worksheet on the board and reminded her students that they must be able to break down how many 10s are in 100. The worksheet required students to generate numbers and explain the value of the number based on its position. Marie had a random number generated on the whiteboard and explained, “I have a 6 in the unit’s position, a 6 in the tens position and a 2 in the hundreds position”. She explained that they must make another number from the value previously generated. Marie allowed the children to brainstorm on their own, and asked “Does anyone have any ideas?”. No one raised their hand to respond, so Marie elaborated that the two numbers cannot have the same number of digits. She then called on a student, “so what are we going to do, Sean?” He stated that they need to change it, and Marie encouraged him to explain how, “Maybe change the 10?”. She asked another student, Sean, if that procedure was allowed and he did not answer. Another student raised their hand to participate and created a new number from 266 by adding 1000 to make 1266. Marie asked her class if she made a new number, to which they all agreed. She then asked if the number respected the rules, and they all said yes.

Marie generated several more numbers and followed this process with other students. One student added larger numbers to his generated value 43, to make 6343. Then another student, Lena, who volunteered to participate received what Marie believed to be difficult value. Marie said “do you think you can do that? You can try! If you can read it you can put the units in their place. You can help her if she needs, Maria.” Maria is the girl who was sitting next to Lena. Lena said, “have a 5 in the hundred positions, a 2 in the unit position and a 4 in the ten position.”

During this exercise, Marie provided different feedback (quantity, quality) to students who volunteered to participate, and always remained positive when students struggled.

To move the mathematics lesson forward, Marie explained the group-based task to her classroom. Students were told to work with the person who sat in front of them. One partner had to write down a number and share it with their partner, who in turn represented the number using blocks that represent values like hundreds, tens and units. A wall divided the partners and prevented the students who built the values with blocks from seeing the written value. Marie said "if your partner doesn't get it right [the blocks] the first time, you're going to tell them you need a 6 in the 1 position. So, you're going to be like her teacher." When a student asked about what happens if they get the value wrong, Marie said "It doesn't matter because this isn't a test". Before allowing her students to start the tasks Marie reminded her students "So, I need you guys to talk about it, because the more you talk about it the more you'll understand its positions."

Students went back to their tables and Marie handed out the materials (i.e., a blank sheet, a wall, blocks) and helped the students to get arranged. She stopped her class, "Can I have your eyes over here – so this is how I need you to be set up with your partner, I need you to have the wall between the two of you and our cubes." Students began the activity with their partners, and two students are overheard saying "580, okay?", "We don't have enough 1's!". They turned to their neighbors and asked to borrow some blocks that represent single units. A pair of girls were observed solving the problem together, wherein one partner counted the blocks to the other partner. During this time, Marie walked around to some of the tables to track her students' progress and success. There was an educational assistant present in the classroom, who was stationed at a desk wherein Marie had indicated that a student has learning difficulties. She asked one pair if they are almost done their work, which they were. She told them to switch roles so that each partner generated and represented then numbers. At another point, a student sat alone waiting for his partner to return so Marie said, “okay I’ll give you the number because its big so you can work on it while he’s gone”. The student represented the number swiftly and correctly, and Marie encouraged him “Wow, you did that in no time!”

As the lesson progressed, students completed their tasks and Marie informed these specific pairs that they could get their snack and talk quietly with their partner. When Marie started to wrap-up the class she asked everyone to put their materials away and return to their desks. She asked everyone a question, “So, is there anything we need to take note of about this?”. Marco raised his hand and explained that he would read the problem and try to prepare for it by figuring each one [position value] out, “So, what I usually did to help Mikey is for 120, I would say 100 and he would put 100 and then 20 and he would put two 10’s”. Marie explained that this was a great strategy for helping his partner, and then told her students to prepare for a recess break.

Grade 4 Classrooms

Emily taught the grade 4 classes in her school, and like her peers reported emphasizing autonomy-supportive instructional practices ($\bar{x}$ = 3.57) and directive instruction ($\bar{x}$ = 3.43) during a typical week of teaching. Compared to her peers, Emily’s self-reported scores were most similar across both instructional sub-scales from the CCQ. Regarding the observations that took place during her mathematics lesson, Emily received slightly lower ratings for complex task (1.5), choice (1.5), control (1), embedded assessment (1), self-evaluation (1), and peer support (0.5) compared to the other teachers. For the remaining features of instruction (i.e., teacher support, and accommodation), Emily was assigned scores of 2 which correspond with these features being meaningfully integrated and emphasized in her classroom. To gain insight into how Emily emphasized different features of instruction, the following section synthesizes observational records of Emily's mathematics lesson and discusses the ways in which her instructional approaches may facilitate or hinder students' SR.

Emily's Observed Mathematics Lesson. To start her mathematics lesson, Emily reviewed previous work with her students before they were instructed to work from their books. She had placed some words on the board (i.e., sum, difference, total, in all, how much more, have enough) that related to word problems that the students had been practicing. Emily asked her students to come to the board and write the words under the appropriate heading: addition or subtraction. Students volunteered themselves, and when they approached the board were asked probing questions like "When we ask for the sum of something are we adding or subtracting?" After filing all the words under the headings, she told her students to turn to their workbooks and a student volunteer read the problem as she wrote problem information on the board. The problem was about a student who needed a certain number of exam points across different years of schooling to get her diploma. Emily said, "So, this is a 1 2 3 problem and there are lots of things to think about. What is the first thing to think about Marie-Claude?" The student struggled to answer so Emily selected another student, "What important information do we need to remember, Shelby?". Shelby stated that there are different classes (e.g., math, English, science) that the student in the problem must complete. Emily corrected the student and stated, "Okay, how about we think about only what we need to remember" and she highlighted information from the problem that was necessary for the students to find the solution. As Emily did this, she asked her students "Maybe I should underline it?" and her students agreed. They then asked if they could write on their own work and followed along and highlighted important information.

Emily asked her students, "What is it that I need to find out?" No one answered and

Emily continued, “How many points does she need in her final year. So, what do we have to do first?” A student called out, “We have to minus” and Emily encouraged the student to provide more information, “from what?” This process continues for a several minutes, wherein Emily talked through which information the students need to find, and which processes they need to engage in (i.e., addition, subtraction) to produce that information, and a strategy to support these mathematical processes (i.e., grouping). She stated, “I’m gonna let you solve the problem. Remember what we said about grouping.” Emily walked around the room, and stopped near students and observed the work they were doing. She asked a student, “What happens when you have zero 100s?” to which they answered, “I go to the 1000s”. A neighboring student asked about his processes, and Emily stated, “That solution would work just as well Tom, that’s your choice.” Emily kept walking around the room when she approached the board at the front of the room, and stated to the entire class, “Only start with your units here [points to board]. You need to regroup this way [pointing to the previous example]. Tyler used his lines to separate and not get mixed up with the place value. That’s really important.” Emily asked students what the next step was but the students were unsure so she reviewed the next step of the problem,

> “What does the 939 come from? Where did we get that number come from? What does this represent? [The class is quiet] This is her first year [pointe to value in word problem], this is her second year [points to value in word problem], what does that number [value in word problem] represent?

A student, April, stated that the value represented the points accumulated so far for the imaginary students’ degree. Emily asked, “So, how many points does she need to get her diploma?” April replied that the student needed five more points and Emily asked how she got that answer to which she replied, “it’s 2345-1788”. Emily wrote the equation on the board and instructed the students to solve the remainder of the problem that followed from this step. She went around the classroom and helped students with the computation, and with their organization. To one student whose work she observed Emily asked, “How did you get 5 minus 8 is 1? Let’s go back. Which is a bigger number 5 or 8? Use lines to separate your work so you don’t get confused.” After Emily worked with some students, she stated to the classroom, “Remember that it asks you to explain your answer. You need to tell me how many points she needs. If you finish, you can go back to your other work. I’m going to come back to the answer soon.” Shortly after, Emily went to the front of the classroom and worked through the final answer. A student volunteered information, and Emily explained that they started in the wrong place, and indicated the correct place value to work with. Students continued to volunteer information about their problem-solving process and outcomes when Emily stated they needed to pack up for lunch and said, “Okay, we definitely need to keep practicing this subtraction business.”

Grade 5 Classrooms

Amy taught the grade 5 classes and self-reported that during a typical week of teaching she emphasized autonomy-supportive instructional practices ($\bar{x}$ = 3.71) and directive instruction ($\bar{x}$ = 2.86). Compared to her peers, Amy had the lowest self-reported scores on the directive instruction sub-scale, though her autonomy-supportive score was closer to the middle of her colleagues’ scores. Concerning the observations of her classrooms, Amy was provided ratings of 2 for: complex task, choice, control, teacher support, embedded assessment, and accommodation. This indicates that Amy was observed emphasizing these practices during mathematics instruction in ways that were meaningful for her students’ SR. For observational ratings of self-evaluation and peer support, Amy received 1.5 respectively. This suggests that there were instances where Amy’s instruction provided some meaningful opportunities for self-evaluation and peer support, but perhaps some other instructional practice or classroom variable prevented full integration of these methods in manners that meaningfully supported students SR. Below, observational records are used to describe Amy's mathematics lesson and highlight the presence of instructional features that emphasize students' SR skills.

Amy's Observed Mathematics Lesson. In Amy's classroom, students sat at individual desks in three rows. Amy stood at the front of her classroom and said, "So were going to talk about a few things that we've already done that you've already seen so this is review. What's the page about that I had you open up in front of you – Jordan?" Her student replied that it is about area. "Yes, its area. What can you guys tell me about area?" A student raised their hand and explained that they used exponents and students in the class mumbled about what an exponent means. Amy noticed and asked, "What does the exponent mean?" Some students raised their hands and she selected one to answer. They stated that area is length times width, as opposed to exponents. Amy explained that length times width is the formula for basic area, then probed the class to recall what they know about area. She moved through several short examples that students provided regarding spaces that have area, (e.g., soccer fields), and why someone would want to know area of a space (e.g., so they know where to put soccer nets).

Amy shifted the conversation of the class, "Okay now I'm going to talk about a completely different topic and bring them both together – don't be scared – were going to talk about fractions, decimals and percent." She requested examples of a fraction, percent, and a decimal that are the same as each other and stated, "I know I'm digging deep here." Amy's students raised their hands and provided examples which she allowed them to work through aloud as they changed the value from fraction, decimal, and percent in any order. None of the students who participated struggled with this and Amy moved onto the next aspect of her lesson,

> "So, I am going to give you a grid and you are going to plot out an imaginary classroom for me. So, I am giving you that the area of the room has to be 60 squares squared, but I am not giving you this length or this width. How are you going to figure these out?

A student stated that they had to figure out only one of the sides of a shape to get the length and the width. When Amy recognized that student was thinking of area for squares, she informed her students "I said square, but it does not have to be a square." Amy asked her students for examples of what kinds of numbers they can use to get an area of 60 squares squared, and provided no feedback regarding the correctness of the examples they provided. Rather, she gave feedback like, "Wow, 6 by 10! That would be a super skinny room." Next, Amy provided her class with information regarding the area of various components (e.g., desks, carpet space) that she wanted in an imaginary classroom. She wrote down a legend on the board that had fractions, decimals, and percentages and stated, "You can work in teams with one other person, and you can move around the room. If you want to work alone you can choose to work alone." Students began to select partners and spaces to work, some students worked alone. Early on she reminded her students, "Don't take too long to get settled, you have only 15 minutes to get this done." Amy suggested to two students that they work at the mission control center, a space at the front of the room where the teacher sat with the students and provided more consistent procedural and evaluative feedback. When asked later, Amy stated that both students experience learning difficulties, though it was not clarified if these difficulties extended across all learning domains, or if they were specific to mathematics. Amy reminds her students "You can always come to mission control, or raise your hands if you need help".

Throughout the lesson, Amy moved around the room and tracked students' progress. She asked a pair of students who were nearly finished to show her how they sorted out the room using language about fractions, percentages, and decimals. She requested, “Now what I want you to do is kick it up a notch and find the fraction that is left, the part of the room that is not colored.” Later, a pair of students who stated that they were having a hard time figuring out the blue section of the room (where legend stated blue for carpet = 0.1) looked to the students beside them who appeared to be moving through the problem, but did not ask for their support. Rather, one girl reminded the other, “Well, there’s mission control at the front desk.” Pairs of students asked each other questions as they solved different portions of the grid and changed values from fractions, decimals, and percentages. At various times, Amy asked pairs of students probing questions like “How did you get 10%?” which referred to a value in the legend that was represented as a decimal (i.e., 0.1)”. Her students responded with information like “Well, we’re just eye balling it for now and then we will solve it”. Amy agreed that was a good strategy. Amy stopped her class, and explained that they needed to get ready for lunch. She praised the work they did, and stated that it was clear that the students were thinking hard about the problem.

Grade 6 Classrooms

Teacher Jessica reported emphasizing autonomy-supportive instructional practices ($\bar{x}$ = 2.86) and directive instruction ($\bar{x}$ = 3.57) during a typical week of teaching. The score that Jessica self-reported for autonomy-supportive instruction suggests that Jessica implemented less autonomy-supportive instruction compared to her peers and more directive instruction than Amy and Emily. Yet, observational scores of Jessica’s instructional practices during mathematics teaching reflect the highest ratings amongst her counterparts. That is, she was assigned a score of 2 for each feature of instruction that was observed across classrooms. These scores suggest that researchers observed meaningful examples of instructional practices that are known to support students’ SR. The following section delineates the observational record of her instructional practices during mathematics and offers insight into the potentially positive consequences of directive instruction for students' SR during mathematics learning.

Jessica's Observed Mathematics Lesson. At the start of Jessica's lesson, she asked her students to open their math homework from the previous day. "Okay, your homework last night was decomposing, and it was also changing fractions to decimals and percentages. Did anyone have trouble with decomposing? […] did anyone have trouble with fractions, decimals and percentages?" A student stated that they had trouble with decimals, so Jessica inquired about the student's difficulty and explained to the student and classroom that there were multiple correct answers. Jessica then turned to her SMART board and selected different students to provide her with numbers, "Carlie, give me a digit. Marie-Claude, give me a digit." The students provided numbers which created a final large sum of 2654.636. Jessica then asked her students who wanted to help decompose the number and a student raised their hand "Michelle, are you going to decompose it?" Michelle began to decompose the number; the following is an excerpt of the exchange that took place between Jessica and Michelle:

Michelle: "6 x 1000, 2 x 100, 5 times 10, 4 x 1."

Jessica: "Just like that?"

Michelle: "Yah, no."

Jessica: "What is missing?"

Michelle: "A bracket and a plus sign." […]

Jessica: "Ok cool. If these are tenths, what are these (points to board)?"

Michelle: "Hundredths."

Jessica: "OK we're going to say 6 times what?"

Michelle: "6 x 10."

Jessica: “6 x 10 is still going to be 60.”

Michelle: “6 times 10 over 1.”

Jessica: “10 over 1 still gives you 10.” (Turns to the rest of the class) “Talking is impolite. If you know how to do this be patient and listen.”

Michelle: “1 over 10.”

Jessica: “OK, good for you. 1 over 10.”

Michelle: “OK, 6 times 1 over 10 and 3 times 1 over 100 and 6 times 1 over 1000.”

Jessica: “That was a good job, Michelle. OK, is there another way of doing it? Is there a more sophisticated way?”

Jessica then encouraged another student, Adam, to answer the question using a method of their choice. Adam’s used exponents to solve the problem which Jessica indicated was the more sophisticated method of decomposition. Jessica and this student followed the same type of exchange as that recorded with Michelle. That is, Jessica asked probing questions about how Adam arrived at his answers, why he followed the procedures he stated, and asked him to identify different numbers by values (e.g., hundredths). Next, Sean attempted to decompose a number using exponents, and he struggled to do so early in the process. Jessica recommended him to use a procedure that was more familiar to him to which he obliged and successfully decomposed the value. By the end of this section of instruction, Jessica worked through five methods of decomposition with her students, and offered little to no prompts that suggested there was a correct way to decompose. Jessica then navigated the entire class towards a new decomposition task on the whiteboard, and asked her students how they could use information from what they learned in previous weeks to decompose 156.789 on a base ten grid. She then stated, “Talk amongst yourselves for thirty seconds and figure out where you would put it.”

Some students talked to their partners about the question at hand, others asked Jessica, or the teaching assistant for help. After approximately 3 minutes Jessica called the attention of her students back to the front of the classroom and surveyed their solutions. When students were asked to provide solutions, only four students raised their hands and Jessica stated, “That’s not enough hands up. Take [another] fifteen seconds to talk about it.” Shortly after discussing her students’ solutions, (e.g., asking them how they came to their answers), she wrapped up her class and the observational period ended.

Summary of Classroom Observations and Opportunities to Support SR

Observational records demonstrated that each teacher incorporated complex tasks during their mathematics lesson that explicitly embedded assessment and allowed for self-evaluation or was prompted by the teacher in their individual practices. Additionally, each teacher exhibited meaningful instances of accommodation to the learning tasks they employed, or their instructional approaches, to meet their students’ needs. Across classrooms, tasks varied in that some were more highly structured (e.g., worksheets in Emily’s class) than others (e.g., paired learning task in Marie’s class). Specifically, grade 3 and 5 students engaged in complex learning tasks that were less structured as there were multiple correct approaches for engaging in problem-solving, and in some instances multiple representations of final answers (e.g., Amy’s fake classroom design). Additionally, it was clear that each classroom lesson included content that extended across multiple learning units. Although observational records indicated that many of these tasks did not necessarily embed opportunities for assessment or promote self-evaluation, the delivery of the lessons required classroom level participation (e.g., working through problems out loud) prior to independent work. In some cases, the mathematics lesson and activities required students to work in pairs. In both cases, classroom teacher and peers acted as an instructional resource in prompting students to monitor and evaluate their learning. In line with previous research (Hillyer & Ley, 1996; Perry, 2013; Perry et al., 2006; Perry & VandeKamp, 2000), students in these classrooms demonstrated metacognitive processes when they explained their learning processes to the classroom, their teacher or their work partner, and tried different procedures (e.g., adding instead of exponents) or learning strategies (e.g., re-calculating, asking for help) when faced with learning challenges.

Though previous research has indicated that the use of highly structured tasks relates to less learning engagement, and learning strategy use from students (Lodewyk et al., 2009), it is possible that the use of highly structured tasks in mathematics supported students' cognitive capacities. That is, the hierarchical procedures may guide students' problem-solving and free up cognitive resources needed to engage in learning and regulatory processes (e.g., monitoring, evaluating). This was mirrored in observational records as students in the grade 6 classrooms, wherein highly structured worksheets were used were observed engaging in the learning activities, attempting challenging tasks, and persisting in their learning. Additionally, ANOVA findings indicated that these students demonstrated significant increases to their SRL skills across the school year. However, grade 4 students who were also observed interacting with highly structured mathematics activities, were less successful in terms of their self-regulatory development. The teacher for the grade 4 classrooms, Emily, received the lowest observational rating for complex tasks. Although her score was only slightly lower when compared to the other teachers (1.5 out of 2), this was the only classroom that displayed a decrease in their mean scores for ER and SRL across the school year. Whether this can be accounted for by the type of task that was used is not certain as observations were limited in that they took place over a single mathematics lesson. To gain insight on the types of tasks teachers use in mathematics and their role in supporting students' ER and SRL outcomes, future research should examine classroom practices over multiple cycles.

Notably, the highly structured learning task that was employed in the grade 4 mathematics lesson did not embed opportunities for assessment compared to the more loosely structured learning tasks used in other classrooms. For example, the work sheets that Emily's students worked on did not explicitly prompt students to monitor or evaluate their progress. Rather, the hierarchical procedures involved in their mathematics problem-solving required them to monitor the success of the products of their work before moving onto subsequent steps. Observational records demonstrated that the grade 4 students struggled with this type of monitoring and evaluation as Emily had to step in several times with her students, both independently and at a classroom level, to ensure students were tracking their steps, and the accuracy of their work, as they moved through problem-solving. These actions are in line with previous research which has highlighted that instructional practices that emphasize students SR are not mutually exclusive (Perry et al., 2018). That is, teachers' instructional behaviors can prompt students to engage in self-evaluations when the tasks lack this explicit feature. However, the alignment between teacher feedback and students' needs will bear the weight of supporting students' metacognitive processes and accommodating task demands to students' abilities. Given the ratio of teachers to students in a single classroom, approximately 1:30, this can be a challenging feat. Therefore, there is a need for learning tasks that explicitly embed assessment, though these may be challenging to acquire from the mathematics curriculum in any given schoolboard. Teachers may need education on the value of embedded assessment and self-evaluations for students learning and self-regulatory outcomes and support to adapt mathematics tasks to more frequently include these features.

Observational records also pointed to the importance of instrumental feedback for supporting student SR in classrooms. Teacher support was pivotal for the successful integration of the learning activities across each classroom. Specifically, teachers engaged in the use of probing questions (e.g., how did you find that solution?), encouraged students to try challenging tasks (e.g., moving beyond the parameters of the task and asking students a more complex question), and promoted the use of multiple resources (e.g., asking a partner to help them understand, approaching “mission control”). Based on previous research, these various teacher behaviors likely facilitated students to think about their problem-solving processes (e.g., metacognition), provided opportunities to practice SRL and foster their adaptive expertise (Butler, 2021; Palincsar & Brown, 1984; Perry, 2013; Wentzel, 2002). Observational ratings also suggested that instrumental support from teachers (e.g., well-attuned scaffolding) may have promoted a classroom climate wherein mistakes are viewed as opportunities to learn and students’ motivation for learning is fostered (Perry, 1998; Perry & VandeKamp, 2000). Previous findings have demonstrated that positive classroom climates are related to increasingly positive affective experiences during learning, and less fear of judgment when seeking support and ultimately may support students’ ER and SRL (Hamre & Pianta, 2001, 2005; Paris & Newman,1990). Since teachers acted as agents for other aspects of instruction (e.g., embedded assessment, self-evaluation, accommodation) that are known to support student self-regulatory processes, teacher support may be particularly important for students’ self-regulatory processes. This may be especially true in the domain of mathematics wherein tasks tend to be more structured (e.g., hierarchical procedures) and may not explicitly embed opportunities for assessment and limit opportunities for self-evaluation, and may be difficult to accommodate to students’ various learning support needs. However, not all students’ ER and SRL skills significantly changed during the year, and grade 4 students displayed significant decreases to their SR skills. Therefore, instrumental support from teachers may support students' metacognitive processes, buffer against negative affective experiences, and enhance motivation for learning but may not be sufficient if other instructional practices that emphasize students SR are lacking. That is, instrumental teacher support alone is not enough to promote positive patterns of ER and SRL in classrooms for middle to upper elementary-aged students.

Finally, teachers were observed providing their students with procedural and evaluative feedback at individual (e.g., student) and classroom levels. That is, teachers would provide students with solicited and unsolicited support during their mathematics lessons to help them succeed in their learning endeavours. However, research findings have called the nature of teacher feedback on student learning and self-regulatory processes into question. That is, when feedback is perceived as critical, as opposed to co-operative and sensitive, students tend to experience less satisfaction and motivation in learning (Cameron & Morrison, 2011; Pierro et al., 2006), which are negatively related to positive patterns of self-regulatory engagement. Though some teachers were recorded providing unsolicited evaluative feedback, it is likely that these were attempts to meet the students' needs and would have helped them proceed with their learning endeavours. It should be noted that observational records did not capture any explicitly negative interactions between teachers and their students, most if not all interactions appeared to be encouraging. However, the current study was limited in that it could only capture the explicit behaviors and verbalizations that were present in the classrooms. Since mathematics problem-solving is an emotionally laden learning domain for elementary-aged students (Di Leo et al., 2019), it is likely that students experienced affect that was not captured during the observations but may impact their metacognition, motivation, and behavior (Di Leo & Muis, 2020; Efklides, 2018; Pekrun, 2018). This points to a need for future research that includes multiple sources of data, like classroom observations paired with teacher and student interviews. Employing these multiple sources of data may provide insight into student's experiences of different learning practices, and help researchers understand how to better support educators to deliver effective lessons that promote learning and self-regulatory skills in concert.

