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The Development of Adolescent Students' Self-Directed Learning Skills Within a Montessori Program During COVID-19: A Longitudinal Mixed-Methods Study

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Abstract

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by

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Students who develop and apply their self-directed learning skills have advantages in school over those who do not (Betts & Knapp, 1981; Candy, 1991; Guglielmino, 1977; Schunk & Zimmerman, 2012). This is because self-directed learning (SDL) skills enable autonomous learning where students self-initiate, solve problems, develop new ideas, and monitor themselves with minimal external guidance (Knowles, 1976; Zimmerman, 2000). Despite the importance of these skills, research shows that few students consistently engage in SDL (Dent & Koenka, 2016; Zimmerman & Schunk, 2001). Because of SDL's multi-faceted and complex nature, it is difficult to discern why this is the case (Dent & Koenka, 2016; Zimmerman & Schunk, 2001). Multiple dynamic, interacting factors, including maturation, environmental supports, and historical events, likely contribute to students' SDL development (Hoyle & Dent, 2017). As such, recent literature suggests that a relational dynamic systems (RDS) approach can help elucidate the dynamic, context-dependent patterns by which SDL skills unfold (Hoyle & Dent, 2017). According to RDS theories, development occurs within multi-level, interacting, relational systems; therefore, the bi-directional relationship between the person and their environment should be the unit of analysis (Lerner et al., 2011).

This study aimed to provide a systematic investigation of the development of SDL skills, accounting for important contextual and developmental influences as well as individual pathways. Adolescence appears to be an optimal time for students to gain SDL skills (Brown, 1978; Brown et al., 1983); hence, this study focused on that developmental period. Also, because the Montessori educational approach is conducive to SDL skill development (Lillard, 2017; Rathunde, 2009, 2014), it was used as the school backdrop for this study. Furthermore, during data collection, a global pandemic caused by COVID-19 impacted school environments and was also included as a developmental context in this study. Specifically, this study utilized a longitudinal convergent mixed methods design to (1) identify patterns of SDL skill development across adolescence, (2) illustrate the reasons for those changes, and (3) illuminate the indirect effect of COVID-19 on students' SDL. Emergent themes from student interviews conducted over four years augmented growth curve analysis results from an accelerated longitudinal design utilizing student surveys to address the research questions. Descriptive, correlational, multi-level model (MLM), and repeated-measures ANOVA analyses of student survey responses across four years (4 waves) of data collection with students grades 7 through 12 (n = 284) were applied to address the quantitative research questions. Emergent themes, derived through thematic analysis of 29 interviews, or 11 cases of students with a range of SDL skills (average, above average, and below average), addressed the qualitative research questions. Finally, quantitative results and qualitative findings were combined and compared to investigate convergence, divergence, and expansion areas that addressed integrative research questions.

Findings shed important light on the development of adolescent students' SDL skills across adolescence. Quantitative results and qualitative analyses were combined to address the research question: *Do adolescent students' SDL skills increase, decrease, or remain stable*

throughout middle school and high school? Findings resulted in areas of convergence and divergence across methods. Despite some diverging quantitative results, namely a non-significant growth model, other quantitative results, a non-significant no-growth model and descriptive plots, converged with qualitative findings from student interviews to suggest that within and between students, SDL skill development can include a combination of growth, decline, or stability over time. Findings from this study also suggest that each SDL skill can develop on its own timetable. Also, findings suggest a developmental pattern whereby SDL skills vary more in middle school than in high school. These findings have begun to disentangle contradictory results of earlier SDL research (e.g., Heater, 2005; Pajares & Valiante, 2002; Reio & Ward, 2005). From a practice perspective, the findings imply that it may benefit students to have tailored interventions that meet them where they are developmentally, considering each SDL skill individually and all together.

The second integrative research question that was addressed in this study was: *What roles do factors like grade level and the Montessori learning environment play in SDL development?* Quantitative results and qualitative findings converged to suggest that students' SDL skills develop, at least in part, as a factor of the length of time a student has been immersed in the Montessori program. The findings also show that a student's maturation may play a role in SDL skill development, especially when environmental contexts are supportive. In addition, qualitative interviews with students identified features of the Montessori program, such as open work time, scaffolded opportunities to be self-directed, autonomy support, and supportive teachers that aided students in their SDL development, which also aligns with the literature (Zumbrunn et al., 2011). This finding strengthens prior research, which found cursory evidence for how Montessori schools support the development of SDL skills (Ervin et al., 2010).

In addition, quantitative results and qualitative findings diverged for the third overarching research question: *Have changes in the learning environment associated with COVID-19 shaped the development of students' SDL skills? If so, how?* Although the quantitative results from this study failed to detect any indirect effects of the impact of COVID-19 on students' SDL, qualitative findings found that changes in their learning environment as a result of COVID-19 impacted students' SDL both negatively and positively. Research has also found that the global pandemic drastically impacted the school environment, so it is most likely that the quantitative measure failed to detect