Unlike teacher support, evidence of meaningful peer support was somewhat varied across classrooms. Observational records demonstrated that peer support was an integral aspect of the mathematics lessons for grade 3, 5, and 6 students, though Amy received a slightly lower score for peer support in her classroom (i.e., 1.5 out of 2). For example, most classrooms demonstrated meaningful instances of peer support wherein students had to consider one another's learning processes (e.g., review work at the board), create and share understanding (e.g., how exponents work with area), and adjust feedback to meet their classmates' abilities (e.g., the numbers they choose to generate for their partners). Previous research has demonstrated the peer support in classrooms is particularly meaningful as it helps foster a community of learning wherein students experience less negative affect. That is, students who experience positive peer support tend to be less fearful of judgement when seeking help, and frame mistakes as learning opportunities as opposed to failures (Hutchinson, 2013; Paris & Newman,1990). As such, students in these classrooms may experience less need to engage in ER to regulate negative emotions. Additionally, these students may express more positive patterns of SRL, as negative affect can challenge students' abilities to engage in adaptive SRL (Tice et al., 2004). Findings have also suggested that peer support promotes students' metacognitive, motivational, and emotional processes (Eisenberg et al., 2004; Järvenoja & Järvelä, 2009; Hadwin et al., 2018; Whitebread et al., 2007). Therefore, instructional practices that allowed for instrumental peer-support among classroom students may have experienced increased opportunities to engage their SRL processes.

Even classrooms wherein teachers' instructional practices limited opportunities for peer support amongst their students displayed instances of students learning within their community of peers. For example, Emily, the teacher for grade 4 classrooms, was assigned the lowest rating for observed practices that foster instrumental support between classroom peers (i.e., 0.5 for peer-support) compared to other teachers. However, when Emily provided her students with feedback, neighbouring peers would listen and compare the feedback to their own progress (e.g., Tom asked if his approach to problem-solving was correct based on what he heard). These small instances likely lend to creating a community wherein students can learn from one another indirectly. However, based on the observational records it is likely that her students were missing opportunities to engage in peer-support in ways that promote shared perspective taking, explaining ones' own reasoning and behaving in socially appropriate and supportive ways. Although peer support tends to help create affectively safe learning spaces, some findings indicate that students need to demonstrate appropriate levels of ER abilities to be able to effectively engage in peer support and collaborative learning (Whitebread et al., 2007). Therefore, it is possible that Emily actively chose to instruct her students in manners that reduced opportunities for peer support based on her knowledge of her students' existing self-regulatory skills. Since the current study captured few observations that clearly exemplified the how instructional practices directly influence students' ER skills, it is limited in the conclusions that can be drawn regarding the role of classroom instruction on students' ER. Therefore, future research may be designed to measure how peer support relates to students SR abilities over time. Specifically, research that examines young students' collaborative classroom-based mathematics learning may provide important theoretical and practical insight about how to design instruction to support students’ ER and SRL.

Findings from the observational records also suggested that teachers self-reported instructional practices were in line with observed practices as each teacher was witnessed employing autonomy-supportive and directive instructional practices. Previous research has shown that autonomy-supportive instruction supports students to develop a sense of agency over their own learning, which in turn support students’ self-regulatory processes (Deci & Ryan, 1985; Corno, 2001; Perry et al., 2020). For example, findings have demonstrated students who were provided opportunities to make choices about their learning, or exert control over the levels of learning challenges, engaged in metacognitive processes (e.g., selecting appropriate materials for their abilities), were motivated (e.g., find their work enjoyable), and experienced less negative feedback (e.g., are not upset about teacher feedback and learn and adjust; Perry & VandeKamp, 2000). Interestingly, researcher ratings of teacher instructional practices including opportunities for choice and control was varied between classrooms.

For example, observations of grade 3 classrooms indicated that Marie provided limited opportunities for her students to make choices about and exert control over their own learning. In fact, Maries’ observational ratings were among the lowest assigned scores (e.g., 1 out of 2), yet the grade 3 students demonstrated significant increases in their self-regulatory skills. Interestingly, Maries’ self-reported autonomy-supportive and directive instructional practices were the highest among her peers. A review of the observational records of Marie’s classroom indicated that although grade 3 students’ opportunities to make choices about or exert control over their learning during the mathematics lesson were limited (e.g., choosing which number to represent), they were also provided with significant teacher and peer support during a complex and appropriate learning task. Though some findings indicate that directive instruction can be hinder students’ learning and SR processes (Pierro et al., 2006; Perry et al., 2020), classroom observations from the current study align with research that has shown directive instruction can support students learning needs. As has been demonstrated with young students (e.g., preschool, early elementary), it may be that these students are in a developmental period where direction is more helpful for their learning processes and does not negatively influence their motivation (Cameron et al., 2009). That is, reduced choice and control during mathematics learning may support young students at the level of their cognitive abilities such that they can successfully employ their self-regulatory skills in tandem with their mathematics skills and knowledge that are still developing (Lillard, 2005). This may be especially true in the context of mathematics learning, as it is a strategically and procedurally complex subject (Di Leo et al., 2019). Moreover, previous research findings have demonstrated that presence of multiple instructional practices that emphasize SR may provide students with opportunities that are necessary to develop positive patterns of SR, compared to any single instructional practice (Butler, 2021; Michalsky, 2021; van Loon et al., 2021).

However, on this basis it would be expected that grade 4 students’ ER and SRL skills would also increase during the school year. Researcher ratings of Emily’s instructional practices with her grade 4 students were like those of Marie (choice = 1.5, control = 1). Yet, findings from the repeated measures ANOVAs demonstrated that grade 4 students’ ER and SRL skills significantly decreased during the school year. Therefore, it may be the case that grade 4 students were limited across other afore mentioned features of instruction (e.g., embedded assessment, self-evaluation, peer-support). When paired with limited autonomy supportive practices like opportunities to make choice and exert control over one’s learning, this may have resulted in few opportunities for grade 4 students to practice and develop their SR skills. It may also be the case that differences between teachers' instructional practices as they pertain to "choice" and "control" are related to the instructional tasks that teachers employed. For example, observational records suggested that more highly structured tasks limited opportunities for choice (e.g., how to represent problem solutions) and control (e.g., problem-solving procedures, strategy use, level of challenge). As such, the highly structured worksheet that Emily used with her grade 4 students may have afforded fewer instances of autonomy than during typical lessons, and the presence of other instructional practices (e.g., embedded assessment, instrumental support) that make up for the limiting nature of highly structured tasks were lacking. Additionally, it may be the case that because students in grade 4 started the school year with the lowest mean scores for ER and SRL (see Table 10) that Emily adapted her learning practices to limit choice and control to better support her students' self-regulatory abilities. However, teachers' intentions behind their instructional practices, or their knowledge regarding the importance of different instructional practices for their students SR skills were not captured in the current study. As such, the current study is limited in providing insight regarding why teachers implement different instructional practices in their classrooms.

For grade 5 and 6 teachers Amy and Jessica, respectively, were assigned the highest observational scores (i.e., 2 out of 2) for choice and control. Interestingly, these teachers rated themselves quite differently in terms of their autonomy-supportive and directive instructional practices, wherein Amy had the second highest autonomy score ($\bar{x} = 3.71$), and the lowest directive score ($\bar{x} = 2.86$). On the other hand, Jessica had the lowest autonomy score ($\bar{x} = 2.86$), and second highest directive score ($\bar{x} = 3.57$). Based on previous research findings that students who are provided with meaningful opportunities to make choices about, and exert control over their learning, are likely to develop their SR skills (Eshel & Kohavi, 2003; Lodeyk et al., 2009; Perry et al., 2018) it was interesting that ANOVA findings demonstrated that for grade 5 and 6 students, only grade 6 students demonstrated significant increases to their SRL skills from the start to the end of the school year. Recall that the use of teacher reports of students' ER and SRL skills may have resulted in a ceiling effect, wherein students' fall scores are relatively high. However, it may also be the that grade 5 and 6 students are developmentally in a space where the rate of their SR change has slowed, or become less pronounced (e.g., shifting from behavioral to overt). Future research that employs multiple measures of students SR skills, including self-reports and think alouds may extend research understanding of ER and SRL development for middle to upper elementary-aged students.

However, opportunities for students to make choices about and exert control over their learning may be related to teachers' directive instructional practices in classrooms (e.g., elaboration, task clarification, clear expectations). Teachers were observed behaving in directive ways when they stopped their lesson to clarify expectations (e.g., this is how to set up your work space), to providing necessary information regarding the task before they started and when they got stuck, or explicitly stating which learning strategies they should use to be successful (e.g., organization, grouping). Specifically, instances of directive instruction supported students' engagement in independent learning and helped them manage classroom expectations which in turn supported self-regulatory and learning processes (Bohn et al., 2004; Cameron et al., 2009; McWilliam et al., 2003). Moreover, observational records demonstrated that students across all classrooms instructed in ways that provided their students with opportunities to make choices and exert control over their learning experiences. Therefore, it is possible that teachers who emphasize directive instructional practices in concert with autonomy-supportive practices in their classrooms may provide students with a strong foundation to support their learning and SR skills. This is in line with researcher calls regarding the need for multiple approaches to instruction to better foster students learning and self-regulatory processes (Butler, 2021). Future research should continue to examine classroom instructional behaviors including autonomy-supportive and directive instruction for students at various stages of their academic careers and across various learning domains. Doing so may provide theoretical insight into how best to foster students' learning and self-regulatory processes in classrooms. Moreover, future research that examines individual trajectories of change over multiple learning cycles, and in distinct learning domains may support researcher understanding of how to foster students' long-term development of SR skills. That is, findings may demonstrate that fostering autonomy at a young age may relate to less SR development at that period but may be related to increased SR skills later in their academic careers (e.g., high school, university) when learning becomes more self-directed.

In all, findings from teachers' observations demonstrated that instructional features that support students SR are not mutually exclusive (Perry et al., 2018; Perry et al., 2021), as complex tasks are most beneficial for students when they appropriately challenge students' needs, can accommodate students' needs and incorporate opportunities for teacher support (Perry et al., 2020; Stefanou et al., 2004). Additionally, teacher and peer support provided opportunities for students to monitor their own learning and allowed students opportunities to make choices about and exert control over their own learning needs. As a result, findings from the current study support previous research that has indicated that instructional practices can be layered together to support students' SR processes (Butler, 2021; Michalsky, 2021; Perry et al., 2018; van Loon et al., 2021). That is, no single instruction practice supports students' learning processes in a manner more effective than many diverse and intentional practices do together.

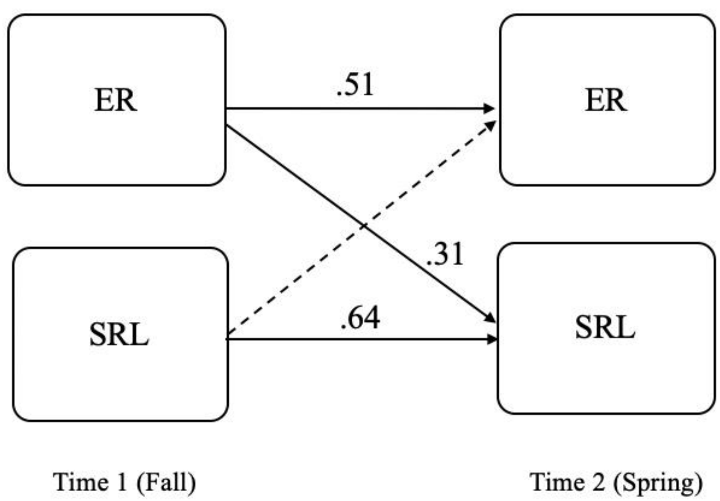
Additionally, findings from the observational records highlighted methodological difficulties for observing students' ER processes during classroom-based learning. That is, observational records did not capture any instances of students' emotions or ER in relation to the mathematics lessons or in relation to classroom instructional practices. Given previous research has demonstrated that elementary-aged students frequently report experiencing curiosity, confusion and frustration (Di Leo et al., 2019) it is likely that students experienced emotions during their math lessons, and attempted to regulate those emotions, but that during the short (1-hour) observation they did not verbalize those experiences. Given that each of the observed lessons were reviews of previous work that students may be more familiar with the tasks and may have been more prepared to participate, thereby reducing their affective experiences related to their learning. Additionally, a single observation of a classroom lessons may fall short in capturing students' emotions, ER and SRL. Future research should include multiple methods of assessment for classroom-based instruction over multiple instructional periods. Specifically, teacher and student interviews may provide insight into what students perceive about their teachers' instructional behaviors, learning preferences, and affective experiences during learning.

Cross-lagged Path Analysis

To assess the final research question "Are there interdependent relationships between students' development of classroom-based ER and SRL such that ER skills in the fall predict SRL skills in the spring, and vice-versa?", a cross-lagged path analysis was conducted using Mplus 8.0 (Muthén & Muthén, 2017). The Maximum Likelihood estimator was employed, and bootstrapping was set at 5000 iterations (Muthén & Muthén, 2017). To test the proposed interdependent model of development, ER and SRL from the fall were included as independent variables and ER and SRL from the spring were included as dependent variables. Students' age during the fall was included as a covariate (see Figure 7). Though research findings that indicate that models with small sample size and relatively low *df* have increased rejection rates for fit indices like the RMSEA (e.g., RMSEA > 0.10; Kenny et al., 2015; Chen et al., 2008), results from the cross-lagged path analysis demonstrated that the model was over fit to the data, $\chi2$ (df = 7) = 405.00, $p < 0.001$, CFI = 1.00, TLI = 1.00, RMSEA = 0.00 CI [0.00, 0.00], SRMR = 0.00. Results of the path analysis demonstrated that early ER significantly predicted later ER (β = 0.51, p <0.001), and predicted later SRL (β= 0.31, p = 0.02). Additionally, early SRL predicted later SRL (β = 0.64, p < 0.001), and but did not predict later ER (β = 0.13, p = 0.28). Age also significantly predicted SRL **(**β = -0.17, p = 0.01) but did not predict ER (β = -0.02, p = 0.76).

Figure 7

Final cross-lagged panel model



Note. Students' age in the fall was included as a covariate. Dashed lines represent non-statistically significant paths. Solid lines represent statistically significant paths at p < 0.05.

Discussion

Students' classroom-based ER and SRL skills are important predictors of their academic outcomes across learning domains and stages of education (Hutchinson et al., 2021; Muis et al., 2016; Winne, 2018). As such, researchers have highlighted that it is an important goal of childhood to learn how to regulate one's own emotions and learning to succeed in different learning endeavours (Aldao et al., 2015; Bonano & Burton, 2013; Gross, 2015). To date, research findings have indicated that ER and SRL are processes that become more sophisticated over time (Usher & Schunk, 2018; Perry & Calkins, 2018; Raffaeli et al.,2005), and have a shared reliance on the same underlying processes (e.g., executive functions, metacognition, motivation, strategic action; Diamond, 2016; Hutchinson et al., 2021; Perry et al., 2018). Additionally, findings have shown that different classroom practices can facilitate or hinder students' self-regulatory skills (Cameron et al., 2009; Hamre & Pianta 2001; Perry et al., 2021; Whitebread et al., 2007). However, a bulk of SR research that has been conducted with young students has relied on measures of behavior and executive functioning as opposed to measuring the higher order processes involved in all targets of SR and has been conducted during play-based or literacy learning (Blair & Razza, 2007; Stefanou et al., 2004; Zacahriou & Whitebread, 2019). Research with older students (e.g., high school, university) has employed self-reports, online measures, and cognitive measures of SR (e.g., think aloud, emote aloud) and has assessed students' self-regulatory processes in complex learning domains like science and mathematics (Green & Azevedo, 2009; Green et al., 2021; Lodewyk & Winne, 2005; McCardle & Hadwin, 2015). As such, questions remain regarding the nature of middle to upper elementary-aged students' self-regulatory development including if ER and SRL skills increase significantly over the course of a school year, and whether classroom practices that are known to support students' SR do so in the context of mathematics. Finally, there is a paucity of research which has examined the relationships between students' ER and SRL skills across the school year for middle to upper elementary-aged students.

To address this question, the current study examined whether students SR skills (i.e., ER and SRL) developed over the course of a school year. Though previous research findings have demonstrated that childrens' ER skills, like all targets of SR, tend to develop over time because of physiological maturation (e.g., cognitive development) and the accumulation of experience regulating emotion (Cole et al., 2018; Perry & Calkins, 2018) findings from a repeated measures ANOVA demonstrated that student's ER skills did not significantly increase from the start of the school year to the end of the year. Though these findings challenge extant literature, there are several possible reasons for these outcomes. First and most notably, grade 3 students demonstrated positive changes in their ER skills over time, whereas grade 4 students demonstrated decreases in their ER skills. The opposing valance of these findings may cancel each other out and result in an overall finding that is statistically non-significant. This is especially true since grade 5 and grade 6 students demonstrated very little change to their ER scores overtime. Specifically, the mean scores for grade 5 students' ER skills in the fall ($\bar{x}$ = 4.93) and the spring ($\bar{x}$ = 5.02) were similar, as were the mean scores for grade 6 students (fall $\bar{x}$ = 4.97, spring $\bar{x}$ = 5.08). Based on these findings, it appears that these students demonstrated relatively effective patterns of ER early in the school year, which in turn limit opportunities to demonstrate increases in their ER skills at the level of their metacognitive, motivational and behavioral processes.

It should be noted that these findings may also reflect the use of the teacher report tool employed in the current study, the SRISI (Hutchinson, 2013). Previous research has typically employed measures of students' ER and SRL skills that capture specific strategy use like cognitive reappraisal, or learning strategies like planning, monitoring and evaluating (Di Leo et al., 2019; Frenzel et al., 2024; Muis et al., 2015). Moreover, self-reports and cognitive protocols like emote and think alouds have been popular tools to employ in research with older students

(Di Leo & Muis, 2020; Losenno et al., 2020), whereas teacher reports and behavioral measures are frequently more often employed with younger students (e.g., preschool, early elementary; Hamre & Pianta, 2001; Hudson & Jacques, 2014; Hutchinson et al., 2021). Therefore, the use of a single teacher-report tool that uses items to reflect the underlying SR processes involved in ER and SRL with middle to upper-elementary-aged students may capture different aspects of students SR abilities. Although, teachers are considered reliable predictors of their student's SR abilities situated in typical classroom practices and behaviors (Hutchinson et al., 2021; Kaufmann, 2020; Whitebread et al., 2009,) these findings highlight the importance of using multiple sources of data in future research (McCardel & Hadwin, 2015).

Regarding changes to students SRL skills across the school year, a second repeated measures ANOVA demonstrated that students SRL skills significantly increased overtime. These findings are in line with previous research which has demonstrated that students SRL skills tend to become more robust and sophisticated overtime (Diamond, 2016; Hutchinson et al., 2015; Usher & Schunk, 2018). Like the findings for ER, grade 4 students demonstrated a decrease in their SRL skills over time. Since it is not likely that students experienced decreases to their executive functioning, or the cognitive, motivational, and behavioral processes that underlie SR, these findings may suggest that students did not meet teachers' expectations for their SRL abilities. Again, these findings call into question the power of employing a single measure of students' SR in the form of a teacher report tool. Findings also indicated that grade 5 and 6 students displayed relatively similar mean scores for SRL from the fall to the spring (grade 5 fall $\bar{x}$ = 5.13, spring $\bar{x}$ = 5.28; grade 6 fall $\bar{x}$ = 4.94, spring $\bar{x}$ = 5.11). Although grade 6 students did display significant increases to their SRL skills, the change in their mean scores was small. As was the case with ER findings, this may indicate that there is a ceiling effect wherein teachers' ratings of these students' SRL scores at the start of the year were rated so highly that there was very little opportunity to display increases to their skills. Interestingly, findings from this ANOVA demonstrated that only 5% of the variance in students' final SRL scores was accounted for by their previous scores. This suggests that there are additional variables that predicted students later SRL scores outside of their earlier abilities.

Previous research has highlighted the role of environmental variables in students' self-regulatory development and may account for more of the variance in the students' SRL change. Specifically, the use of complex learning tasks, instrumental support from teachers and peers, and the presence of autonomy-supportive and directive instructional practices have all been shown to foster students' ER and SRL. For these reasons, teachers, specifically their instructional practices, were included as a factor in each of the repeated measures ANOVAs to determine if change in students' ER and SRL skills were also a function of classrooms practices. Although findings from the repeated measures ANOVA demonstrated that the main effect of ER was not significant, there was a statistically significant interaction between teachers' instructional practices in their classrooms and change in students' ER scores across the school year. The same held true for students SRL skills. That is, students' ER and SRL scores differed as a function of their teachers' classroom practices. Specifically, the interaction between classroom practices accounted for 14% of variance between students' spring ER scores, and 13% of their spring SRL skills. Specifically, findings demonstrated that classroom practices accounted for 15% of the variance in grade 3 students' ER skills, and 19% of their SRL skills. Additionally, 45% of the variance in grade 4 students' ER skills and 22% of their SRL skills was accounted for by their classroom teacher's practices. Recall that grade 4 students' ER skills significantly decreased over time, which diverges from previous findings that SR skills typically increase overtime due to maturation and the accumulation of practice and experience (Diamond, 2016; Cole et al., 2018; Hoyle & Dent, 2018). It is possible that because these students' early ER skills were low compared to their peers in other classrooms, as evidenced by their mean scores in the fall ($\bar{x}$ = 4.71), that Emily employed instructional practices to try and support their needs. That is, the instructional practices present in the grade 4 classrooms may not have caused students low ER skills, nor did they facilitate students' ER skills.

Regarding grade 5 and grade 6 students, findings from the repeated measures ANOVAs demonstrated that the only significant interaction was between classroom practices and grade 6 students SRL skills. Specifically, 12% of the variance of grade 6 students' spring SRL scores could be accounted for by their teachers' classroom practices. Since grade 5 students did not demonstrate significant change to their ER or SRL, nor did grade 6 students' ER skills, interaction effects cannot be interpreted for students in these regards. However, a question arises regarding why grade 3 students' ER skills improved over the year but grade 5 and 6 students' skills development was limited? It is possible that these findings are a result of maturational processes that are still developing for grade 3 students, including executive functioning and more complex cognitive processes like metacognition (Davidson et al., 2006; Diamond, 2016; Hoyle & Dent, 2018; Miyake & Freidman, 2012). Therefore, there may be more opportunity for students' ER abilities to become more pronounced across the school year.

On the other hand, grade 5 and 6 students may begin the school year with relatively effective patterns of ER and thereby demonstrate fewer increases (e.g., sophistication, robustness) to their ER skills during the school year. It may also be the case that older students are more capable of masking their emotions and ER efforts during classroom-based learning. This is in line with previous research which has demonstrated that ER tends to become more covert as children develop and thereby become more difficult to measure (Calkins & Dedmon, 2010; Cole et al., 2018; McCabe et al., 2004). As such, teachers may have struggled to witness and gauge the changes that are taking place to their students' ER skills during the school year. Though the current study was designed to account for differences in SR due to age, and ICC's did not suggest that nested analyses were necessary, there may be developmental processes (e.g., physiological maturation) that account for differences in ER and SRL from the fall to the spring. These findings reinforce a need for future research that directly assesses the differences between students within different classrooms. Specifically, multi-level structural equation modeling would provide valuable statistical insight regarding how differences at the classroom level are related to differences in students' self-regulatory skills across the school year. Unfortunately, it was not within the scope of this study to employ such analyses given statistical power required.

In summary, findings from both repeated measures ANOVAs revealed that: (1) SRL significantly increased across the school year, except for grade 4 students who demonstrated decreased mean scores from the fall to the spring for ER and SRL, and (2) there were significant interaction effects between classroom membership and both targets of SR. Indeed, typical maturation that takes place in children is a predictor of change in their self-regulatory abilities. However, important questions regarding the role of classroom practices remain. To provide insight regarding the ways in which classrooms practices accounted for differences in students' SR skills, and why grade 4 students' SR scores fell as opposed to rose, teachers' reports of their pedagogical practices and researcher observations of classroom instruction were reviewed.

Findings from the split-median analyses indicated that each of the teachers (Marie, Emily, Amy, and Jessica), reported emphasizing autonomy-supportive with mean scores that ranged from 2.86 to 4.57, and directive instructional practices with a range of scores from 2.86 to

3.79. That is, each teachers' average scores on both sub-scales fell above the mid-point value (M = 2.5). These findings are in line with hypotheses that teachers would report engaging in both practices since previous research has demonstrated that students need opportunities to participate in independent and autonomous learning while simultaneously relying on scaffolding, clarification, and direction to be successful in their learning endeavours (Butler, 2021; Cameron et al., 2009; Perry et al., 2018; van Loon et al., 2021). For practical reasons, teachers would engage in autonomy-supportive and directive instruction to better manage classroom resources (e.g., time, energy). That is, teachers need students to be able to work independently so that they effectively instruct and support their learners' needs in classrooms.

Fortunately, previous research has indicated that students learning and SR skills benefit for a variety of instructional approaches (Butler, 2021; Michalsky, 2021; van Loon et al., 2021). For example, research findings have demonstrated that autonomy-supportive instructional practices positively promote learning engagement and satisfaction, provide opportunities for students to develop their SR skills in classrooms, and predict learning outcomes (Pierro et al., 2009; Perry et al., 2021). Moreover, findings have demonstrated that directive instructional practices may support young students' (e.g., preschool, elementary) academic abilities and outcomes (Bohn et al., 2006; Cameron et al., 2009; McWilliam et al., 2003). Specifically, elaboration (e.g., step-by-step instructions), clarifications (e.g., clear expectations) and feedback (e.g., assessment), may support students' learning needs such that they can independently engage in learning and be successful in their learning endeavors (Cameron & Morrison, 2011). This is likely a result of the cognitive load associated to engaging in complex problem-solving with basic skills (e.g., cognitive, behavioral) that are still developing alongside academic knowledge (e.g., content, procedures, strategies) and self-regulatory processes (e.g., metacognition, monitoring, evaluation; Lillard, 2005).

However, teachers' reasoning for implementing these practices are unknown as the current study did not capture information regarding teacher beliefs, or knowledge about SR and the role of instructional practices. Additionally, the small sample of teachers who participated in the current study (n= 4), limited the types of analyses that could be used to assess teachers' self-reported instructional behaviors. Although the inclusion of both the autonomy-supportive and directive instructional sub-scales meets calls to understand complex teaching practices as opposed to any practice in isolation (Butler, 2021), the split-median analysis does not provide insight regarding how students respond to these two types of instructional practices and whether they support students SR processes during learning. Moreover, teachers' ratings of their typical classroom practices could only be compared based on their average scores and whether they were coded as high (e.g., > 2.5) or low (e.g., < 2.5). To address these limits and extend researcher understandings of whether instructional practices may support students' ER an SRL, observational records of teachers' practices during mathmatics lessons were examined.

Findings from the observational analyses suggested that instructional practices like employing complex tasks, offering instrumental support (i.e., teacher and peer), supporting students' autonomy, and providing direction may support students' ER and SRL skills. Specifically, observational records suggested that employing these instructional practices may have fostered students SR skills in three ways. First, the presence of these instructional practices in classrooms provided students with meaningful opportunities to engage in the processes that underlie all targets of SR (i.e., executive functioning, metacognition, motivation, and strategic action). In turn, students' ER and SRL skills may have become more coordinated and sophisticated. Second, students' who were enrolled in classrooms wherein teachers employed appropriate combinations of these instructional practices may have experienced less negative affect. Since previous research has indicated that negative affect can interrupt students' use of effective and adaptive SRL (Tice et al., 2004), these classroom practices may have indirectly fostered students' SRL. Finally, teachers emphasize these instructional behaviors were observed providing their students with opportunities to engage in SRL, which supports their acquisition of adaptive and developmentally appropriate SR skills and ultimately promotes positive learning outcomes reduces their experience of negative affect.

However, findings from the observational records of teachers' mathematics lessons demonstrated that there are differences in teachers' instructional practices in classrooms during mathematics learning. Specifically, observations indicated that all teachers implemented instructional practices that are known to emphasize SR but the meaningfulness of the instruction differs. That is, some teachers were more prepared to implement instructional practices in manners that fostered students' metacognition, motivation, and provided opportunities to engage in SRL. Additionally, observations demonstrated that instructional practices were not implemented in isolation. Rather, findings from the current study support previous research which has demonstrated that teaching practices that emphasize students SR are not mutually exclusive (Perry et al., 2018). These findings have practical implications for educators and policy makers, such that students' SR skills can be supported at a broad level in classrooms and schools. However, continued research that employs mixed methods may enhance the yield of findings and provide rich insight into classroom processes that facilitate or hinder students' ER and SRL specifically. Moreover, future research that examines learners at different stages of their academic careers (e.g., preschool, high school, university) will extended researchers understandings of the nature of SR, and how best to foster it in students, at different developmental periods. These lines of inquiry hold practical implications for teacher education and the development of classroom-based SR interventions.

Given the findings that students ER and SRL skills change during the school year, and that teachers' classroom practices can account for some of the change in students SR skills, it was important to assess how ER and SRL are related to one another over time. Previous research has indicated there are possible interdependent relationships between targets of SR (Hoyle & Dent, 2018; Usher & Schunk 2018), and as such students' skills and abilities in one target (e.g., ER) may be related to their skills and abilities in another (e.g., SRL). Unfortunately, fit indices from the path analysis indicated that the hypothesized model was over fit to the data. That is, the hypothesized cross-lagged path model resembled the data provided by participants in this study exactly or too closely (Muthén & Muthén, 2017). Since the model was not necessarily complex (e.g., several paths), this is likely a result of the small sample size (n= 145) and limited power. It is also possible that the ceiling effects that were displayed by ANOVA results for grade 5 and 6 students' ER skills may influence the model fit. That is, if students' ER skills remained consistent overtime they would be highly related (e.g., limited variance) and result in a near perfect prediction. Therefore, future research should collect data from large samples of participants to conduct higher level analyses like structural equation modeling (e.g., latent growth curve analyses) so that within and between-student differences can be examined

Though firm conclusions cannot be drawn from this analysis, one may consider the information that was provided in the larger scale of the findings. In line with the ANOVA findings, path analyses indicated that early ER did not predict later ER. Since previous research has indicated that childrens' ER skills tend to increase over time (Calkins & Dedmon, 2010; Cole et al., 2018), it is possible that the grade 4 students' decrease in ER skills, and the limited change grade 5 and 6 students displayed in their mean scores may account for this non-significant path. However, findings suggested that students' SRL skills in the fall predicted their later SRL skills. These findings align with previous research (Diamond, 2016; Zachariou & Whitebread, 2019) which has indicated that students' SRL skills tend to become more coordinated and sophisticated over time. Additionally, path analyses suggested that students' early ER skills may be related to their SRL skills later in the school year. This is in line with theorist suggestions that adaptive ER skills support students learning endeavors as they are related to positive modulation of disruptive affect, and may ultimately preserve the cognitive resources that are necessary for SRL (Gross, 2015; Frenzel et a., 2024; Harley et al., 2019). Although these findings need further investigation, there are practical implications to be considered. Specifically, supporting students' ER skills early in the school year also foster their development of effective SRL skills.

The alternative path, wherein students' early SRL skills predict their later ER skills, was non-significant. This is counter to some research which suggests that adaptive patterns of SRL may support students learning success, thereby reducing negative affect (Muis et al., 2015; Pekrun, 2018; Tice et al., 2004) and the need to regulate negative affective experiences. Rather, it is possible that students who demonstrate adaptive and effective SRL skills may have difficulty with regulating their emotions given a lack of experience applying and refining their ER skills. To gain insight into the relationships between ER and SRL and how they develop in tandem future research may assess students' emotions during learning, as well as their ER and SRL skills. In doing so, researchers may capture information that informs how emotional experiences shape opportunities to engage in and refine ones' self-regulatory skills.

Finally, findings from the path analysis indicated that age is an important covariate to student in SR research. Specifically, findings suggest that age negatively predicted students SRL skills. In line with findings from the ANOVA, it is possible that these findings are the result of slowed increases to older students' SRL skills during the school year. It is also likely that the significant decrease is grade 4 students SRL skills would add to this negative relationship between age and students SRL skills. Finally, the use of a single measure of students SR skills in the form of a teacher report may lend to this finding, especially considering that the SRISI was developed and validated with a slightly younger learner population (kindergarten to grade 6 students). That is, teachers may be reporting on their students' SR abilities based on what they believe to be appropriate developmental bench marks as opposed to where students' skills are in that time. Though the current study employed the SRISI (Hutchinson et al., 2021) to assess students' ER and SRL skills with items that assess the underlying processes involved in SR (i.e., metacognition motivation, strategic action) future research would benefit from the use of multiple data sources for students SR skills. Such research would extend theoretical insights

Limitations

Regarding the current study, there are several limitations which should be addressed. First, the current study aimed to measure students' ER and SRL as individual latent factors that consisted of items that captured the underlying metacognitive and motivational processes and strategic action that underlies each target of SR. Unfortunately, this aim was not entirely met as the motivational items for SRL in the fall and the spring were non-normal and were therefore removed from the analysis. This resulted in the removal of the motivational items for ER to remain consistent in the underlying structure of both targets of SR. Future research should continue to assess the development of ER and SRL using measures that assess underlying SR processes like metacognition, motivation, and strategic action.

Second, the current study relied on teachers' reports to measure students' classroom-based ER and SRL skills. Though findings suggest that teachers can provide reliable and consistent ratings of their students' SR abilities within classrooms (Hutchinson et al., 2021; Perry & Miesels, 1996), researchers call for the use of multiple data sources to increase reliability of data (McCardle & Hadwin, 2015). Therefore, future research should collect information from the participant (i.e., student), as well as other knowledgeable references points (e.g., teachers, educational assistants). Moreover, employing self-reports in tandem with cognitive protocols (e.g., think alouds) may provide important opportunities for the triangulation of data and provide insight into the how specific ER and SRL strategies develop overtime.

Lastly, the small sample size (*n* = 145 students, 4 teachers) precluded the use of some statistical analyses like multi-level modeling and latent-growth curve analysis. As such, the influence of classroom instruction on developmental growth trends could not be quantitatively captured. Moreover, the classroom observations that took place during mathematics instruction provided important information about the roles of instruction on students' SR skills in this specific domain, but does not align with the global measures of classroom SR and instruction (e.g., domain general) that were employed in this study. Future research with larger participant samples should continue to assess how contextual variables influence students' development of ER and SRL develop over time in the context of classroom-based learning to gain insight into the interdependent relationships between these two targets of SR and the roles of classroom context. Additionally, the use mixed methods at multiple-levels (e.g., students, teachers) may support researchers and educators in understanding how to design and implement learning to support students' classroom-based ER and SRL during the school year.

Conclusion

Findings from the current study suggest that there are important developmental processes and environmental factors involved in students' development of classroom-based ER and SRL skills. These findings reinforce that it is an important goal for researchers, educators, and policy makers to work together to understand how to support students' development of SR, and in turn their academic success, in schools. Specifically, researchers should continue to employ diverse measures (e.g., cognitive, behavioral, self-reports, observations) to explore how ER and SRL develop together in classrooms. Moreover, researchers should continue to work with teachers to examine which features of instruction support students' SR in diverse learning domains (e.g., literacy, mathematics, science). Together, this may reveal the importance of diverse instructional practices which in turn informs teacher education, pedagogical design, and the development of classroom-based SR interventions.

References

Aldao, A., Sheppes, G., & Gross, J. J. (2015). Emotion regulation flexibility. *Cognitive Therapy and Research*, *39*(3), 263-278. https://doi.org/10.1007/s10608-014-9662-4

Bandura, A. (1989). Regulation of cognitive processes through perceived self-efficacy. *Developmental Psychology*, 25, 725– 739. https://doi.org/10.1037/0012-1649.25.5.729

Ben-Eliyahu, A., & Bernacki, M. L. (2015). Addressing complexities in self-regulated learning: A focus on contextual factors, contingencies, and dynamic relations. *Metacognition and Learning*, *10*, 1-13. https://doi.org/10.1007/s11409-015-9134-6

Blair, C., Calkins, S., & Kopp, L. (2010). Self-regulation as the interface of emotional and cognitive development: Implications for education and academic achievement. In R. H. Hoyle (Ed.), *Handbook of personality and self-regulation* (pp. 64–90). Wiley Blackwell. https://doi.org/10.1002/9781444318111.ch4

Blair, C., & Razza, R. P. (2007). Relating effortful control, executive function, and false belief understanding to emerging math and literacy ability in kindergarten. *Child Development*, *78*(2), 647-663. https://doi.org/10.1111/j.1467-8624.2007.01019.x

Bohn, C. M., Roehrig, A. D., & Pressley, M. (2004). The first days of school in the classrooms of two more effective and four less effective primary-grades teachers. *Elementary School Journal*, *104*, 269–287. https://doi.org/10.1086/499753

Bonanno, G. A., & Burton, C. L. (2013). Regulatory flexibility: An individual differences perspective on coping and emotion regulation. *Perspectives on Psychological Science*, *8*(6), 591-612. https://doi.org/10.1177/1745691613504116

Bryce, D., Whitebread, D. & Szűcs, D. (2015). The relationships among executive functions, metacognitive skills and educational achievement in 5 and 7-year-old children.

Metacognition and Learning 10, 181–198. https://doi.org/10.1007/s11409-014-9120-4

Butler, D. L. (2021). Enabling educators to become more effective supporters of SRL: Commentary on a special issue. *Metacognition and Learning*, *16*(3), 667-684. https://10.1007/s11409-021-09282-8

Calkins, S.D., & Dedmon, S.E. (2010). Physiological and behavioral regulation in two-year-old children with aggressive/destructive behavior problems. *Journal of Abnormal Child Psychology, 28*, 103–118. https://doi.org/10.1023/A:1005112912906

Calkins, S. D., Graziano, P. A., Berdan, L. E., Keane, S. P., & Degnan, K. A. (2008). Predicting cardiac vagal regulation in early childhood from maternal–child relationship quality during toddlerhood. *Developmental Psychobiology: The Journal of the International Society for Developmental Psychobiology*, *50*(8), 751-766.

Calkins, S. D., Graziano, P. A., Berdan, L. E., Keane, S. P., & Degnan, K. A. (2008). Predicting cardiac vagal regulation in early childhood from maternal–child relationship quality during toddlerhood. *Developmental Psychobiology: The Journal of the International Society for Developmental Psychobiology*, *50*(8), 751-766. https://doi.org/10.1002/dev.20344

Cameron, C. E., & Morrison, F. J. (2011). Teacher activity orienting predicts preschoolers' academic and self-regulatory skills. *Early Education & Development*, *22*(4), 620-648. https://doi.org/10.1080/10409280903544405

Cameron Ponitz, C. E., Rimm-Kaufman, S. E., Brock, L. L., & Nathanson, L. (2009). Early adjustment, gender differences, and classroom organizational climate in first grade. *Elementary School Journal, 110*, 142–162. https://doi.org/10.1086/605470

Chen, F., Curran, P. J., Bollen, K. A., Kirby, J., & Paxton, P. (2008). An empirical evaluation of the use of fixed cutoff points in RMSEA test statistic in structural equation models. *Sociological Methods & Research*, *36*(4), 462-494. https://doi.org/10.1177/0049124108314720

Cole, P. M., Lougheed, J. P., & Ram, N. (2018). The development of emotion regulation in early childhood. In P. M. Cole & T. Hollenstein (Eds.), *Emotion Regulation: A matter of time*. (pp. 73–100). Routledge. https://doi.org/10.4324/9781351001328

Corno, L. (2001). Volitional aspects of self-regulated learning. In B. J. Zimmerman & D. H. Schunk (Eds.), *Self-regulated learning and academic achievement: Theoretical perspectives* (2 ed., pp. 191-225). Mahwah, NJ: Lawrence Erlbaum Associates Publishers.

Davidson, M. C., Amso, D., Anderson, L. C., & Diamond, A. (2006). Development of cognitive control and executive functions from 4 to 13 years: Evidence from manipulations of memory, inhibition, and task switching. *Neuropsychologia*, *44*(11), 2037-2078. https://doi.org/10.1016/j.neuropsychologia.2006.02.006

Davis, E. L., & Levine, L. J. (2013). Emotion regulation strategies that promote learning: Reappraisal enhances children’s memory for educational information. *Child Development*, *84*(1), 361–374. https://doi.org/10.1111/j.1467-8624.2012.01836.x

Deci, E. L., & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behavior*. New York, NY: Plenum.

Dennis, T., Hong, M., & Solomon, B. (2010). Do the association between exuberance and emotion regulation depend on effortful control? *International Journal of Behavioral Development*, *34*. https://doi.org/10.1177/0165025409355514

Dennis, T. A., & Kelemen, D. A. (2009). Preschool children's views on emotion regulation:

Functional associations and implications for social-emotional adjustment. *International Journal of Behavioral Development*, *33*(3), 243-252. https://doi.org/10.1177/0165025408098024

Diamond, A. (2016). Why assessing and improving executive functions early in life is critical. In J. A. Griffin, P. McCardle, & L. S. Freund (Eds.), *Executive function in preschool-age children: Integrating measurement, neuro-development and translational research* (pp. 11–43). Washington, DC: American Psychological Association.

Di Leo, I., & Muis, K. R. (2020). Confused, now what? A Cognitive-Emotional Strategy Training (CEST) intervention for elementary students during mathematics problem solving. *Contemporary Educational Psychology*, *62*, 101879. https://doi.org/10.1016/j.cedpsych.2020.101879

Di Leo, I., Muis, K. R., Singh, C., & Psaradellis, C. (2019). Curiosity Confusion? Frustration! The role and sequencing of emotions during mathematics problem solving. *Contemporary Educational Psychology, 58,* 121–137. https://doi.org/10.1016/j.cedpsych.2019.03.001

Eisenberg, N., Spinrad, T. L., Fabes, R. A., Reiser, M., Cumberland, A., Shepard, S. A., ... & Thompson, M. (2004). The relations of effortful control and impulsivity to children's resiliency and adjustment. *Child Development*, *75*(1), 25-46. https://doi.org/10.1111/j.1467-8624.2004.00652.x

Eshel, Y., & Kohavi, R. (2003). Perceived classroom control, self-regulated learning strategies, and academic achievement. *Educational Psychology 23*(3), 249-260. https://doi.org/10.1080/0144341032000060093

Frenzel. A.C., Goetz, T., & Stockinger, K. (2024). Emotions and emotion regulation. In P.

Schutz & K. R. Muis (Eds.), *Handbook of Educational Psychology*.

Graziano, P. A., Calkins, S. D., & Keane, S. P. (2011). Sustained attention development during the toddlerhood to preschool period: Associations with toddlers' emotion regulation strategies and maternal behavior. *Infant and Child Development*, *20*(6), 389-408. https://doi.org/10.1002/icd.731

Greene, J. A., & Azevedo, R. (2009). A macro-level analysis of SRL processes and their relations to the acquisition of a sophisticated mental model of a complex system. *Contemporary Educational Psychology*, *34*, 18–29. https://doi.org/10.1016/j.cedpsych.2008.05.006

Greene, J. A., Plumley, R. D., Urban, C. J., Bernacki, M. L., Gates, K. M., Hogan, K. A., ... & Panter, A. T. (2021). Modeling temporal self-regulatory processing in a higher education biology course. *Learning and Instruction*, *72*, 101201. https://doi.org/10.1016/j.learninstruc.2019.04.002

Gross, J. J. (1998). The emerging field of emotion regulation: An integrative review. *Review of General Psychology*, *2*(3), 271-299. https://doi.org/10.1037/1089-2680.2.3.271

Gross, J. J. (2015). Emotion regulation: current status and future prospects. *Psychological Inquiry*, *26*(1), 1-26. https://doi.org/10.1080/1047840X.2014.940781

Gross, J. J., & John, O. P. (2003). Individual differences in two emotion regulation processes: Implications for affect, relationships, and well-being. *Journal of Personality and Social Psychology*, *85*(2), 348. https://doi:10.1037/0022-3514.85.2.348

Gross, J. J., & Thompson, R. A. (2007). Emotion regulation: Conceptual foundations. In J. Gross (Ed.). *Handbook of emotion-regulation* (pp. 3–24). New York, NY: Guilford Publications.

Hadwin, A., Järvelä, S., & Miller, M. (2018). Self-regulation, co-regulation, and shared regulation in collaborative learning environments. *Educational Psychologist, 50*(3), 204-219. https://doi:10.1080/00461520.2015.1075400

Hamre, B. K., & Pianta, R. C. (2001). Early teacher–child relationships and the trajectory of children's school outcomes through eighth grade. *Child Development*, *72*(2), 625–638. https://doi.org/10.1111/1467-8624.00301

Hamre, B. K, & Pianta, R. C., (2005). Can instructional and emotional support in the first-grade classroom make a difference for children at risk of school failure? *Child Development* *76*(5), 949–967. https://doi.org/10.1111/j.1467-8624.2005.00889.x

Hillyer, J., & Ley, T. C. (1996). Portfolios and second graders' self-assessments of their development as writers. *Reading Improvement*, *133*(3), 148-159.

Howse, R. B., Calkins, S. D., Anastopoulos, A. D., Keane, S. P., & Shelton, T. L. (2003). Regulatory contributors to children's kindergarten achievement. *Early Education and Development*, *14*(1), 101-120. https://doi.org/10.1207/s15566935eed1401_7

Hoyle, R. H., & Dent, A. L. (2018). Developmental trajectories of skills and abilities relevant for self-regulation of learning and performance. In D. H. Schunk & J. A. Greene (Eds.), *Educational psychology handbook series. Handbook of self-regulation of learning and performance* (pp. 49–63). Routledge/Taylor & Francis Group.

Hudson, A., & Jacques, S. (2014). Put on a happy face! Inhibitory control and socioemotional knowledge predict emotion regulation in 5-to 7-year-olds. *Journal of Experimental Child Psychology*, *123*, 36-52. https://doi.org/10.1016/j.jecp.2014.01.012

Hutchinson, L. R. (2013). Young children's engagement in self-regulation at school (Unpublished doctoral dissertation). University of British Columbia, British

Columbia. https://doi.org/10.14288/1.0073717

Hutchinson, L. R., & Perry, N. E. (2014). Development and Validation of the SRISI. Manuscript submitted for publication.

Hutchinson, L. R., Perry, N. E., & Shapka, J. D. (2021). Assessing young children's self-regulation in school contexts. *Assessment in Education: Principles, Policy & Practice*, *28*(5-6), 545-583. https://doi.org/10.1080/0969594X.2021.1951161

Hutchinson, L. R., Perry, N. E., Yee, N., Restrepo, Dantzer, B., & Lo (2015, August). Demographic variables in children's self-regulation. Poster session presented at the American Psychological Association Annual Conference, Toronto. ON

IBM Corp. Released 2021. IBM SPSS Statistics for Macintosh, Version 28.0. Armonk, NY: IBM Corp

Järvenoja, H., & Järvelä, S. (2009). Emotion control in collaborative learning situations: Do students regulate emotions evoked by social challenges. *British Journal of Educational Psychology, 79*, 463-481. https://doi.org/10.1348/000709909X402811

Kenny, D. A., Kaniskan, B., & McCoach, D. B. (2015). The performance of RMSEA in models with small degrees of freedom. *Sociological Methods & Research*, *44*(3), 486-507. https://doi.org/10.1177/0049124114543236

Koole, S. L., & Veenstra, L. (2015). Does emotion regulation occur only inside people's heads? Toward a situated cognition analysis of emotion-regulatory dynamics. *Psychological Inquiry*, *26*(1), 61-68. https://doi.org/10.1080/1047840X.2015.964657

Kopp, C. B. (1982). Antecedents of self-regulation: A developmental perspective. *Developmental Psychology, 18*(2), 199–214. https://doi.org/10.1037/0012-1649.18.2.199

Kuhn, D. (1999). *Metacognitive development*. In L. Balter & C. S. Tamis-Lemonda (Eds.), Child psychology. *A handbook of contemporary issues* (pp. 259–286). Philadelphia: Psychology Press.

Leerkes, E. M., Supple, A. J., O'Brien, M., Calkins, S. D., Haltigan, J. D., Wong, M. S., & Fortuna, K. (2015). Antecedents of maternal sensitivity during distressing tasks: Integrating attachment, social information processing, and psychobiological perspectives. *Child Development*, *86*(1), 94-111. https://doi.org/10.1111/cdev.12288

Lillard, A. S. (2005). *Montessori: The science behind the genius*. New York, NY: Oxford University Press.

Linnenbrink, E. A. (2005). The dilemma of performance-approach goals: The use of multiple goal contexts to promote students' motivation and learning. *Journal of Educational Psychology*, *97*(2), 197-213. https://doi.org/10.1037/0022-0663.97.2.197

Lodewyk, K. R., Winne, P. H., & Jamieson-Noel, D. L. (2009). Implications of task structure on self-regulated learning and achievement. *Educational Psychology*, *29*(1), 1-25. https://doi.org/10.1080/01443410802447023

Lodewyk, K. R., & Winne, P. H. (2005). Relations among the structure of learning tasks, achievement, and changes in self-efficacy in secondary students. *Journal of Educational Psychology*, *97*(1), 3. https://doi.org/10.1037/0022-0663.97.1.3

Losenno, K. M., Muis, K. R., Munzar, B., Denton, C. A., & Perry, N. E. (2020). The dynamic roles of cognitive reappraisal and self-regulated learning during mathematics problem solving: A mixed methods investigation. *Contemporary Educational Psychology*, *62*. https://doi.org/10.1016/j.cedpsych.2020.101869

McCabe, L. A., Cunnington, M., & Brooks-Gunn, J. (2004). The development of self-regulation in young children: Individual characteristics and environmental contexts. In R. F. Baumeister & K. D. Vohs (Eds.), *Handbook of self-regulation: Research, theory, and applications* (p. 340–356). The Guilford Press.

McCardle, L., & Hadwin, A. F. (2015). Using multiple, contextualized data sources to measure l earners' perceptions of their self-regulated learning. *Metacognition and Learning, 10*(1), 43–75. https://doi.org/10.1007/s11409-014-9132-0

McClelland, M. & Cameron, C. (2011). Self-regulation and academic achievement in elementary school children. *New Directions for Child and Adolescent Development, 2011*(133), 29-44. https://doi.org/10.1002/cd.302

McCrudden, M. T., Marchand, G., & Schutz, P. (2019). Mixed methods in educational psychology inquiry. *Contemporary Educational Psychology, 57,* 1–8. https://doi.org/10.1016/j.cedpsych.2019.01.008

McCrudden, M. T., & Marchand, G. (2020). Multilevel mixed methods research and educational psychology. *Educational Psychologist, 55*(4), 197-207. https://doi.org/10.1080/00461520.2020.1793156

McKinnon, R. D., & Blair, C. (2018). Does early executive function predict teacher–child relationships from kindergarten to second grade? *Developmental psychology, 54*(11), 2053. https://doi.org/10.1037/dev0000584

Mikulincer, M., Shaver, P. R., & Pereg, D. (2003). Attachment theory and affect regulation: The dynamics, development, and cognitive consequences of attachment-related strategies. *Motivation and Emotion, 27*(2), 77-102. https://doi.org/10.1023/A:1024515519160

Miyake, A., & Friedman, N. P. (2012). The nature and organization of individual differences in executive functions: Four general conclusions. *Current Directions in Psychological Science, 21*(1), 8–14. https://doi.org/10.1177/0963721411429458

Muis, K. R. (2007). The role of epistemic beliefs in self-regulated learning. *Educational Psychologist, 42*(3), 173–190. https://doi.org/10.1080/00461520701416306

Muis, K. R., Psaradellis, C., Lajoie, S. P., Di Leo, I., & Chevrier, M. (2015). The role of epistemic emotions in mathematics problem-solving. *Contemporary Educational Psychology,* 42, 172–185. https://doi.org/10.1016/j.cedpsych.2015.06.003

Muis, K. R., Psaradellis, C., Chevrier, M., Di Leo, I., & Lajoie, S. P. (2016). Learning by preparing to teach: Fostering self-regulatory processes and achievement during complex mathematics problem-solving. *Journal of Educational Psychology, 108*, 474–492. https://doi.org/10.1037/edu0000071.

Munzar, B., Muis, K. R., Denton, C. A., & Losenno, K. M. (2020). Elementary students' cognitive and affective responses to impasses during mathematics problem-solving. *Journal of Educational Psychology*. https://doi.org/10.1037/edu0000460.

Nowacek, E. J., McKinney, J. D., & Hallahan, D. P. (1990). Instructional behaviors of more and less effective beginning regular and special educators. *Exceptional Children, 57*, 140–149.

Pekrun, R. (2018). Control-value theory: A social-cognitive approach to achievement emotions. In G. A. D. Liem & D. M. McInerney (Eds.), *Big theories revisited 2: A volume of research on sociocultural influences on motivation and learning* (pp. 162-190). Charlotte: Information Age Publishing. https://doi.org/10.4236/me.2018.9505

Perry, N. B., & Calkins, S. D. (2018). A biopsychosocial perspective on the development of emotion regulation across childhood. In *Emotion regulation* (pp. 3-30). Routledge.

Perry, N. E. (1998). Young children's self-regulated learning and contexts that support it. *Journal of Educational Psychology*, *90*(4), 715. https://doi.org/10.1037/0022-0663.90.4.71

Perry, N. E. (2013). Understanding classroom processes that support children’s self-regulation of learning [Monograph]. British Journal of Educational Psychology, Monograph Series II: Psychological Aspects of Education – Current Trends, 10, 45–68.

Perry, N. E., Hutchinson, L. R., Yee, N., & Määttä, E. (2018). Advances in understanding young children’s self-regulation of learning. In D. Schunk, & J. Greene (Eds.). *Handbook of self- regulated learning and performance* (pp. 457–472). (2nd ed.). New York: Routledge. https://doi.org/10.4324/9781315697048-29

Perry, N. E., Lisaingo, S., Yee, N., Parent, N., Wan, X., & Muis, K. (2020). Collaborating with teachers to design and implement assessments for self-regulated learning in the context of authentic classroom writing tasks. *Assessment in Education: Principles, Policy & Practice*, *27*(4), 416-443. https://doi.org/10.1080/0969594X.2020.1801576

Perry, N. E., Phillips, L., & Dowler, J. (2004). Examining features of tasks and their potential to promote self-regulated learning. *Teachers College Record*, *106*(9), 1854-1878.

Perry, N. E., Phillips, L., & Hutchinson, L. R. (2006). Mentoring student teachers to support self-regulated learning. *Elementary School Journal*, *106*(3), 237-254.

Perry, N. E., & VandeKamp, K. O. (2000). Creating classroom contexts that support young children's development of self-regulated learning. *International Journal of Educational Research*, *33*, 821-843. https://doi.org/10.1016/S0883-0355(00)00052-5

Pierro, A., Presaghi, F., Higgins, T. E., & Kruglanski, A. W. (2009). Regulatory mode preferences for autonomy supporting versus controlling instructional styles. *British Journal of Educational Psychology*, *79*(4), 599-615.

https://doi.org/10.1348/978185409X412444

Raffaelli, M., Crockett, L. J., & Shen, Y. L. (2005). Developmental stability and change in self-regulation from childhood to adolescence. *The Journal of Genetic Psychology*, *166*(1), 54-76. https://doi.org/10.3200/GNTP.166.1.54-76

Reeve, J. (2006). Teachers as facilitators: What autonomy-supportive teachers do and why their students benefit. *Elementary School Journal*, 106(3), 225-236. https://doi.org/10.1086/501484

Rottweiler, A.-L., Taxer, J. L., & Nett, U. E. (2018). Context matters in the effectiveness of emotion regulation strategies. *American Education Research Association Open, 4(*2), 233285841877884. https://doi.org/10.1177/2332858418778849

Rudasill, K. M., & Rimm-Kaufman, S. E. (2009). Teacher–child relationship quality: The roles of child temperament and teacher–child interactions. *Early Childhood Research Quarterly*, *24*(2), 107–120. https://doi.org/10.1016/j.ecresq.2008.12.003

Sameroff, A. (2010). A unified theory of development: A dialectic integration of nature and nurture. *Child Development*, *81*(1), 6-22. https://doi.org/10.1111/j.1467-8624.2009.01378.x

Scherer, K. R., & Moors, A. (2019). The emotion process: Event appraisal and component differentiation. *Annual Review of Psychology*, *70*, 719-745. https://doi.org/https://doi.org/10.1146/annurev-psych-122216011854

Schutz, P. A., & Davis, H. A. (2000). Emotions and self-regulation during test taking. *Educational Psychologist*, *35*(4), 243-256. https://doi.org/10.1207/S15326985EP3504_03

Sheppes, G., & Meiran, N. (2008). Divergent cognitive costs for online forms of reappraisal and distraction. *Emotion*, *8*(6), 870-874. https://doi.org/10.1037/a0013711

Stefanou, C. R., Perencevich, K. C., DiCintio, M., & Turner, J. C. (2004). Supporting autonomy in the classroom: Ways teachers encourage student decision making and ownership. *Educational Psychologist, 39*, 97-110. https://doi.org/10.1207/s15326985ep3902_2

Strain, A. C., & D'Mello, S. K. (2015). Affect regulation during learning: The enhancing effect of cognitive reappraisal. *Applied Cognitive Psychology, 29*(1), 1–19. https://doi.org/10.1002/acp.3049

Tice, M. D., Baumeister, R. F., & Zhang, L. (2004). The role of emotion in self-regulation: Differing roles of positive and negative emotion. In P. Philippot & R. S. Feldman (Eds.), *The regulation of emotion* (pp. 213-226). Mahwah, NJ: Lawrence Erlbaum Associates.

Usher, E. L., & Schunk, D. H. (2018). *Social cognitive theoretical perspective of self- regulation*. In D. H. Schunk, & J. A. Greene (Eds.). Educational psychology handbook series. Handbook of self-regulation of learning and performance (pp. 19–35). Routledge/ Taylor & Francis Group. https://doi.org/10.4324/9781315697048-2

van Loon, M. H., Bayard, N. S., Steiner, M., & Roebers, C. M. (2021). Connecting teachers' classroom instructions with children's metacognition and learning in elementary school. *Metacognition and Learning*, *16*, 623-650. https://doi.org/10.1007/s11409-020-09248-2

Vand der Stel, M., Veenman, M. V., Deelen, K., & Haenen, J. (2010) The increasing role of metacognitive skills in math: A cross-sectional study from a developmental perspective. *Mathematics Education,* 42(2), 219- 229.

Veenman, M. V. J., & Spaans, M. A. (2005). Relation between intellectual and metacognitive skills: Age and task differences. *Learning and Individual Differences, 15*(2), 159–176. https://doi.org/10.1016/j.lindif.2004.12.001

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

Walker, J. M. T. (2008). Looking at teaching practices through the lens of parenting style. *The Journal of Experimental Education,76*(2), 218-240. https://doi.org/10.3200/JEXE.76.2.218-240

Wentzel, K. R. (2002). Are effective teachers like good parents? Teaching styles and student adjustment in early adolescence. *Child Development, 73,* 287-301. https://doi.org/10.1111/1467-8624.00406

Whitebread, D., Bingham, S., Grau, V., Pino-Pasternak, D., & Sangster, C. (2007). Development of metacognition and self-regulated learning in young children: Role of collaborative and peer-assisted learning. *Journal of Cognitive Education and Psychology, 6*, 433-455. https://doi.org/10.1891/194589507787382043

Whitebread, D., Coltman, P., Pasternak, D. P., Sangster, C., Grau, V., Bingham, S., ... & Demetriou, D. (2009). The development of two observational tools for assessing metacognition and self-regulated learning in young children. *Metacognition and Learning, 4,* 63-85. https://doi.org/10.1007/s11409-008-9033-1

Winne, P. H. (2018). Cognition and metacognition within self-regulated learning. In D. H. Schunk & J. A. Greene (Eds.), *Handbook of self-regulation of learning and performance* (2nd ed.). New York: Routledge.

Winne, P. H., & Perry, N. E. (2000). Measuring self-regulated learning. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 531–566). Academic Press. https://doi.org/10.1016/B978-012109890-2/50045-7

Zachariou, A., & Whitebread, D. (2019). Developmental differences in young children's self-regulation. *Journal of Applied Developmental Psychology*, *62*, 282-293. https://doi.org/10.1016/j.appdev.2019.02.002

Zimmerman, B. J. (2013). Theories of self-regulated learning and academic achievement: An overview and analysis. In B. J. Zimmerman & D. H. Shunk (Eds.) *Self-regulated learning and academic achievement*, (pp. 1-36). (2nd ed.) Routledge.

Zimmerman, B. J., & Schunk, D. H. (2011). Self-regulated learning and performance: An introduction and an overview. In D. H. Schunk & B. J. Zimmerman (Eds.) *Handbook of self-regulation of learning and performance*, (pp. 15-26). Routledge. https://doi.org/10.4324/9780203839010

Chapter 5. Final Discussion

General Discussion

Life is ripe with emotion, especially for young students who attempt to meet the demands of increasingly advanced stages of education, all while managing the challenges of growing up. The integration of emotions in research on learning, and more specifically research on self-regulation (SR), has allowed for more in-depth explorations of why, when, and how students regulate their emotions. Moreover, scholars' interest in understanding how students' engagement in emotion regulation (ER) relates to their self-regulated learning (SRL) during learning and developmentally across time, has continued to grow. Though the growing body of SR research has helped mobilize knowledge such that ER and SRL have become more common in educational and personal spheres, open questions remain regarding how to foster effective patterns of ER and SRL for students during classroom-based learning.

Calls have been placed to situate research on ER within learning domains to better understand the efficacy of ER strategies for students' educational outcomes. Moreover, scholars have identified a need for research that examines the intersection of ER and SRL during learning, and the developmental relationships between these two targets of SR. Finally, the role of classroom instruction on students' SR skills during school, specifically during mathematics problem-solving, has been under investigated. Therefore, this dissertation is a response to calls placed by researchers across the fields developmental and educational psychology who examine ER, SRL, and the role of classroom-based learning.

Contributions

To develop this dissertation, I drew on several fields of literature including the learning sciences, and cognitive, clinical, developmental, and educational psychology to inform my research questions and hypotheses. Additionally, the research design, measurements, and analyses were selected amongst some of the best available resources across these fields to align with the theoretical perspectives and participants (e.g., sample size, student demographics) selected. Moreover, results were interpreted through an interdisciplinary lens. Within each chapter, my aim was to produce original research contributions that extend and clarify theoretical knowledge, and its practical applications. To do so, the empirical studies in this dissertation were conducted to capture middle to late elementary-aged students' self-regulatory processes (i.e., ER, SRL) during regular classrooms activities and across the school year. The inclusion of teacher level analyses in Chapter 4 also provided a unique opportunity to examine whether specific features of classroom instruction facilitated or hindered students' ER and SRL. Beyond this, I have made several contributions to the field of research on SR which are elaborated below.

My dissertation began with a comprehensive review of literature (Chapter 2) that delineated how research on SR has developed over decades to include studies of emotions, ER and SRL in educational contexts across different developmental periods (e.g., kindergarten, university) and learning domains (e.g., literacy, mathematics). In synthesizing theoretical frameworks and empirical findings across relevant fields of research, I identified gaps in the extant literature. What emerged was a clear need for researchers to more fully integrate developmental and educational research on SR to assess the relationships between elementary-aged students' ER and SRL. More specifically, conclusions of the review indicated: (1) the need for researchers to examine how different ER strategies may support students' SRL processes during classroom activities, (2) to assess the relationships between students' development of ER skills and SRL skills during the school year, (3) to evaluate whether features of classroom instruction facilitate differences in students self-regulatory skills and (4) how features of instruction that emphasize students' SR may differ across learning domains.

Two empirical studies were presented to address these gaps in the literature. Chapter 3 presented the first empirical manuscript which contributed to literature as it enhanced researchers understanding of the role of cognitive reappraisal and expressive suppression during elementary-aged students' mathematics problem-solving in classrooms. First, SRL frameworks were reinforced as findings demonstrated that elementary-aged students tend to engage in SRL in a loosely linear matter during mathematics problem-solving. Additionally, current conceptions of which ER strategies support students' learning were challenged, as elementary-aged students use of suppression was revealed to positively predict their engagement in early SRL. Finally, the role of ER as an antecedent to SRL, and the mediating role of early SRL between ER and later SRL all served to extend theoretical understanding of the relationships between these two targets of SR during mathematics problem-solving.

Chapter 3 presented the second empirical manuscript which contributed to researchers' understandings of the development of classroom-based SR skills during the school year. This manuscript contributed to the literature by establishing that middle to upper-elementary-aged students' SRL skills significantly develop during the school year. The use of a teacher report tool that captured students' SR skills that reflect metacognitive, motivational, and strategic processes enhances methodological possibilities for future research. Additionally, findings theoretically extend researchers' understanding of the relationships between classroom enrollment and students' self-regulatory development by demonstrating: (1) that differences in pedagogical practice may support students' development of ER and SRL and, (2) instructional practices that emphasize students' SR may differ for mathematics problem-solving. Finally, findings also indicated that there may be relationships between students' development of their SRL skills and their ER skills, though a small sample size and low power negated the certainty of this finding.

It should be noted that these contributions were all related to elementary-aged students and are situated in classroom-based mathematics learning. Contributions from Chapter 3 highlighted that contrary to previous findings that expressive suppression negatively predicts cognitive, affective, and learning processes, that suppression may be effective for these students to employ in this domain. That is, given the strategically challenging and emotionally laden nature of mathematics problem-solving for students at this age, engagement in suppression may benefit these students' learning processes and outcomes. Contributions from Chapter 4 establish that SR skills do develop during the school year for students of this age, and that there are differences in development across different classrooms. Additionally, conclusions from this manuscript highlight that instructional practices may facilitate students SR, and that these practices may differ across learning domains. Findings also point to possible developmental relationships between students' ER and SRL skills that need to be further examined. Finally, the use of think-aloud protocols, survey items for ER and SRL that measure underlying SR processes (e.g., metacognition, motivation, strategic action), and classroom-based observations reinforce current methodological possibilities, or provide venues to future methodological approaches.

Future Directions

The manuscripts included in this dissertation were not without limitations, and serve as a building block for continued investigations into SR. This section extends the calls placed for future research in each of the manuscripts, and details the theoretical and methodological contributions of these proposals. First, it is important to discuss the possible reciprocal relationships between students' engagement in ER and SRL. Conclusions from Chapter 3 suggested that there were no significant bi-directional relationships between cognitive reappraisal, expressive suppression and the four phases of SRL (i.e., task definition, planning and goal setting, enactment of learning strategies, monitoring and evaluation) during students' mathematics problem-solving. This is counter to previous research which has demonstrated that there are bi-directional relationships between students' engagement in effective patterns of ER, namely cognitive reappraisal and SRL during learning activities (Losenno et al., 2020). It is possible that the inclusion of multiple ER strategies, especially two strategies that have in ways been classified as opposing in terms of their effectiveness for supporting learning processes and outcomes, may have influenced this outcome. Consequently, future research should continue to assess the possible reciprocal relationships between multiple ER strategies and SRL during students' learning activities.

As indicated in Chapters 2 and 3 it is also possible that SRL may be an important predictor of students' ER. Recall that students who demonstrate effective patterns of SRL may experience less affect (e.g., less negative or less intense) during learning and thereby reduce their need to engage in ER. Therefore, these two targets of SR may be theoretically interchangeable antecedents to one another. Though scholars already have theoretical support for assessing SRL as a predictor of ER, findings from Chapter 4 also hinted at this potential. That is, students' early SRL skills may not only serve as an antecedent to their ER during learning and achievement activities, but may also be an important predictor of their later ER skills. Future research that examines if ER and SRL are interchangeable antecedents to one another, and whether there are developmental relationships between them may extend theoretical knowledge. These lines of research, when conducted with similar student samples (e.g., age, developmental abilities) and similar contexts (e.g., learning domain, level of schooling) may provide empirical evidence about the relationships between ER and SRL and add clarity to theory.

To build on this, it is necessary for researchers to continue the investigation of why, when, and how students engage in ER during learning and achievement activities. To gain insight as to why students select ER strategies during learning or achievement activities, future research may include measures of students' emotions, self-efficacy, and task value for the activity at hand. Previous research has indicated that each of these variables relate to students' emotion processes and thereby ER, and highlight the importance of context (e.g., learning domain, high/low stakes activity) when conducting SR research (Harley et al., 2019). To better understand when and how students employ ER strategies, researchers may consider measuring transitions between ER strategies during learning activities. For example, it is possible that when students experience certain emotions (e.g., confusion) that they choose to employ reappraisal (e.g., confusion is normal, an opportunity for learning), and with other emotions (e.g., boredom) they choose to employ suppression. Moreover, it is possible that students may attempt to employ reappraisal and, when unsuccessful (e.g., the emotion persists, learning is blocked), they may switch to suppression to move on with their learning or achievement efforts.

Conclusions from Chapter 3 and 4 highlighted the need for increasingly advanced methodologies when conducting classroom-based SR research. Though teachers' judgements of their students SR have been considered reliable when they are situated in typical classroom activities (Hutchinson et al., 2021; Whitebread et al., 2009), it is critical that future research uses multiple measures of students' ER and SRL. For example, scholars may benefit from the triangulation of methods including self- and other-reports (e.g., teacher, parent), online trace methods (e.g., think-aloud, emote-aloud, facial expression, eye-tracking), and physiological measures (e.g., heart rate, galvanic skin response). The inclusion of these types of methods may provide insight into the underlying processes involved SR, as well as the specific ER and SRL strategies that students know and favor. Moreover, the triangulation of data through multiple methods may produce more reliable ratings of which regulatory strategies students employ, and at which point they employ them during the learning or achievement activity.

Another direction for future research is related to the role of educators in students' development of classroom-based SR skills overtime. Findings from Chapter 3 gave insight into whether differences in pedagogical practices may facilitate or hinder students' self-regulatory development in the context of mathematics learning. An important next step is for researchers to investigate which pedagogical practices support or impede the development of ER and SRL skills, and to do so across learning domains. That is, future research should assess which ER and SRL strategies teachers instruct to students, the methods in which these strategies are instructed, and how this differs from math and science, to literacy and social sciences (e.g., geography). Additionally, the authentic classroom-based context of the current dissertation highlights that future research on ER and SRL should integrate research regarding socially-situated forms of self-regulation. These lines of inquiry would provide a rich overview of the actual classroom processes that take place between teachers and students, and students and their peers. In turn, research that situates learning in social processes, and is domain specific, may provide clarity regarding how best to support students self-regulatory and learning processes.

Moreover, developing reliable methods for capturing and assessing how teachers instruct ER strategies to their students is critical. For example, the development of a coding scheme to pair onto observational analyses of classrooms instruction may provide important insight regarding how students learn to regulate their emotions during learning. Continuing to employ multiple methods like teacher reports paired with teacher interviews, and researcher conducted observational analyses of classrooms holds theoretical and practical value. Namely, the possible theoretical contributions regarding how teachers instruct ER in their classrooms would support researchers' understandings of how to build interventions that support educators in teaching for SR at a global classroom-level and in schools.

Finally, it would be beneficial for interdisciplinary researchers to consider how ER and SRL are related to learning outcomes for students who experience cognitive difficulties, learning difficulties, or express neuro-divergences. Literature in developmental and clinical psychology have attended to students who display maladaptive patterns of cognition, learning, and behavior (Butler & Schnellert, 2015; Calkins & Dedmon, 2010; Eisenberg et al., 2010) or express neuro-divergences (Aldao & Nolen-Hoeksema, 2012; Forslund et al., 2016). However, there is limited research in these fields that is situated in authentic learning contexts. Literature in educational psychology and the learning sciences has tended to focus on the learners who are considered developmentally or neurologically typical. As a result, little is known about how ER and SRL unfold during learning, and develop overtime for students who express cognitive difficulties, learning difficulties or neuro-divergencies. Moreover, research that examines how features of classroom instruction can facilitate or curtail these students' classroom-based SR skills is limited. Future research should explore how ER and SRL strategy use may differ in development, coordination, sophistication, and usefulness for these under-examined students. Thrashing out this line of research may support collaborative efforts between scholars, educators, and policy makers to better support students' self-regulatory development and ultimately their educational success and personal well-being.

To successfully address these calls placed for future research, theorists will have to continue to integrate theoretical knowledge from various domains such as cognitive, developmental, educational and clinical psychology. To this end, interdisciplinary perspectives will help facilitate research that includes multiple targets of SR such as ER, and SRL in tandem and may extend to include socially-situated forms of SR. Since empirical findings continue to hint at possible interdependent relationships between ER and SRL, the continued investigation of multiple targets of SR in concert is critical to extending theoretical knowledge regarding each target. Moreover, an intentional marriage of quantitative and qualitative approaches to measuring classroom-based SR across levels (e.g., students, teachers) will continue to support theoretical advances and empirical research. To successfully push this field of SR research into the realm of future possibilities, scholars will be required the use and continue to develop multiple methodologies that include: self-reports, reports from relevant others, online trace methods, physiological responses, and observations of classrooms practices. These calls for future research hold important implications for children as students' self-regulatory abilities are still developing during the middle to upper elementary aged years and simultaneously serve as a foundation for current and future academic and personal success.

Conclusion

The research I conducted for this dissertation meets the requirements set forth such that it extends theory on self-regulation by delineating the developmental underpinnings of self-regulation to highlight the relationships between students' engagement in ER and SRL, and development of their self-regulatory (i.e., ER, SRL) skills. By pairing student reports of their own ER strategy use with think–aloud protocols during a typical classroom-based mathematics problem-solving activity, the current dissertation captured the relationships between students' engagement in ER strategies and SRL, how SR unfolds during problem-solving (i.e., ER, SRL) and how their self-regulatory engagement influenced their problem-solving outcomes. Additionally, the current dissertation captured important relationships between the development of students' ER and SRL using teacher reports of their students' ER and SRL. Moreover, by methodologically pairing teachers' reports of their instructional behaviors with researchers' observational analyses of instructional practices during mathematics the current study extended researcher understanding of whether pedagogical practices may facilitate students' self-regulatory development. Together, findings from this research enhance researchers understanding of the role of different ER strategies during mathematics problem-solving and demonstrate that there are important relationships between ER and SRL during problem-solving, and over time as students' SR skills develop within classroom-based learning. In considering differences in instruction across classrooms (i.e., the degree to which certain pedagogical practices are present in the classroom), the current dissertation provides insight into the role of pedagogical practices in facilitating students' self-regulatory development during mathematics instruction.

References

Aldao, A., & Nolen-Hoeksema, S. (2012). When are adaptive strategies most predictive of psychopathology? *Journal of Abnormal Psychology*, *121*(1), 276-281. https://doi.org/10.1037/a0023598

Butler, D. L., & Schnellert, L. (2015). Success for students with learning disabilities: What does self-regulation have to do with it? In T. Cleary (Ed.), *Self-regulated learning interventions with at-risk youth: Enhancing adaptability, performance, and well-being* (pp. 89–111). American Psychological Association. https://doi.org/10.1037/14641-005

Calkins, S. D., & Dedmon, S. E. (2010). Physiological and behavioral regulation in two-year-old children with aggressive/destructive behavior problems. *Journal of Abnormal Child Psychology*, *28*, 103–118. https://doi.org/10.1023/A:1005112912906

Eisenberg, N., Spinrad, T. L., & Eggum, N. D. (2010). Emotion-related self-regulation and its relation to children's maladjustment. *Annual Review of Clinical Psychology*, *6*, 495–525. https://doi.org/10.1146/annurev.clinpsy.121208.131208

Forslund, T., Brocki, K. C., Bohlin, G., Granqvist, P., & Eninger, L. (2016). The heterogeneity of attention-deficit/hyperactivity disorder symptoms and conduct problems: Cognitive inhibition, emotion regulation, emotionality, and disorganized attachment. *The British Journal of Developmental Psychology*, *34*(3), 371–387. https://doi.org/10.1111/bjdp.12136

Harley, J. M., Pekrun, R., Taxer, J. L., & Gross, J. J. (2019). Emotion regulation in achievement situations: An integrated model. *Educational Psychologist*, *54*(2), 106–126. https://doi.org/10.1080/00461520.2019.1587297

Hutchinson, L. R., Perry, N. E., & Shapka, J. D. (2021). Assessing young children's self-regulation in school contexts. *Assessment in Education: Principles, Policy & Practice*, *28*(5-6), 545-583. https://doi.org/10.1080/0969594X.2021.1951161

Losenno, K. M., Muis, K. R., Munzar, B., Denton, C. A., & Perry, N. E. (2020). The dynamic roles of cognitive reappraisal and self-regulated learning during mathematics problem solving: A mixed methods investigation. *Contemporary Educational Psychology, 62*. https://doi.org/10.1016/j.cedpsych.2020.101869

Whitebread, D., Coltman, P., Pasternak, D. P., Sangster, C., Grau, V., Bingham, S., ... & Demetriou, D. (2009). The development of two observational tools for assessing metacognition and self-regulated learning in young children. *Metacognition and Learning*, *4*, 63-85. https://doi.org/10.1007/s11409-008-9033-1

Bibliography

Ahmed, W., van der Werf, G., Kuyper, H., & Minnaert, A. (2013). Emotions, self-regulated learning, and achievement in mathematics: A growth curve analysis. *Journal of Educational Psychology*, *105*, 150-161. https://doi.org/10.1037/a0030160

Aldao, A., & Nolen-Hoeksema, S. (2012). When are adaptive strategies most predictive of psychopathology? *Journal of Abnormal Psychology*, *121*(1), 276-281. https://doi.org/10.1037/a0023598

Aldao, A., Sheppes, G., & Gross, J. J. (2015). Emotion regulation flexibility. *Cognitive Therapy and Research*, *39*(3), 263-278. https://doi.org/10.1007/s10608-014-9662-4

Azevedo, R., Harley, J., Trevors, G., Duffy, M., Feyzi-Behnagh, R., Bouchet, F., & Landis, R. (2013). Using trace data to examine the complex roles of cognitive, metacognitive, and emotional self-regulatory processes during learning with multi-agent systems. In *International handbook of metacognition and learning technologies* (pp. 427-449). Springer, New York, NY.

Bandura, A. (1989). Regulation of cognitive processes through perceived self-efficacy. *Developmental Psychology*, 25, 725– 739. https://doi.org/10.1037/0012-1649.25.5.729

Ben-Eliyahu, A., & Bernacki, M. L. (2015). Addressing complexities in self-regulated learning: A focus on contextual factors, contingencies, and dynamic relations. *Metacognition and Learning*, *10*, 1-13. https://doi.org/10.1007/s11409-015-9134-6

Ben-Eliyahu, A., & Linnenbrink-Garcia, L. (2015). Integrating the regulation of affect, behavior, and cognition into self-regulated learning paradigms among secondary and post-secondary students. *Metacognition and Learning*, *10*(1), 15–42. https://doi.org/10.1007/s11409-014-9129-8

Blair, C., Calkins, S., & Kopp, L. (2010). Self-regulation as the interface of emotional and cognitive development: Implications for education and academic achievement. In R. H. Hoyle (Ed.), *Handbook of personality and self-regulation* (pp. 64–90). Wiley Blackwell. https://doi.org/10.1002/9781444318111.ch4

Blair, C., & Diamond, A. (2008). Biological processes in prevention and intervention: the promotion of self-regulation as a means of preventing school failure. *Development and Psychopathology*, *20*(3), 899–911. https://doi.org/10.1017/S0954579408000436

Blair, C., & Razza, R. P. (2007). Relating effortful control, executive function, and false belief understanding to emerging math and literacy ability in kindergarten. *Child Development*, *78*(2), 647-663. https://doi.org/10.1111/j.1467-8624.2007.01019.x

Blankson, A. N., Weaver, J. M., Leerkes, E. M., O'Brien, M., Calkins, S. D., & Marcovitch, S. (2017). Cognitive and emotional processes as predictors of a successful transition into school. *Early Education and Development*, *28*(1), 1-20. https://doi.org/10.1080/10409289.2016.1183434

Blumenfeld, P., Mergendollar, J., & Swarthout, D. (1987). Task as a heuristic for understanding student learning and motivation. *Journal of Curriculum Studies, 19*, 135-148. https://doi.org/10.1080/0022027870190203

Bohn-Gettler, C. M., & Rapp, D. N. (2011). Depending on my mood: Mood-driven influences on text comprehension. *Journal of Educational Psychology, 103*(3), 562–577. https://doi.org/10.1037/a0023458

Bohn, C. M., Roehrig, A. D., & Pressley, M. (2004). The first days of school in the classrooms of two more effective and four less effective primary-grades teachers. *Elementary School Journal*, *104,* 269–287. https://doi.org/10.1086/499753

Bonanno, G. A., & Burton, C. L. (2013). Regulatory flexibility: An individual differences perspective on coping and emotion regulation. *Perspectives on Psychological Science*, *8*(6), 591-612. https://doi.org/10.1177/1745691613504116

Bowlby, J. (1982). Attachment and loss: retrospect and prospect. *American Journal of Orthopsychiatry*, *52*(4), 664-678. https://doi.org/10.1111/j.1939-0025.1982.tb01456.x

Brady, S. T., Hard, B. M., & Gross, J. J. (2018). Reappraising test anxiety increases academic performance of first-year college students. *Journal of Educational Psychology*, *110*(3), 395–406. https://doi.org/10.1037/edu0000219

Bryce, D., Whitebread, D. & Szűcs, D. (2015). The relationships among executive functions, metacognitive skills and educational achievement in 5 and 7-year-old children. *Metacognition and Learning 10*, 181–198. https://doi.org/10.1007/s11409-014-9120-4

Bull, R., & Lee, K. (2014). Executive functioning and mathematics achievement. *Child Development Perspectives*, *8*(1), 36–41. https://doi.org/10.1111/cdep.12059

Butler, D. L. (2021). Enabling educators to become more effective supporters of SRL: Commentary on a special issue. *Metacognition and Learning*, *16*(3), 667-684. https://10.1007/s11409-021-09282-8

Butler, D. L., & Cartier, S. C. (2004). Promoting effective task interpretation as an important work habit: A key to successful teaching and learning. *Teachers College Record*, *106*(9), 1729-1758. https://doi.org/10.1111/j.1467-9620.2004.00403.x

Butler, D. L., & Schnellert, L. (2015). Success for students with learning disabilities: What does self-regulation have to do with it? In T. Cleary (Ed.), *Self-regulated learning interventions with at-risk youth: Enhancing adaptability, performance, and well-being* (pp. 89–111). American Psychological Association.

https://doi.org/10.1037/14641-005

Calkins, S.D., & Dedmon, S.E. (2010). Physiological and behavioral regulation in two-year-old children with aggressive/destructive behavior problems. *Journal of Abnormal Child Psychology*, *28*, 103–118. https://doi.org/10.1023/A:1005112912906

Calkins, S. D., & Fox, N. A. (2002). Self-regulatory processes in early personality development: A multilevel approach to the study of childhood social withdrawal and aggression. *Development and Psychopathology*, *14*(3), 477-498. https://doi.org/10.1017/S095457940200305X

Calkins, S. D., Graziano, P. A., Berdan, L. E., Keane, S. P., & Degnan, K. A. (2008). Predicting cardiac vagal regulation in early childhood from maternal–child relationship quality during toddlerhood. *Developmental Psychobiology: The Journal of the International Society for Developmental Psychobiology*, *50*(8), 751-766. https://doi.org/10.1002/dev.20344

Calkins, S. D., & Marcovitch, S. (2010). Emotion regulation and executive functioning in early development: Integrated mechanisms of control supporting adaptive functioning. In S. D. Calkins & M. A. Bell (Eds.), *Human brain development: Child development at the intersection of emotion and cognition* (pp. 37–57). American Psychological Association. https://doi.org/10.1037/12059-003

Cameron, C. E., & Morrison, F. J. (2011). Teacher activity orienting predicts preschoolers' academic and self-regulatory skills. *Early Education & Development*, *22*(4), 620-648. https://doi.org/10.1080/10409280903544405

Cameron Ponitz, C. E., Rimm-Kaufman, S. E., Brock, L. L., & Nathanson, L. (2009). Early adjustment, gender differences, and classroom organizational climate in first grade.

Elementary School Journal, *110*, 142–162. https://doi.org/10.1086/605470

Carr, M., Alexander, J., & Folds-Bennett, T. (1994). Metacognition and mathematics strategy use. *Applied Cognitive Psychology*, *8*(6), 583-595. https://doi.org/10.1002/acp.2350080605

Chen, F., Curran, P. J., Bollen, K. A., Kirby, J., & Paxton, P. (2008). An empirical evaluation of the use of fixed cutoff points in RMSEA test statistic in structural equation models. *Sociological Methods & Research*, *36*(4), 462-494. https://doi.org/10.1177/0049124108314720

Cleary, T. J., & Zimmerman, B. J. (2004). Self-regulation empowerment program: A school-based program to enhance self-regulated and self-motivated cycles of student learning. *Psychology in the Schools*, *41*(5), 537-550. https://doi.org/10.1002/pits.10177

Cole, P. M., Dennis, T. A., Smith-Simon, K. E., & Cohen, L. H. (2009). Preschoolers' emotion regulation strategy understanding: Relations with emotion socialization and child self-regulation. *Social Development*, *18*(2), 324-352. https://doi.org/10.1111/j.1467-9507.2008.00503.x

Cole, P. M., Lougheed, J. P., & Ram, N. (2018). The development of emotion regulation in early childhood. In P. M. Cole & T. Hollenstein (Eds.), *Emotion Regulation: A matter of time*. (pp. 73–100). Routledge. https://doi.org/10.4324/9781351001328

Compagnoni, M., & Losenno, K. M. (2020). " I'm the Best! Or Am I?": Academic Self-Concepts and Self-Regulation in Kindergarten. *Frontline Learning Research*, *8*(2), 131-152.

Corno, L. (2001). Volitional aspects of self-regulated learning. In B. J. Zimmerman & D. H. Schunk (Eds.), *Self-regulated learning and academic achievement: Theoretical perspectives* (2 ed., pp. 191-225). Mahwah, NJ: Lawrence Erlbaum Associates

Publishers.

Cragg, L., & Gilmore, C. (2014). Skills underlying mathematics: The role of executive function in the development of mathematics proficiency. *Trends in Neuroscience and Education*, *3*(2), 63–68. https://doi.org/10.1016/j.tine.2013.12.001

Davidson, M. C., Amso, D., Anderson, L. C., & Diamond, A. (2006). Development of cognitive control and executive functions from 4 to 13 years: Evidence from manipulations of memory, inhibition, and task switching. *Neuropsychologia*, *44*(11), 2037-2078. https://doi.org/10.1016/j.neuropsychologia.2006.02.006

Davis, E. L., & Levine, L. J. (2013). Emotion regulation strategies that promote learning: Reappraisal enhances children's memory for educational information. *Child Development*, *84*(1), 361–374. https://doi.org/10.1111/j.1467-8624.2012.01836.x

Davis, E., Levine, L., Lench, H.C., & Quas, J. (2010). Metacognitive emotion regulation: children's awareness that changing thoughts and goals can alleviate negative emotions. *Emotion, 10*(4), 498-510. https://doi.org/10.1037/a0018428

Deci, E. L., & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behavior*. New York, NY: Plenum.

Dennis, T., Hong, M., & Solomon, B. (2010). Do the association between exuberance and emotion regulation depend on effortful control? *International Journal of Behavioral Development, 34*. https://doi.org/10.1177/0165025409355514

Dennis, T. A., & Kelemen, D. A. (2009). Preschool children's views on emotion regulation: Functional associations and implications for social-emotional adjustment. *International Journal of Behavioral Development*, *33*(3), 243-252. https://doi.org/10.1177/0165025408098024

Derryberry, D., & Rothbart, M. K. (1997). Reactive and effortful processes in the organization of temperament. *Development and Psychopathology*, *9*(4), 633-652. https://doi.org//10.1017/S0954579497001375

DeVellis, R. F. (2016). *Scale development: Theory and applications* (Vol. 26). Sage Publications.

Diamond, A. (2016). Why assessing and improving executive functions early in life is critical. In J. A. Griffin, P. McCardle, & L. S. Freund (Eds.), *Executive function in preschool-age children: Integrating measurement, neuro-development and translational research* (pp. 11–43). Washington, DC: American Psychological Association.

Diamond, A., Barnett, W. S., Thomas, J., & Munro, S. (2007). Preschool program improves cognitive control. *Science, 318*(5855), 1387-1388. https://doi.org/10.1126/science.1151148

Diamond, A., & Lee, K. (2011). Interventions shown to aid executive function development in children 4 to 12 years old. *Science, 333*(6045), 959-964. https://doi.org//10.1126/science.1204529

Di Leo, I., & Muis, K. R. (2020). Confused, now what? A Cognitive-Emotional Strategy Training (CEST) intervention for elementary students during mathematics problem solving. *Contemporary Educational Psychology*, *62*, 101879. https://doi.org/10.1016/j.cedpsych.2020.101879

Di Leo, I., Muis, K. R., Singh, C., & Psaradellis, C. (2019). Curiosity Confusion? Frustration! The role and sequencing of emotions during mathematics problem solving. *Contemporary Educational Psychology, 58,* 121–137. https://doi.org/10.1016/j.cedpsych.2019.03.001

Douglas, H. P., & LeFevre, J. A. (2018). Exploring the influence of basic cognitive skills on the relation between math performance and math anxiety. *Journal of Numerical Cognition*, *3*(3), 642-666. https://doi.org/10.5964/jnc.v3i3.113

Doyle, W. (1983). Academic work. *Review of Educational Research*, *53*(2), 159-199. https://doi.org/10.3102/00346543053002159

Dunn, K. E., Rakes, G. C., & Rakes, T. A. (2014). Influence of academic self-regulation, critical thinking, and age on online graduate students' academic help-seeking. *Distance Education*, *35*(1), 75–89. https://doi.org/10.1080/01587919.2014.891426

Dweck, C. S. (2002). The development of ability conceptions. In A. Wigfield & J. S. Eccles (Eds.), *Educational psychology*. *Development of Achievement Motivation*, (pp. 57-88). Academic Press. https://doi.org/10.1016/B978-012750053-9/50005-X

Dweck, C. S. (2006). *Mindset: The new psychology of success*. Random house.

Efklides, A., Schwartz, B. L., & Brown, V. (2018). Motivation and affect in self-regulated learning: Does metacognition play a role? In D. H. Schunk & J. A. Greene (Eds.), *Educational psychology handbook series. Handbook of self-regulation of learning and performance* (pp. 64–82). Routledge/Taylor & Francis Group.

Eisenberg, N., Cumberland, A., & Spinrad, T. L. (1998). Parental socialization of emotion. *Psychological Inquiry*, *9*(4), 241-273. https://doi.org/10.1207/s15327965pli0904_1

Eisenberg, N., Fabes, R. A., Nyman, M., Bernzweig, J., & Pinuelas, A. (1994). The relations of emotionality and regulation to children's anger-related reactions. *Child Development*, *65*(1), 109–128. https://doi.org/10.1111/j.1467-8624.1994.tb00738.x

Eisenberg N., & Spinrad T.L. (2004). Emotion-related regulation: Sharpening the definition. *Child Development*, *75*(2), 334–39. https://doi.org/10.1111/j.1467-8624.2004.00674.x

Eisenberg, N., Spinrad, T. L., & Eggum, N. D. (2010). Emotion-related self-regulation and its relation to children's maladjustment. *Annual Review of Clinical Psychology*, *6*, 495–525. https://doi.org/10.1146/annurev.clinpsy.121208.131208

Eisenberg, N., Spinrad, T. L., Fabes, R. A., Reiser, M., Cumberland, A., Shepard, S. A., ... & Thompson, M. (2004). The relations of effortful control and impulsivity to children's resiliency and adjustment. *Child Development*, *75*(1), 25-46. https://doi.org/10.1111/j.1467-8624.2004.00652.x

Eshel, Y., & Kohavi, R. (2003). Perceived classroom control, self-regulated learning strategies, and academic achievement. *Educational Psychology 23*(3), 249-260. https://doi.org/10.1080/0144341032000060093

Fabes, R. A., & Eisenberg, N. (1992). Young children's coping with interpersonal anger. *Child Development*, *63*(1), 116-128. https://doi.org/10.1111/j.1467-8624.1992.tb03600.x

Feldman R. (2015). Mutual influences between child emotion regulation and parent-child reciprocity support development across the first 10 years of life: Implications for developmental psychopathology. *Development and Psychopathology*, *27*(4), 1007–1023. https://doi.org/10.1017/S0954579415000656

Forslund, T., Brocki, K. C., Bohlin, G., Granqvist, P., & Eninger, L. (2016). The heterogeneity of attention-deficit/hyperactivity disorder symptoms and conduct problems: Cognitive inhibition, emotion regulation, emotionality, and disorganized attachment. *The British Journal of Developmental Psychology*, *34*(3), 371–387. https://doi.org/10.1111/bjdp.12136

Frenzel. A.C., Goetz, T., & Stockinger, K. (2024). Emotions and emotion regulation. In P. Schutz & K. R. Muis (Eds.), *Handbook of Educational Psychology*. Routledge.

Fuchs, L. S., & Fuchs, D. (2002). Mathematical problem-solving profiles of students with mathematics disabilities with and without comorbid reading disabilities. *Journal of Learning Disabilities*, *35*(6), 564-574. https://doi.org/10.1177/00222194020350060701

Gilmore, C. K., Göbel, S. M., & Inglis, M. (2018). An introduction to mathematical cognition. New York, NY: Routledge

Gilmore, C., Keeble, S., Richardson, S., & Cragg, L. (2017). The interaction of procedural skill, conceptual understanding and working memory in early mathematics achievement. *Journal of Numerical Cognition*, *3*(2). https://doi.org/10.5964/jnc.v3i2.51

Goetz, T., & Hall, N. C. (2020). Emotion and achievement in the classroom. In J. Hattie & E. M. Anderman (Eds.), *Visible Learning Guide to Student Achievement* (pp. 145-152). Routledge.

Goetz, T., Frenzel, A. C., Pekrun, R., Hall, N. C., & Lüdtke, O. (2007). Between-and within-domain relations of students' academic emotions. *Journal of Educational Psychology*, *99*(4), 715-733. https://doi.org/10.1037/0022-0663.99.4.715

Grau, V., & Whitebread, D. (2012). Self and social regulation of learning during collaborative activities in the classroom: The interplay of individual and group cognition. *Learning and Instruction*, *22*(6), 401-412. https://doi.org/10.1016/j.learninstruc.2012.03.003

Graziano, P. A., Reavis, R. D., Keane, S. P., & Calkins, S. D. (2007). The role of emotion regulation in children's early academic success. *Journal of School Psychology*, *45*(1), 3–19. https://doi.org/10.1016/j.jsp.2006.09.002

Graziano, P. A., Calkins, S. D., & Keane, S. P. (2011). Sustained attention development during the toddlerhood to preschool period: Associations with toddlers' emotion regulation strategies and maternal behavior. *Infant and Child Development*, *20*(6), 389-408. https://doi.org/10.1002/icd.731

Greene, J. A. (2017). *Self-regulation in education*. Routledge.

Greene, J. A., Plumley, R. D., Urban, C. J., Bernacki, M. L., Gates, K. M., Hogan, K. A., ... & Panter, A. T. (2021). Modeling temporal self-regulatory processing in a higher education biology course. *Learning and Instruction*, *72*, 101201. https://doi.org/10.1016/j.learninstruc.2019.04.002

Gross, J. J. (1998). The emerging field of emotion regulation: An integrative review. *Review of General Psychology*, *2*(3), 271-299. https://doi.org/10.1037/1089-2680.2.3.271

Gross, J. J. (2015). Emotion regulation: current status and future prospects. *Psychological Inquiry*, *26*(1), 1-26. https://doi.org/10.1080/1047840X.2014.940781

Gross, J. J., & John, O. P. (2003). Individual differences in two emotion regulation processes: Implications for affect, relationships, and well-being. *Journal of Personality and Social Psychology*, *85*(2), 348. https://doi:10.1037/0022-3514.85.2.348

Gross, J. J., & Thompson, R. A. (2007). Emotion regulation: Conceptual foundations. In J. Gross (Ed.). *Handbook of emotion-regulation* (pp. 3–24). New York, NY: Guilford Publications.

Gullone, E., & Taffe, J. (2012). The emotion regulation questionnaire for children and adolescents (ERQ–CA): A psychometric evaluation. *Psychological Assessment*, *24*(2), 409–417. https://doi:10.1037/a0025777

Gunzenhauser, C., & Suchodoletz, A. V. (2014). Preschoolers' use of suppression influences subsequent self-control but does not interfere with verbal memory. *Learning and*

Individual Differences, *32*, 219–224. https://doi.org/10.1016/j.lindif.2014.03.007

Hadwin, A., Järvelä, S., & Miller, M. (2018). Self-regulation, co-regulation, and shared regulation in collaborative learning environments. *Educational Psychologist, 50*(3), 204-219. https://doi:10.1080/00461520.2015.1075400

Hamre, B. K., & Pianta, R. C. (2001). Early teacher–child relationships and the trajectory of children's school outcomes through eighth grade. *Child Development*, *72*(2), 625–638. https://doi.org/10.1111/1467-8624.00301

Hamre, B. K, & Pianta, R. C., (2005). Can instructional and emotional support in the first-grade classroom make a difference for children at risk of school failure? *Child Development 76*(5), 949–967. https://doi.org/10.1111/j.1467-8624.2005.00889.x

Harley, J. M., Jarrell, A., & Lajoie, S. P. (2019a). Emotion regulation tendencies, achievement emotions, and physiological arousal in a medical diagnostic reasoning simulation. *Instructional Science, 47*, 151-180. https://10.1007/s11251-018-09480-z

Harley, J. M., Pekrun, R., Taxer, J. L., & Gross, J. J. (2019b). Emotion regulation in achievement situations: An integrated model. *Educational Psychologist*, *54*(2), 106–126. https://doi.org/10.1080/00461520.2019.1587297

Hillyer, J., & Ley, T. C. (1996). Portfolios and second graders' self-assessments of their development as writers. *Reading Improvement, 133*(3), 148-159.

Howse, R. B., Calkins, S. D., Anastopoulos, A. D., Keane, S. P., & Shelton, T. L. (2003). Regulatory contributors to children's kindergarten achievement. *Early Education and Development*, *14*(1), 101-120. https://doi.org/10.1207/s15566935eed1401_7

Hoyle, R. H., & Dent, A. L. (2018). Developmental trajectories of skills and abilities relevant for self-regulation of learning and performance. In D. H. Schunk & J. A. Greene (Eds.), *Educational psychology handbook series. Handbook of self-regulation of learning and performance* (pp. 49–63). Routledge/Taylor & Francis Group.

Huang, C. (2011). Achievement goals and achievement emotions: A meta-analysis. *Educational Psychology Review*, *23*, 359-388. https://doi.org/10.1007/s10648-011-9155-x

Hudson, A., & Jacques, S. (2014). Put on a happy face! Inhibitory control and socioemotional knowledge predict emotion regulation in 5-to 7-year-olds. *Journal of Experimental Child Psychology*, *123*, 36-52. https://doi.org/10.1016/j.jecp.2014.01.012

Hutchinson, L. R. (2013). Young children's engagement in self-regulation at school (Unpublished doctoral dissertation). University of British Columbia, British Columbia. https://doi:10.14288/1.0073717

Hutchinson, L. R., & Perry, N. E. (2014). Development and Validation of the SRISI. Manuscript submitted for publication.

Hutchinson, L. R., Perry, N. E., & Shapka, J. D. (2021). Assessing young children's self-regulation in school contexts. *Assessment in Education: Principles, Policy & Practice*, *28*(5-6), 545-583. https://doi.org/10.1080/0969594X.2021.1951161

Hutchinson, L. R., Perry, N. E., Yee, N., Restrepo, Dantzer, B., & Lo (2015, August). Demographic variables in children's self-regulation. Poster session presented at the American Psychological Association Annual Conference, Toronto. ON

IBM Corp. Released 2021. IBM SPSS Statistics for Macintosh, Version 28.0. Armonk, NY: IBM Corp

Jacobse, A. E., & Harskamp, E. G. (2012). Towards efficient measurement of metacognition in mathematical problem solving. *Metacognition and Learning*, *7*(2), 133-149. https://doi.org/10.1007/s11409-012-9088-x

Jang, H., Reeve, J., & Deci, E. L. (2010). Engaging students in learning activities: It is not autonomy support or structure, but autonomy support and structure. *Journal of Educational Psychology*, 102(3), 588–600. https://doi.org/10.1037/a0019682

Järvenoja, H., & Järvelä, S. (2009). Emotion control in collaborative learning situations: Do students regulate emotions evoked by social challenges. *British Journal of Educational Psychology*, *79*, 463-481. https://doi.org/10.1348/000709909X402811

Kalokerinos, E. K., Résibois, M., Verduyn, P., & Kuppens, P. (2017). The temporal deployment of emotion regulation strategies during negative emotional episodes. *Emotion*, *17*(3), 450-458. https://doi.org/10.1037/emo0000248

Karabenick, S. A., & Sharma, R. (2012). Seeking academic assistance as a strategic learning resource. In *Student motivation, cognition, and learning* (pp. 205-228). Routledge.

Kashdan, T. B., & Rottenberg, J. (2010). Psychological flexibility as a fundamental aspect of health. *Clinical Psychology Review*, *30*(7), 865-878. https://doi.org/10.1016/j.cpr.2010.03.001

Kenny, D. A., Kaniskan, B., & McCoach, D. B. (2015). The performance of RMSEA in models with small degrees of freedom. *Sociological Methods & Research*, *44*(3), 486-507. https://doi.org/10.1177/0049124114543236

Koole, S. L., & Aldao, A. (2016). The self-regulation of emotion: Theoretical and empirical advances. In K. D. Vohs, & R. F. Baumeister (Eds.), *Handbook of self-regulation* (3rd ed., pp. 101-112). New York: Guilford.

Koole, S. L., & Veenstra, L. (2015). Does emotion regulation occur only inside people's heads? Toward a situated cognition analysis of emotion-regulatory dynamics. *Psychological Inquiry*, *26*(1), 61-68. https://doi.org/10.1080/1047840X.2015.964657

Kopp, C. B. (1982). Antecedents of self-regulation: A developmental perspective. *Developmental Psychology*, *18*(2), 199–214. https://doi.org/10.1037/0012-1649.18.2.199

Kopp, C. B. (1989). Regulation of distress and negative emotions: A developmental view. *Developmental Psychology*, *25*(3), 343–354. https://doi.org/10.1037/0012-1649.25.3.343

Kuhn, D. (1999). *Metacognitive development*. In L. Balter & C. S. Tamis-Lemonda (Eds.), Child psychology. *A handbook of contemporary issues* (pp. 259–286). Philadelphia: Psychology Press.

Leerkes, E. M., Supple, A. J., O'Brien, M., Calkins, S. D., Haltigan, J. D., Wong, M. S., & Fortuna, K. (2015). Antecedents of maternal sensitivity during distressing tasks: Integrating attachment, social information processing, and psychobiological perspectives. *Child Development*, *86*(1), 94-111. https://doi.org/10.1111/cdev.12288

Lillard, A. S. (2005). *Montessori: The science behind the genius*. New York, NY: Oxford University Press.

Linnenbrink, E. A. (2005). The dilemma of performance-approach goals: The use of multiple goal contexts to promote students' motivation and learning. *Journal of Educational Psychology*, *97*(2), 197-213. https://doi.org/10.1037/0022-0663.97.2.197

Loderer, K., & Pekrun, R. (2019, August). Regulation of achievement emotions: Towards a theory-driven program of research. Presentation at the European Association for Research on Learning and Instruction Conference, Aachen, GR

Lodewyk, K. R., Winne, P. H., & Jamieson-Noel, D. L. (2009). Implications of task structure on self-regulated learning and achievement. *Educational Psychology*, *29*(1), 1-25.

https://doi.org/10.1080/01443410802447023

Lodewyk, K. R., & Winne, P. H. (2005). Relations among the structure of learning tasks, achievement, and changes in self-efficacy in secondary students. *Journal of Educational Psychology*, *97*(1), 3. https://doi.org/10.1037/0022-0663.97.1.3

Loe, I. M., & Feldman, H. M. (2007). Academic and educational outcomes of children with ADHD. *Journal of Pediatric Psychology*, *32*(6), 643-654. https://doi.org/10.1093/jpepsy/jsl054

Losenno, K. M., Muis, K. R., Munzar, B., Denton, C. A., & Perry, N. E. (2020). The dynamic roles of cognitive reappraisal and self-regulated learning during mathematics problem solving: A mixed methods investigation. *Contemporary Educational Psychology, 62*. https://doi.org/10.1016/j.cedpsych.2020.101869

McCabe, L. A., Cunnington, M., & Brooks-Gunn, J. (2004). The development of self-regulation in young children: Individual characteristics and environmental contexts. In R. F. Baumeister & K. D. Vohs (Eds.), *Handbook of self-regulation: Research, theory, and applications* (p. 340–356). The Guilford Press.

McCardle, L., & Hadwin, A. F. (2015). Using multiple, contextualized data sources to measure learners' perceptions of their self-regulated learning. *Metacognition and Learning*, *10*(1), 43–75. https://doi.org/10.1007/s11409-014-9132-0

McClelland, M. & Cameron, C. (2011). Self-regulation and academic achievement in elementary school children. *New Directions for Child and Adolescent Development*, *2011*(133), 29-44. https://doi.org/10.1002/cd.302

McKinnon, R. D., & Blair, C. (2018). Does early executive function predict teacher–child relationships from kindergarten to second grade? *Developmental psychology*,*54*(11),

2053. https://doi.org/10.1037/dev0000584

McRae, K., & Gross, J. J. (2020). Emotion regulation. *Emotion*, *20*(1), 1–9. https://doi.org/http://dx.doi.org/10.1037/emo0000703

McRae, K., Misra, S., Prasad, A. K., Pereira, S. C., & Gross, J. J. (2011). Bottom-up and top-down emotion generation: Implications for emotion regulation. *Social Cognitive and Affective Neuroscience*, *7*, 253–262. https://doi.org/10.1093/scan/nsq103

McWilliam, R. A., Scarborough, A. A., & Kim, H. (2003). Adult interactions and child engagement. *Early Education and Development*, *14*(1), 7-28. https://doi.org/10.1207/s15566935eed1401_2

Meinhardt, J., & Pekrun, R. (2003). Attentional resource allocation to emotional events: An ERP study. *Cognition and Emotion*, *17*(3), 477-500. https://doi.org/10.1080/02699930244000039

Meyers, L. S., Gamst, G., & Guarino, A. J. (2016). Applied multivariate research: Design and interpretation (3rd ed.). Thousand Oaks, CA: Sage.

Michalsky, T. (2021). Preservice teachers' professional vision for and capacity to teach self-regulated learning: Effects of scaffolding level. *Teachers College Record*, *122*(3), 1-48. https://doi.org/10.1007/s11409-020-09251-7

Mikulincer, M., Shaver, P. R., & Pereg, D. (2003). Attachment theory and affect regulation: The dynamics, development, and cognitive consequences of attachment-related strategies. *Motivation and Emotion*, *27*(2), 77-102. https://doi.org/10.1023/A:1024515519160

Ministère de l'éducation, du loisir et du sport. (2009). Start your engines! Situational problem for Elementary Cycle Three—Year One [Reference document and teacher's guide].

Quebec, Canada: Author.

Ministère de l'Éducation et Enseignement Supérieur. (2018). The Quebec curriculum Grades 1–6: Mathematics, science, and technology [Program of studies]. Retrieved from http://www.education.gouv.qc.ca/fileadmin/site_web/documents/education/jeunes/pfeq/PFEQ_mathematique-primaire_EN.pdf.

Miyake, A., & Friedman, N. P. (2012). The nature and organization of individual differences in executive functions: Four general conclusions. *Current Directions in Psychological Science*, *21*(1), 8–14. https://doi.org/10.1177/0963721411429458

Montague, M. (2008). Self-regulation strategies to improve mathematical problem solving for students with learning disabilities. *Learning Disability Quarterly*, *31*(1), 37-44. https://doi.org/10.2307/30035524

Muis, K. R. (2007). The role of epistemic beliefs in self-regulated learning. *Educational Psychologist*, *42*(3), 173–190. https://doi.org/10.1080/00461520701416306

Muis, K. R., Chevrier, M., & Singh, C. A. (2018). The role of epistemic emotions in personal epistemology and self-regulated learning. *Educational Psychologist*, *53*(3), 165-184. https://doi.org/10.1080/00461520.2017.1421465

Muis, K. R., & Franco, G. M. (2009). Epistemic beliefs: Setting the standards for self-regulated learning. *Contemporary Educational Psychology*, *34*(4), 306-318. https://doi.org/10.1016/j.cedpsych.2009.06.005

Muis, K. R., Psaradellis, C., Lajoie, S. P., Di Leo, I., & Chevrier, M. (2015). The role of epistemic emotions in mathematics problem solving. *Contemporary Educational Psychology*, 42, 172–185. https://doi.org/10.1016/j.cedpsych.2015.06.003

Muis, K. R., Psaradellis, C., Chevrier, M., Di Leo, I., & Lajoie, S. P. (2016). Learning by preparing to teach: Fostering self-regulatory processes and achievement during complex mathematics problem solving. *Journal of Educational Psychology*, *108*, 474–492. https://doi.org/10.1037/edu0000071.

Munzar, B., Muis, K. R., Denton, C. A., & Losenno, K. M. (2020). Elementary students' cognitive and affective responses to impasses during mathematics problem-solving. *Journal of Educational Psychology*. https://doi.org/10.1037/edu0000460

Muthén, L. K., & Muthén, B. O. (2017). *Mplus User's Guide* (8th ed.). Los Angeles, CA: Muthén & Muthén.

Nowacek, E. J., McKinney, J. D., & Hallahan, D. P. (1990). Instructional behaviors of more and less effective beginning regular and special educators. *Exceptional Children, 57*, 140–149.

Obergriesser, S., & Stoeger, H. (2020). Students' emotions of enjoyment and boredom and their use of cognitive learning strategies–How do they affect one another? *Learning and Instruction*, *66*, 101285. https://doi.org/10.1016/j.learninstruc.2019.101285

Pekrun, R. (2018). Control-value theory: A social-cognitive approach to achievement emotions. In G. A. D. Liem & D. M. McInerney (Eds.), *Big theories revisited 2: A volume of research on sociocultural influences on motivation and learning* (pp. 162-190). Charlotte: Information Age Publishing. https://doi.org/10.4236/me.2018.9505

Pekrun, R., Goetz, T., Titz, W., & Perry, R. P. (2002). Academic emotions in students' self- regulated learning and achievement: A program of qualitative and quantitative research. *Educational Psychologist*, 37(2), 91–105. https://doi.org/10.1207/S15326985EP3702_4

Pekrun, R., Lichtenfeld, S., Marsh, H.W., Murayama, K., & Goetz, T. (2017). Achievement emotions and academic performance: longitudinal models of reciprocal effects. *Child Development*, *88*(5), 1653-1670. https://doi.org/10.1111/cdev.12704

Perry, N. B., & Calkins, S. D. (2018). A biopsychosocial perspective on the development of emotion regulation across childhood. In *Emotion regulation* (pp. 3-30). Routledge.

Perry, N. E. (1998). Young children's self-regulated learning and contexts that support it. *Journal of Educational Psychology*, *90*(4), 715. https://doi.org/10.1037/0022-0663.90.4.71

Perry, N. E. (2013). Understanding classroom processes that support children’s self-regulation of learning [Monograph]. British Journal of Educational Psychology, Monograph Series II: Psychological Aspects of Education – Current Trends, 10, 45–68.

Perry, N. E., Brenner, C. A., & MacPherson, N. (2015). Using teacher learning teams as a framework for bridging theory and practice in self-regulated learning. In T. Cleary (Ed.), *Self-regulated learning interventions with at-risk youth: Enhancing adaptability, performance, and well-being* (pp. 229–250). American Psychological Association. https://doi.org/10.1037/14641-011

Perry, N. E., Hutchinson, L. R., Yee, N., & Määttä, E. (2018). Advances in understanding young children’s self-regulation of learning. In D. Schunk, & J. Greene (Eds.). *Handbook of self- regulated learning and performance* (pp. 457–472). (2nd ed.). New York: Routledge. https://doi.org/10.4324/9781315697048-29

Perry, N. E., Lisaingo, S., Yee, N., Parent, N., Wan, X., & Muis, K. (2020). Collaborating with teachers to design and implement assessments for self-regulated learning in the context of authentic classroom writing tasks. *Assessment in Education: Principles, Policy & Practice*, *27*(4), 416-443. https://doi.org/10.1080/0969594X.2020.1801576

Perry, N. E., Mazabel, S., Dantzer, B., & Winne, P. (2018). Supporting self-regulation and self-determination in the context of music education. In G. A. D. Liem & D. M. McInerney (Eds.), *Big theories revisited 2: A volume of research on sociocultural influences on motivation and learning* (pp. 295-318). (2nd ed.). Information Age Press.

Perry, N. E., Mazabel, S., & Yee, N. (2020b). Using self-regulated learning to support students with learning disabilities in classrooms. In *Handbook of educational psychology and students with special needs* (pp. 292-314). Routledge.

Perry, N. E., Phillips, L., & Dowler, J. (2004). Examining features of tasks and their potential to promote self-regulated learning. *Teachers College Record, 106*(9), 1854-1878.

Perry, N. E., Phillips, L., & Hutchinson, L. R. (2006). Mentoring student teachers to support self-regulated learning. *Elementary School Journal, 106*(3), 237-254.

Perry, N. E., & VandeKamp, K. O. (2000). Creating classroom contexts that support young children's development of self-regulated learning. *International Journal of Educational Research, 33*, 821-843. https://doi.org/10.1016/S0883-0355(00)00052-5

Pierro, A., Presaghi, F., Higgins, T. E., & Kruglanski, A. W. (2009). Regulatory mode preferences for autonomy supporting versus controlling instructional styles. *British Journal of Educational Psychology*, *79*(4), 599-615. https://doi.org/10.1348/978185409X412444

Raffaelli, M., Crockett, L. J., & Shen, Y. L. (2005). Developmental stability and change in self-regulation from childhood to adolescence. *The Journal of Genetic Psychology*, *166*(1), 54-76. https://doi.org/10.3200/GNTP.166.1.54-76

Reeve, J. (2006). Teachers as facilitators: What autonomy-supportive teachers do and why their students benefit. *Elementary School Journal*, 106(3), 225-236. https://doi.org/10.1086/501484

Reeve, J., Ryan, R. M., & Deci, E. L. (2018). Sociocultural influences on student motivation as viewed through the lens of self-determination theory. In G. A. D. Liem & D. M. McInerney (Eds.), *Big theories revisited 2: A volume of research on sociocultural influences on motivation and learning* (pp. 15–40). Information Age Press

Richards, J. M., & Gross, J. J. (2000). Emotion regulation and memory: The cognitive costs of keeping one's cool. *Journal of Personality and Social Psychology, 79*(3), 410. https://doi.org/10.1037/0022-3514.79.3.410

Richter, T., & Schmid, S. (2010). Epistemological beliefs and epistemic strategies in self-regulated learning. *Metacognition Learning*, 5, 47–65. https://doi.org/10.1007/s11409-009-9038-4

Rimm-Kaufman, S. E., Curby, T. W., Grimm, K. J., Nathanson, L., & Brock, L. L. (2009). The contribution of children's self-regulation and classroom quality to children's adaptive behaviors in the kindergarten classroom. *Developmental Psychology, 45*(4), 958–972. https://doi.org/10.1037/a0015861

Robinson, K. M., & Dubé, A. K. (2013). Children's additive concepts: promoting understanding and the role of inhibition. *Learning and Individual Differences*, 23, 101–107. https://doi.org/10.1016/j.lindif.2012.07.016

Rottweiler, A.-L., Taxer, J. L., & Nett, U. E. (2018). Context matters in the effectiveness of emotion regulation strategies. *American Education Research Association Open, 4*(2), 233285841877884. https://doi.org/10.1177/2332858418778849

Rudasill, K. M., & Rimm-Kaufman, S. E. (2009). Teacher–child relationship quality: The roles of child temperament and teacher–child interactions. *Early Childhood Research Quarterly, 24*(2), 107–120. https://doi.org/10.1016/j.ecresq.2008.12.003

Ryan, K. E., Ryan, A. M., Arbuthnot, K., & Samuels, M. (2007). Students' motivation for standardized math exams. *Educational Researcher*, *36*(1), 5-13. https://doi.org/10.3102/0013189X0629

Sameroff, A. (2010). A unified theory of development: A dialectic integration of nature and nurture. *Child Development*, *81*(1), 6-22. https://doi.org/10.1111/j.1467-8624.2009.01378.x

Scherer, K. R., & Moors, A. (2019). The emotion process: Event appraisal and component differentiation. *Annual Review of Psychology*, *70*, 719-745. https://doi.org/https://doi.org/10.1146/annurev-psych-122216011854

Schmeichel, B. J., Volokhov, R. N., & Demaree, H. A. (2008). Working memory capacity and the self-regulation of emotional expression and experience. *Journal of Personality and Social Psychology*, *95*(6), 1526-1540. https://doi.org/10.1037/a0013345

Schneider, W., & Artelt, C. (2010). Metacognition and mathematics education. *International Journal of Mathematics Education*, *42*(2), 149-161. https://doi.org/10.1007/s11858-010-0240-2

Schoenfeld, A. (1982). Some thoughts on problem-solving research and mathematics education. In F. K. Lester & J. Garofalo (Eds.), *Mathematical problem solving: Issues and research* (pp. 27-37). Philadelphia, PA: The Franklin Institute Press.

Schunk, D. H., & Zimmerman, B. J. (2007). Influencing children's self-efficacy and self-regulation of reading and writing through modeling. *Reading & Writing Quarterly: Overcoming Learning Difficulties*, *23*(1), 7-25. https://doi.org/10.1080/10573560600837578

Schutz, P. A., & Davis, H. A. (2000). Emotions and self-regulation during test taking. *Educational Psychologist*, *35*(4), 243-256. https://doi.org/10.1207/S15326985EP3504_03

Shafir, R., Schwartz, N., Blechert, J., & Sheppes, G. (2015). Emotional intensity influences pre-implementation and implementation of distraction and reappraisal. *Social Cognitive and Affective Neuroscience*, *10*, 1329–1337. https://doi.org/10.1093/scan/nsv022

Sheppes, G. (2020). Transcending the "good & bad" and "here & now" in emotion regulation: Costs and benefits of strategies across regulatory stages. In *Advances in experimental social psychology* (Vol. 61, pp. 185-236). Academic Press.

Sheppes, G., & Levin, Z. (2013). Emotion regulation choice: selecting between cognitive regulation strategies to control emotion. *Frontiers in Human Neuroscience*, *7*, 179. https://doi.org/10.3389/fnhum.2013.00179

Sheppes, G., & Meiran, N. (2007). Better late than never? On the dynamics of online regulation of sadness using distraction and cognitive reappraisal. *Personality and Social Psychology Bulletin*, *33*(11), 1518-1532. https://doi.org/10.1177/0146167207305537

Sheskin, D. J. (2004). *Handbook of parametric and nonparametric statistical procedures* (4th ed.). Boca Raton, FL: Chapman & Hall/ CRC.

Stefanou, C. R., Perencevich, K. C., DiCintio, M., & Turner, J. C. (2004). Supporting autonomy in the classroom: Ways teachers encourage student decision making and ownership. *Educational Psychologist, 39*, 97-110. https://doi.org/10.1207/s15326985ep3902_2

Stipek, D. J. (1981). Children's perceptions of their own and their classmates' ability. *Journal of Educational Psychology, 73*(3), 404-410.

Strain, A. C., & D'Mello, S. K. (2015). Affect regulation during learning: The enhancing effect of cognitive reappraisal. *Applied Cognitive Psychology, 29*(1), 1–19.

https://doi.org/10.1002/acp.3049

Suri, G., Whittaker, K., & Gross, J. J. (2015). Launching reappraisal: It's less common than you might think. *Emotion*, *15*(1), 73–77. https://doi.org/10.1037/emo0000011

Tabachnick, B. G., & Fidell, L. S. (2013). *Using multivariate statistics* (6th ed.). Boston, MA: Allyn Bacon.

Throndsen, I. (2011). Self-regulated learning of basic arithmetic skills: A longitudinal study. *British Journal of Educational Psychology*, *81*(4), 558-578. https://doi.org/10.1348/2044-8279.002008

Tice, M. D., Baumeister, R. F., & Zhang, L. (2004). The role of emotion in self-regulation: Differing roles of positive and negative emotion. In P. Philippot & R. S. Feldman (Eds.), *The regulation of emotion* (pp. 213-226). Mahwah, NJ: Lawrence Erlbaum Associates.

Turner, J. C. (1995). The influence of classroom contexts on young children's motivation for literacy. *Reading Research Quarterly*, *30*(3), 410-441. https://doi.org/10.2307/747624

Usher, E. L., & Schunk, D. H. (2018). *Social cognitive theoretical perspective of self- regulation*. In D. H. Schunk, & J. A. Greene (Eds.). Educational psychology handbook series. Handbook of self-regulation of learning and performance (pp. 19–35). Routledge/ Taylor & Francis Group. https://doi.org/10.4324/9781315697048-2

van Grinsven, L., & Tillema, H. (2006). Learning opportunities to support student self-regulation: Comparing different instructional formats. *Educational Research*, *48*(1), 77-91. https://doi.org/10.1080/00131880500498495

van Loon, M. H., Bayard, N. S., Steiner, M., & Roebers, C. M. (2021). Connecting teachers' classroom instructions with children's metacognition and learning in elementary school. *Metacognition and Learning*, *16*, 623-650.

https://doi.org/10.1007/s11409-020-09248-2

Vand der Stel, M., Veenman, M. V., Deelen, K., & Haenen, J. (2010). The increasing role of metacognitive skills in math: A cross-sectional study from a developmental perspective. *Mathematics Education, 42*(2), 219- 229. https://doi.org/10.1007/s11858-009-0224-2

Veenman, M. V. J., & Spaans, M. A. (2005). Relation between intellectual and metacognitive skills: Age and task differences. *Learning and Individual Differences, 15*(2), 159–176. https://doi.org/10.1016/j.lindif.2004.12.001

Vernon-Feagans, L., Willoughby, M., & Garrett-Peters, P. (2016). Predictors of behavioral regulation in kindergarten: Household chaos, parenting, and early executive functions. *Developmental Psychology*, *52*(3), 430. https://doi.org/10.1037/dev0000087

Verschaffel, L., Depaepe, F., & Van Dooren, W. (2015). Individual differences in word problem solving. In R. Cohen Kadosh & A. Dowker (Eds.), *The Oxford Handbook of Numerical Cognition* (pp. 953–976). Oxford: Oxford University Press.

Vilenius-Tuohimaa, P. M., Aunola, K., & Nurmi, J. E. (2008). The association between mathematical word problems and reading comprehension. *Educational Psychology, 28*(4), 409-426. https://doi.org/10.1080/01443410701708228

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

Walker, J. M. T. (2008). Looking at teaching practices through the lens of parenting style. *The Journal of Experimental Education,76*(2), 218-240. https://doi.org/10.3200/JEXE.76.2.218-240

Webb, T. L., Miles, E., & Sheeran, P. (2012). Dealing with feeling: A meta-analysis of the effectiveness of strategies derived from the process model of emotion regulation.

Psychological Bulletin, *138*(4), 775–808. https://doi.org/10.1037/a0027600

Wentzel, K. R. (2002). Are effective teachers like good parents? Teaching styles and student adjustment in early adolescence. *Child Development, 73,* 287-301. https://doi.org/10.1111/1467-8624.00406

Wentzel, K. R. (2004). Understanding classroom competence: The role of social-motivational and self-Processes. In R. V. Kail (Ed.), *Advances in child development and behavior, Vol. 32* (p. 213–241). Elsevier Academic Press.

Whitebread, D., Bingham, S., Grau, V., Pino-Pasternak, D., & Sangster, C. (2007). Development of metacognition and self-regulated learning in young children: Role of collaborative and peer-assisted learning. *Journal of Cognitive Education and Psychology, 6*, 433-455. https://doi.org/10.1891/194589507787382043

Whitebread, D., Coltman, P., Pasternak, D. P., Sangster, C., Grau, V., Bingham, S., ... & Demetriou, D. (2009). The development of two observational tools for assessing metacognition and self-regulated learning in young children. *Metacognition and Learning, 4,* 63-85. https://doi.org/10.1007/s11409-008-9033-1

Winne, P.H. (2017). Theorizing and researching levels of processing in self-regulated learning. *British Journal of Educational Psychology, 88,* 9-20. https://doi.org/10.1111/bjep.12173

Winne, P. H. (2018). Cognition and metacognition within self-regulated learning. In D. H. Schunk & J. A. Greene (Eds.), *Handbook of self-regulation of learning and performance* (2nd ed.). New York: Routledge.

Winne, P. H., & Hadwin, A. F. (1998). Studying as self-regulated learning. In D. J. Hacker, J. Dunlosky, & A. C. Graesser (Eds.), *Metacognition in educational theory and practice* (pp. 277–304). Hillsdale: Erlbaum.

Winne, P. H., & Perry, N. E. (2000). Measuring self-regulated learning. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 531–566). Academic Press. https://doi.org/10.1016/B978-012109890-2/50045-7

Wolters, C. A. (2003). Regulation of motivation: Evaluating an underemphasized aspect of self-regulated learning. *Educational Psychologist*, *38*(4), 189–205. https://doi.org/10.1207/s15326985ep3804_1

Yeniad, N., Malda, M., Mesman, J., van IJzendoorn, M. H., & Pieper, S. (2013). Shifting ability predicts math and reading performance in children: a meta-analytical study. *Learning and Individual Differences*, 23,1–9. https://doi.org/10.1016/j.lindif.2012.10.004

Zachariou, A., & Whitebread, D. (2019). Developmental differences in young children's self-regulation. *Journal of Applied Developmental Psychology*, *62*, 282-293. https://doi.org/10.1016/j.appdev.2019.02.002

Zhao, X., Lynch, J. G., & Chen, Q. (2010). Reconsidering Baron and Kenny: Myths and Truths about Mediation Analysis. *Journal of Consumer Research*, *37*(2), 197–206. https://doi.org/10.1086/651257

Zimmerman, B. J. (2000). Attaining self-regulation: a social cognitive perspective. In M. Boekaerts, P. R. Pintrich & M. Zeidner (Eds), *Handbook of Self-regulation*. San Diego, CA: Academic Press.

Zimmerman, B. J. (2008). Investigating self-regulation and motivation: Historical background, methodological developments, and future prospects. *American Educational Research Journal*, *45*(1), 166–183. https://doi.org/10.3102/0002831207312909

Zimmerman, B. J. (2013). Theories of self-regulated learning and academic achievement: An overview and analysis. In B. J. Zimmerman & D. H. Shunk (Eds.) *Self-regulated learning* *and academic achievement*, (pp. 1-36). (2nd ed.) Routledge.

Zimmerman, B. J., & Schunk, D. H. (2011). Self-regulated learning and performance: An introduction and an overview. In D. H. Schunk & B. J. Zimmerman (Eds.) *Handbook of self-regulation of learning and performance*, (pp. 15-26). Routledge. https://doi.org/10.4324/9780203839010

Appendix A

Informed Consent

McGill

Department of Educational & Counselling Psychology
Département de psychopédagogie et de counseling

Faculty of Education
McGill University
3700 McTavish
Montreal, Quebec, Canada H3A 1Y2

Faculté des sciences de l'éducation
Université McGill
3700 rue McTavish
Montréal (Québec) Canada H3A 1Y2

Tel/Tél : (514) 398-4241
Fax/Télécopieur: (514) 398-6968
www.mcgill.ca/edu-ecp

Dear Parent/Legal Tutor,

I am a professor in the Department of Educational and Counselling Psychology at McGill University. My areas of expertise include learning and motivation across the lifespan. I am conducting a multi-year research study in collaboration with Teacher (Grade 3), Teacher (Grade 4), Teacher (Grade 5) and Teacher (Grades 6) at School, and we would like to ask your permission to have your child participate. All children from Grades 3 through 6 are invited to participate. This study began in May 2017 and will continue until June 2019. Children in Grade 3 who sign up this September 2017 may participate until the end of Grade 4. Children in Grade 4 may participate until the end of Grade 5. Those in Grade 5 may participate until the end of Grade 6, and those in Grade 6 may participate this year. The purpose of this research is to examine how student characteristics (achievement, motivation, emotion and behavior) and features of classroom contexts (tasks, instructional practices, interpersonal interactions) relate to self-regulated learning through the elementary grades. "Self-regulated" describes individuals who control their thoughts and actions to achieve goals and respond productively in their environment. Specifically, we are interested in understanding: (a) how children's self-regulated learning responds to variations in classroom experiences across time and contexts; and, (b) how teachers' instructional practices support self-regulated learning.

The purpose of this research is to understand how children's classroom experiences help them develop strategies for learning and problem-solving in mathematics. For teachers, the information that we gather from this study may help to inform mathematics instruction designed to better meet the needs of all students. For students, they may learn how to better regulate their learning and emotions, which may lead to better learning outcomes in mathematics.

What would your child have to do?

For the 2017-2018 and 2018-2019 academic years, your child will be asked to participate in two sessions – one in October, and one in May. Before the session begins, your child will respond to items used to measure his or her value for learning mathematics, and confidence in learning and problem-solving in mathematics. Then, he or she will be given a mathematics problem (one used in the regular curriculum). Your child will work on the mathematics problem during regular class time and his/her thought processes will be audio-recorded. After completing the mathematics problem, your child will then complete a questionnaire that will measure his or her emotions experienced during problem-solving. Performance on the mathematics problem will also be measured. These sessions will occur during regularly scheduled class activities and will take no more than 1 hour.

Moreover, for each year of the study, we will collect:

1. Teachers' ratings of children developing self-regulation: Your child's teacher will respond to questions about how your child approaches learning.
2. Teachers' descriptions of their classroom contexts: Your child's teacher will describe her classroom context by responding to questions about how she provides opportunities for children to develop self-regulated learning in her classrooms.
3. Classroom observations: My research assistants and I will observe your child's classroom two times each year (October and May). These observations help us understand how different teachers implement activities that support self-regulation, and how students take up these opportunities on a day-to-day basis.

Other Important Information

First, in all cases, your child's responses will be kept confidential. Confidentiality is protected by assigning a random identification number to each child. This number will be stored in a file separate from the information used to analyze the results. The audio-recording of your child's thought processes while completing each problem will be heard only by the research team. All information and audio files will be kept in a locked room that is accessible only to the research team. Participation in this study is completely voluntary on the part of your child. We expect that students who participate in this study will benefit given that they will have the opportunity to further develop their numeracy skills through practice. Moreover, to compensate your child for his or her time, your child will receive an iTunes gift card for $10 for each year that he or she participates.

Your child may withdraw from the study at any time for any reason. Moreover, participating (or not participating) in this study will not in any way affect his or her regular classroom activities and will not negatively influence his or her grades. Given that this study will be conducted during regularly scheduled activities, the students who do not consent will be doing the same thing as those who do consent. We will simply not use their information for the study. Risks to your child are minimal and should be no greater than those associated with everyday classroom activities. The students will be informed of all aspects of the study before they participate, as described here in the consent form. We will gladly answer any questions and address any concerns they may have. We plan to publish the results of the study in journals designed for teachers and researchers. No reference will be made to the school or to your child in written or oral materials that could link them to this study. All information will be stored in a locked facility at McGill University for at least five years after the completion of the study. After this time, all information gathered will be destroyed. If you have any questions or concerns about this research, you may contact Dr. Krista Muis at (514) 398-3445. If you have any concerns regarding ethics, please contact the Ethics Officer, Lynda McNeil at (514) 398-6831.

To ensure the study is being conducted properly, authorized individuals such as a member of the Research Ethics board, may have access to your child's information. By signing this consent form, you are allowing such access. Please sign below if you have read the above information and consent to participate in this study. Agreeing to participate in this study does not waive any of your rights or release the researchers from their responsibilities. A copy of this consent form will be given to you and the researcher will keep a copy.

Thank you for your co-operation,

Krista R. Muis, PhD
Associate Professor and Canada Research Chair
Faculty of Education, McGill University

Yes. I, __________________________________ (Parent/ Legal Tutor), give permission for my child ________________________ (name of child) to participate in all research aspects as described above.

I give permission to audio-record my child while completing the tasks. c yes c no

Signature of Parent/Legal Tutor: _____________________________

Date: _____/_________/_________
Day Month Year

Birth date of child: _____/_________/_________
Day Month Year

No. I, __________________________________ (Parent/ Legal Tutor), do NOT give my child ________________________ (name of child) permission to participate in this research.

Informed Assent

Dear Student,

I am a professor at McGill University and am doing a project with your teacher. We would like to learn more about how you solve math problems, the feelings you have about math, and how those change over the school year. We will continue this project at school from October 2017 until June 2019. During the time you are at Dorset, you may participate each year until the end of the study (or until you leave Dorset).

What will you do?

For each school year, you will work on two math problems – one in October and another one in May. We will ask you to talk out loud to tell us what you are thinking as you solve the problem. The problem will take about 20 minutes to solve, and we will record your voice as you try to solve the math problem. We will also ask you about your feelings about math after solving these problems. Your teacher will also fill out questionnaires about classroom activities, and the kinds of things you do when you learn. We will also visit your classroom a few times to see what kinds of activities happen in your class.

Other Important Information

Your information and audio-recording will be private. We will not tell your teacher or your parent/legal tutor what you say and write.

You can quit this study any time you want. You can say yes or no if you want to take part in the study. This will not affect your school grades. If you do not want to be part of this study, you will be doing the same work as the other students in your class.

If you take part, you will receive an iTunes gift card for $10 for each year that you participate. If you have questions you can call Dr. Krista Muis at (514) 398-3445.

Thank you for reading this letter and for your help,

Krista R. Muis, PhD
Associate Professor and Canada Research Chair
Faculty of Education
McGill University

Yes. I ________________________ (name of child) agree to take part in this study.

I give my permission to audio-record me while I complete the tasks. c yes c no

I am taking part of this project because I want to. I have been told that I can stop at any time.

____
(child's signature)

No. I ________________________ (name of child) DO NOT agree to take part in this study.

____
(child's signature)

Appendix B

Emotions Regulation Questionnaire – Child and Adolescent

(Adapted from Gullone & Taffe, 2012)

We would like to ask you some questions about how you control your emotions while at school. There are no right or wrong answers.

For each item, please answer using the following scale:

Never	Rarely	Sometimes	Often	Always
1	2	3	4	5

1) When I want to feel happier, I think about something different.
1 2 3 4 5

2) I keep my feelings to myself.
1 2 3 4 5

3) When I want to feel less bad (e.g., sad, angry, or worried), I think about something different.
1 2 3 4 5

4) When I am feeling happy, I am careful not to show it.
1 2 3 4 5

5) When I am worried about something, I make myself think about it in a way that makes me feel better.
1 2 3 4 5

6) I control my feelings by not showing them.
1 2 3 4 5

7) When I want to feel happier about something, I change the way I am thinking about it.
1 2 3 4 5

8) I control my feelings about things by changing the way I think about them.
1 2 3 4 5

9) When I am feeling bad (e.g., sad, angry, or worried), I am careful not to show it.
1 2 3 4 5

10) When I want to feel less bad (e.g., sad, angry, or worried) about something, I change the way I am thinking about it.
1 2 3 4 5

Appendix C

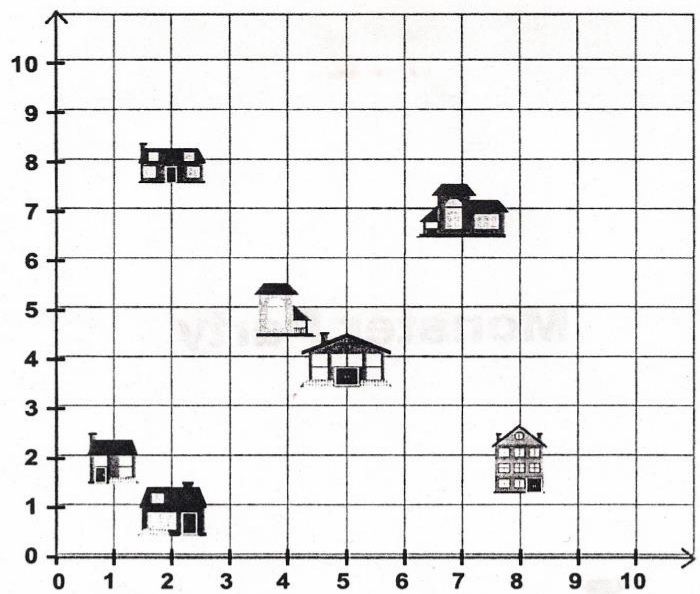
Grade 3 Mathematics Problem-Solving Question and Grading Key

Name: ____________________ Date: ____________

I Solve a Problem

Monster Party

Here is a map of the monsters' town.



The monsters are having a party today. To celebrate, the monsters hand out gooey gummies to each child who comes to their door.

Here is the number of gooey gummies that each monster gives to each child.

1	2	3	4	5	6	7
153	12 tens	1 hundred	10 hundreds	34 tens	234	789

Leo visits the houses located at these number pairs:
(1, 2), (8, 2) and (5, 4).

How many gooey gummies does Leo get?

Name: ______________________ Date: ____________

What I Know

analysis = x/15

- The monsters are having a party and handing out Gooey Gummies
- Leo visits the houses at these number pairs: (1,2) (8,2) (5,4)
- How many Gooey Gummies each house has

What I'm Looking For

analysis = x/15

- How many Gooey Gummies did Leo get in total
- Which houses are at the numbered pairs

Total analysis = x/30

My Solution

House 1: (1,2) application = x/5 justification = x/5
house 1 hands out 153 Gooey Gummies

House 2: (8,2) application = x/5 justification = x/2.5
house 2 hands out 12 tens Gooey Gummies
12 x 10 = 120 = 120 Gooey Gummies
application = x/5 justification = x/5

House 3: (5,4)
house 6 hands out 234 Gooey Gummies
application = x/5
justification = x/5

$$\left.\begin{array}{r} 153 \\ +120 \\ +234 \\ \hline 507 \end{array}\right\}$$
application = x/5
justification = x/2.5

Leo visited houses 1, 2 and 6 where he got 507 Gooey Gummies application = x/5
justification = x/5

Total application = x/30 = (*5)/3 = x/50
Total justification = x/25 = (*4)/5 = x/20

I Solve a Problem – Supplement
Grade 3

NUMBERS
13199 5

Appendix D

Grade 4 Mathematics Problem-Solving Question and Grading Key

AR6-006

Name: ____________________ Date: ________________

VALIDATION SITUATION AR6 Arithmetic (6)						
	Observable manifestations of a level...					
	5	4	3	2	1	
Evaluation Criteria: Analyze Choice						
Evaluation Criteria: Application						
Evaluation Criteria: Justification						

Summer Vacation

During their summer vacation, a family is planning to spend a weekend in Montreal. They want to visit the Insectarium, the Biodome and the Planetarium.

This family has 5 members:

- the grandfather, 67 years old
- Leanne, 10 years old
- the father, 44 years old
- Billy, 9 years old
- the mother, 44 years old

Using the table below, Leanne and Billy calculated the total amount the family must pay to visit the Insectarium, the Biodome and the Planetarium.

	Regular Rates			
	Insectarium	Biodome	Nature Package (Insectarium and Biodome)	Planetarium
Adults	$16.00	$16.00	$27.00	$8.00
Age 65 and over	$12.00	$12.00	$20.25	$6.00
Age 5 to 17	$8.00	$8.00	$13.50	$4.00
Age 2 to 4	$2.50	$2.50	$4.25	free

Leanne says the family must pay a total of $131.25.

Billy says the family must pay a total of $150.00.

The grandfather says that Leanne and Billy are both right. Why? Answer in the space provided on the next page.

I Analyze the Situation

What I know...

- The family wants to visit the Insectarium, the biodome and the planetarium
- The age of all 5 family members and the cost of each attraction

Leanna thinks the total cost will be 131.25$ and Billy thinks it will be 150.00$

analysis = x/10

What I am looking for...

- If Billy and Leanna are both right about the total price for the family to visit all 3 attractions

analysis = x/10

It is essential to think about:

Adding analysis = x/10

place values

equivalents Total analysis = x/30

My answer...

Show all your work.

	① Insectarium	② biodome	③ nature package	④ Planetarium
mom	16.00	16.00	27.00	8.00
dad	+ 16.00	+ 16.00	+ 27.00	+ 8.00
	32.00	32.00	54.00	16.00
gndpa	+ 12.00	+ 12.00	+ 20.25	+ 6.00
	44.00	44.00	74.25	22.00
Billy	+ 8.00	+ 8.00	+ 13.50	+ 4:00
	52.00	52.00	87.75	26.00
Leanna	+ 8.00	+ 8.00	+ 13.50	+ 4.00
	60.00$	60.00$	101.25$	30.00$

⑤ Billy

insectarium + biodome + planetarium

60.00 + 60.00 + 30.00 = 150.00$

Leanna ⑥

nature pack + planetarium

101.25 + 30.00 = 131.25$

1–6: application = x/4 Justification = x/5

Total application: = x/30 = (x5)/3) = x/50

Total Justification: = x/40 = (/2) = x/20

Leanne and Billy are both right because Leanna calculated the family cost using the nature package and Billy did not.

application = x/6 justification = x/10

Show all your work in a clear and organized manner to justify your answer.

Appendix E

Grade 5 Mathematics Problem-Solving Question and Grading Key

OP4-002

Name: ________________ Date: ______________

Uses math reasoning Action Situation OP4 (8)					
Evaluation criteria	Observable indicators corresponding to level				
	A	B	C	D	E
Analysis	30	24	18	12	6
Application	50	40	30	20	10
Justification	20	16	12	8	4

Garden Plot

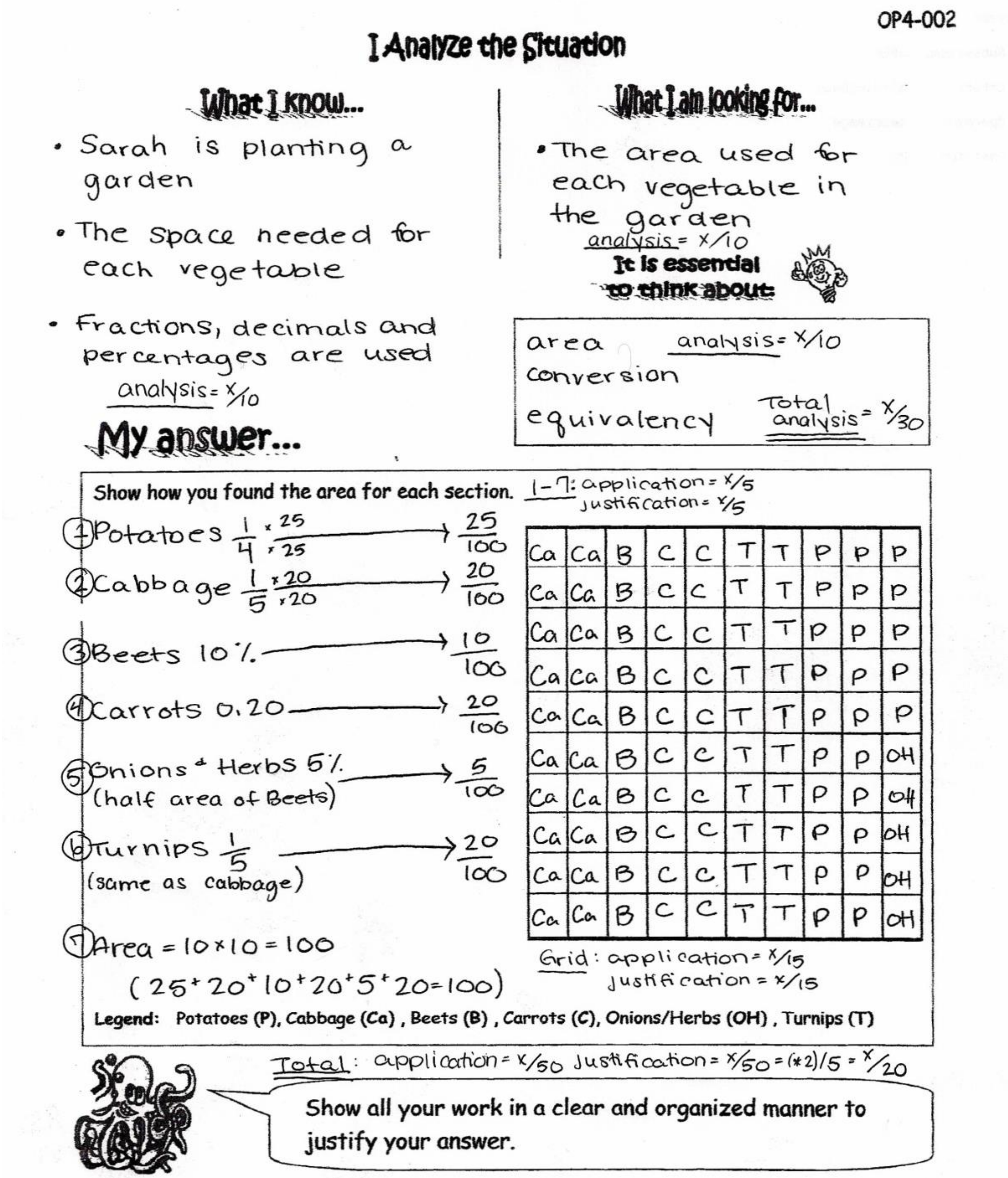
Sarah is planning her kitchen garden. She is planting many root vegetables to last her through the winter.

This is a list of the vegetables and the amount of space Sarah has decided to give each one:

- potatoes: $\frac{1}{4}$ of the garden.
- cabbage: $\frac{1}{5}$ of the garden.
- beets: 10% of the garden.
- carrots: 0.20 of the garden.
- onions and herbs: $\frac{1}{2}$ of the area for beets.
- turnips: the same area as the cabbage.

Help Sarah plan her garden.

The grid on the next page shows the square area of land she will use for the garden.



OP4-002

I Analyze the Situation

What I know...

- Sarah is planting a garden
- The space needed for each vegetable
- Fractions, decimals and percentages are used

analysis = x/10

What I am looking for...

- The area used for each vegetable in the garden

analysis = x/10

It is essential to think about:

area

conversion

equivalency

analysis = x/10

Total analysis = x/30

My answer...

Show how you found the area for each section.

1–7: application = x/5
justification = x/5

① Potatoes $\frac{1}{4}\frac{\times 25}{\times 25} \longrightarrow \frac{25}{100}$

② Cabbage $\frac{1}{5}\frac{\times 20}{\times 20} \longrightarrow \frac{20}{100}$

③ Beets 10% $\longrightarrow \frac{10}{100}$

④ Carrots 0.20 $\longrightarrow \frac{20}{100}$

⑤ Onions + Herbs 5% $\longrightarrow \frac{5}{100}$
(half area of Beets)

⑥ Turnips $\frac{1}{5} \longrightarrow \frac{20}{100}$
(same as cabbage)

⑦ Area = 10×10 = 100
(25+20+10+20+5+20=100)

Ca	Ca	B	C	C	T	T	P	P	P
Ca	Ca	B	C	C	T	T	P	P	P
Ca	Ca	B	C	C	T	T	P	P	P
Ca	Ca	B	C	C	T	T	P	P	P
Ca	Ca	B	C	C	T	T	P	P	P
Ca	Ca	B	C	C	T	T	P	P	OH
Ca	Ca	B	C	C	T	T	P	P	OH
Ca	Ca	B	C	C	T	T	P	P	OH
Ca	Ca	B	C	C	T	T	P	P	OH
Ca	Ca	B	C	C	T	T	P	P	OH

Grid: application = x/15
justification = x/15

Legend: Potatoes (P), Cabbage (Ca), Beets (B), Carrots (C), Onions/Herbs (OH), Turnips (T)

Total: application = x/50 Justification = x/50 = (*2)/5 = x/20

Show all your work in a clear and organized manner to justify your answer.

Appendix F

Grade 6 Mathematics Problem-Solving Question and Grading Key

Let's Get Moving!

A fundraising activity brought in $1 000 that will be spent on sports items for three schools in your area. The organizing committee has decided to divide the money raised as follows.

Distribution of the money raised	
School 1	$\frac{2}{5}$ of the money raised
School 2	$\frac{3}{8}$ of the money raised
School 3	the rest of the money raised

Each school has asked for the following sports items.

School 1	School 2	School 3
10 hopper balls 	2 folding nets  and at least 50 pinnies 	At least 65 cones 

The following is the list of prices for the sports items.

List of prices for the sports items	
Item	**Price** (Taxes included)
Hopper ball	$28.50 for 1 ball
Folding net	$100.50 for 1 net
Package of pinnies	$27 for a package of 8 pinnies
Package of cones	$20 for a package of 6 cones

An extra charge of $\frac{1}{10}$ of the amount of the bill must be added to have the items delivered to each school.

Given the way in which the organizing committee decided to distribute the money, will each school be able to order the sports items that it has requested?

Let's Get Moving!

Show all your work.

School 1: $2/5$ of $1000 = \$400$

Hopper balls = 28.50

$28.50 \times 10 = 285$

$285 \times \frac{1}{10} = 28.50$

$285 + 28.50 = \$313.50 < \$400$

School 2: $3/8$ of $1000 = \$375$

Folding nets + pinnies

$100.50 \times 2 = 201$

$50/8 = 6.25\ldots$ round to 7 packs

$27 \times 7 = 189$

$201 + 189 = 390$

$390 \times \frac{1}{10} = 39$

$390 + 39 = \$429 > \$355$

School 3: Cones

remainder of budget

$1000 - (400 + 375) = \$225$

$65/6 = 10.83\ldots$ round to 11 packs

$220 \times 11 = 220$

$220 \times \frac{1}{10} = 22$

$220 + 22 = \$242 > \$225$

Inferred analysis: $x/30$

- there are 3 schools with different budgets
- Packages cannot be split, must round
- $1/10^{th}$ of total added for delivery

Schools 1, 2, + 3:

application = $x/5$

Justification = $x/5$

Total application:

$= x/20$

$= (*5)/2$

$= x/50$

Total justification:

$= x/20$

Given the way in which the organizing committee decided to distribute the money, will each school be able to order the sports items that it has requested?

☐ Yes ☑ No application = $x/1$ justification = $x/1$

Use rigorous mathematical arguments to explain why.

No they will not be able to order the sports items because school 2 is short \$54 (429 − 375) and school 3 is short \$17 (242 − 225)

application = $x/4$

Justification = $x/4$

Appendix G

Rubric for The Competency to Reason Using Mathematical Processes

		OBSERVABLE INDICATORS				
		Level A	**Level B**	**Level C**	**Level D**	**Level E**
EVALUATION CRITERIA	**Appropriate analysis of a situation**	• Identifies all the elements and actions that allow him/her to meet the requirements of the situation • Chooses the mathematical concepts and processes that allow him/her to meet the requirements of the situation efficiently	• Identifies most of the elements and all actions that allow him/her to meet the requirements of the situation • Chooses the mathematical concepts and processes that allow him/her to meet the requirements of the situation appropriately	• Identifies the elements and actions that allow him/her to meet the requirements of the situation • Chooses the mathematical concepts and processes that allow him/her to meet the main requirements of the situation	• Identifies elements and actions that allow him/her to partially meet the requirements of the situation • Chooses the mathematical concepts and processes that allow him/her to partially meet some of requirements of the situation	• Identifies all the elements and actions that have little or no connection to requirements of the situation • Chooses the mathematical concepts and processes that have little or no connection to requirements of the situation

	Appropriate application of the required processes	• Applies the required concepts and processes appropriately in order to meet the requirements of the task and makes no mistakes	• Applies the required concepts and processes appropriately in order to meet the requirements of the task, but makes minor mistakes	• Applies some of the required concepts and processes, but makes one conceptual or procedural error*, or makes several minor mistakes	• Applies some of the required concepts and processes, but makes two conceptual or procedural errors*, or one conceptual or procedural error regarding a key concept associated with the task	• Applies concepts and processes, but makes several conceptual or procedural errors*, or applies inappropriate concepts and processes
	Correct justification of actions or statements by referring to mathematical concepts and processes	• Presents a clear and complete line of reasoning • Uses rigorous mathematical arguments when required to support his/her actions, conclusions or results	• Presents a clear line of reasoning even though some of its elements are implicit • Uses appropriate mathematical arguments when required to support his/her actions, conclusions or results	• Presents a line of reasoning consisting of incomplete or unclear elements • Uses insufficiently detailed mathematical arguments when required to support his/her actions, conclusions or results	• Presents a line of reasoning consisting of isolated and confusing elements • Uses largely inappropriate mathematical arguments when required to support his/her actions, conclusions or results	• Presents a line of reasoning that has little or no connection to the situation, or does not show any work • Uses mathematical arguments that are erroneous or unrelated to the requirements of the situation

*Students who omit a concept or process are considered to have made a conceptual or procedural error.

Appendix H

Achievement Ratings

(Adapted from SRISI © Hutchinson & Perry, 2010)

Please circle your rating to each question below using the sliding scale from 1 to 7 where:

1 = Not yet meeting expectations
3 = Approaching expectations
5 = Meeting expectations
7 = Exceeding expectations

Statement	Rating						
1. What is this child's achievement level in terms of provincial expectations for Mathematics – Solves a situational problem?	**1**	**2**	**3**	**4**	**5**	**6**	**7**
2. What is this child's achievement level in terms of provincial expectations for Mathematics – Uses mathematical reasoning?	**1**	**2**	**3**	**4**	**5**	**6**	**7**

IEP Status (if applicable): ________________________

Appendix I

The Self-Regulation in School Instrument

(Adapted from SRISI © Hutchinson & Perry, 2010)

Please answer the items below using the sliding rating scale from 1 to 7 where:

1 = Never **4 = Sometimes** **7= Always**

Statement	Rating						
1. Makes realistic evaluations of his/her performance on a task.	1	2	3	4	5	6	7
2. Enjoys and/or values learning new things.	1	2	3	4	5	6	7
3. Is able to talk about feelings or describe emotions.	1	2	3	4	5	6	7
4. Is willing to try challenging tasks.	1	2	3	4	5	6	7
5. Takes responsibility for learning successes and failures by attributing them to factors s/he can control (e.g., working harder, trying a new strategy).	1	2	3	4	5	6	7
6. Is aware of how much time it takes him/her to complete academic tasks.	1	2	3	4	5	6	7
7. Can express/communicate needs and desires.	1	2	3	4	5	6	7
8. Applies appropriate learning strategies to complete assignments/tasks.	1	2	3	4	5	6	7
9. When the child becomes overwhelmed with a difficult academic task, he/she adjusts his/her expectations for learning success.	1	2	3	4	5	6	7
10. Understands what is required to "meet expectations" for academic tasks.	1	2	3	4	5	6	7
11. Negotiates task parameters (e.g., picking a familiar topic to research), when tasks are difficult rather than becoming frustrated or overwhelmed.	1	2	3	4	5	6	7
12. Retains confidence in his/her learning skills and abilities even after making mistakes.	1	2	3	4	5	6	7
13. Can manage a set of directions to complete tasks independently.	1	2	3	4	5	6	7
14. Chooses a quiet space to work if other children are talking.	1	2	3	4	5	6	7
15. Has something positive to say about his/her learning, even when s/he is disappointed because s/he does not do well on an assignment.	1	2	3	4	5	6	7
16. Engages in positive self-talk or other productive strategies when faced with challenging or upsetting situations, rather than letting negative emotions get in the way.	1	2	3	4	5	6	7

Appendix J

Classroom Context Questionnaire

(Adapted from Perry, 1998)

For this questionnaire, you are being asked to rate each statement based on the extent to which you engage in each strategy about events that take place inside your classroom. For each statement, there are two options – A and B. For each option, please rate the extent to which you used that strategy during the past week (Monday to Friday) using the rating scale below. At the end of the questionnaire, please elaborate on any of the items that do not reflect a typical week for you.

1 – Never 2 – Rarely 3 – Sometimes 4 – Often 5 – Always

Statement	**Options and Rating**		**Does your answer reflect what happens in your classroom during a typical week?**
1. When I assigned tasks to students:	A. We discussed strategies they could use to finish a task and then I let them try it on their own. 1 2 3 4 5	B. I provided students with explicit directions about how to finish their tasks. 1 2 3 4 5	A. Yes ☐ No ☐ B. Yes ☐ No ☐
2. When students came to me for help with a problem:	A. I gave them specific directions on how to solve the problem. 1 2 3 4 5	B. I asked them how they could solve the problem—what strategies they could use. 1 2 3 4 5	A. Yes ☐ No ☐ B. Yes ☐ No ☐
3. When students worked on tasks:	A. I encouraged them to work together (e.g., collaborate on a project). 1 2 3 4 5	B. I encouraged them to work independently. 1 2 3 4 5	A. Yes ☐ No ☐ B. Yes ☐ No ☐

4. When students experienced difficulties while working on tasks:	A. I encouraged them to come to me or see what they could do on their own. 1 2 3 4 5	B. I encouraged them to seek help from each other. 1 2 3 4 5	A. Yes ☐ No ☐ B. Yes ☐ No ☐
5. When I assigned tasks to students this week:	A. I included opportunities for them to modify tasks, so they could increase or decrease the level of challenge they experienced. 1 2 3 4 5	B. I included tasks that were at the same the level of difficulty for all students. 1 2 3 4 5	A. Yes ☐ No ☐ B. Yes ☐ No ☐
6. When we worked on activities this week:	A. I asked all students to represent their learning in the same way. 1 2 3 4 5	B. I gave students opportunities to represent their learning in a variety of ways (e.g., through pictures, writing, oral presentations). 1 2 3 4 5	A. Yes ☐ No ☐ B. Yes ☐ No ☐
7. When we finished lessons this week:	A. I provided opportunities or prompted students to reflect on their learning. 1 2 3 4 5	B. Students were not involved in self-assessment. 1 2 3 4 5	A. Yes ☐ No ☐ B. Yes ☐ No ☐
8. When we were working on tasks this week:	A. Students were not involved in setting or discussing criteria for evaluating their work. 1 2 3 4 5	B. Students were either involved in setting criteria for evaluating work or we discussed criteria that related to an assignment. 1 2 3 4 5	A. Yes ☐ No ☐ B. Yes ☐ No ☐

9. When students were working on tasks this week:	A. I let them decide where they wanted to work in the classroom. 1 2 3 4 5	B. I told students where I wanted them to work. 1 2 3 4 5	A. Yes ☐ No ☐ B. Yes ☐ No ☐
10. When students worked together this week:	A. I paired or assigned students to groups according to my assessment of who works well together. 1 2 3 4 5	B. I let students decide with whom to work based on criteria for selecting good working partners. 1 2 3 4 5	A. Yes ☐ No ☐ B. Yes ☐ No ☐
11. As students worked on tasks this week:	A. They made choices about the kinds of topics/subtopics we discussed or wrote about. 1 2 3 4 5	B. I centered our discussions or writing on a particular topic or subtopic. 1 2 3 4 5	A. Yes ☐ No ☐ B. Yes ☐ No ☐
12. When students were working on projects or seatwork this week:	A. I allocated the amount of time I thought students would need to finish their work. 1 2 3 4 5	B. I let them determine how to budget their time to complete their work. 1 2 3 4 5	A. Yes ☐ No ☐ B. Yes ☐ No ☐
13. Currently, students in my classroom are:	A. involved in projects that address multiple goals and connect knowledge and skills from across the curriculum. 1 2 3 4 5	B. working on specific goals that are tied to individual subject areas. 1 2 3 4 5	A. Yes ☐ No ☐ B. Yes ☐ No ☐

14. Currently, students in my classroom are:	A. working on tasks and activities where they are focused on discrete skills and are all producing similar products to showcase their learning. 1 2 3 4 5	B. working on tasks that involve them in multiple processes and give them opportunities to represent their learning with a variety of products. 1 2 3 4 5	A. Yes ☐ No ☐ B. Yes ☐ No ☐

For any of the items that do not reflect a typical week for you (i.e., you selected "No" for a typical week), please indicate the number (#2, etc) and briefly describe why is not a typical week.

____

____

____

____

____

____

____

____

Appendix K

Classroom Observation Instrument

(Adapted from Perry, 1998; Perry, VandeKamp, Mercer, & Nordby 2000)

Researcher ID______________

Teacher______________________________ Observer______________________________

Grade________________________________ Time Start_____________________________

Date_________________________________ Time Stop_____________________________

School_______________________________ Time Total_____________________________

Description:

Examples of Classroom Practices that Support Children's Engagement in Self-Regulation

(Hutchinson © 2013)

Category	Examples
Complex Tasks	The teacher creates meaningful tasks/ activities (e.g., class discussion time on writing outlines, how to effectively brain storm/creating concept maps, guidelines for creating writing summaries) that provide opportunities for children to attain multiple learning goals (e.g., goals to develop skills of how to construct a writing outline, to engage in creative writing, to learn how to work with other students in the classroom). The teacher provides tasks/activities (e.g., supporting all students to keep a personal science log with terminology, diagrams, things children have learned during the unit) that presents students with opportunities to employ skills from across subjects (e.g., writing, art, science) to support learning. The teacher creates tasks/activities (e.g., shared reading activities, experiments) that provide opportunities for children to engage in a number of processes and support children's learning (e.g., predicting, analyzing, reasoning, remembering). Classroom activities and tasks (e.g., creating math problems based on children's understanding of probability) provide opportunities for children to showcase their learning in different ways (e.g., pictures, writing, building a game).
Choice	Children have choices about who they can work with. Children have choices about where to work (e.g., library, hall, or to another area to work quietly – free of distractions). Children make decisions about when they work on tasks and activities (e.g., students prioritize when they will work on reading, writing, math). Children decide what they will work on during a class time (e.g., writing or science or a bit of both).
Control Over Challenge	Children suggest two of their favorite topics (e.g., polar bears, the ocean) as ideas for a group project. Children are supported to ask for guidance for learning from a teacher or peer. Children are supported to use resources (e.g., books, internet) when they are having difficulties finding information about topics they are researching. Children are supported to negotiate with others when they have disagreements about a task or project they are working on with other children.

Category	Examples
Student Self-Evaluation	Children have a large discussion with the class about what they have learned. Children have conferences with the teacher about their learning progress on science project. Students use rubrics or checklists to evaluate their learning (e.g., evaluation criteria set by the class). Students keep journals about what they have learned in a subject using notebooks they review with the teacher.
Teacher Support	Teachers provide hints when work is difficult (e.g., what could you do if you can't spell a word?). Teachers model strategies for cooperating with others (e.g., how would you ask Julia if you wanted to borrow her pencils? What could you say if you have another idea for the group project?). Teachers model thinking strategies so students can work independently (e.g., If I get stuck spelling a word in my head, what strategy could I use to help me figure out how to spell it?"). Teachers anticipate students' needs by scaffolding positive conflict resolution prior to task engagement (e.g., What are some things we can do we do if there is a disagreement between classmates?).
Peer Support	Peers show other children how they have solved a task. Peers ask other children to work collaboratively. Peers volunteer information that can help another child with her/his project. Peers remind classmates to stay on task while working together.
Non-Threatening/Non-Competitive Evaluations	Teachers support children to focus on their personal learning progress (rather than comparing him/herself to peers). Teachers encourage children to view feedback as opportunities for them to improve their learning (rather than as competition). Teachers provide children with support that allows them to learn how to give constructive feedback to other children so that they help each other accomplish learning.

Category	Examples
Communities Of Learners	Teachers and children meet to discuss progress on individual tasks (e.g., what's involved, what materials are needed, who to ask for expertise). Teachers lead a large discussion so that all children have opportunities to share their ideas and strategies for learning with other classmates. Teachers provide children with support (e.g., strategies student can use to help themselves make their learning more interesting based on their interests) that is tailored to an individual child's needs for learning, emotional support/warmth, and guidance. Individual children are supported by their classmates and teachers when they recognize they need help from someone else to complete work.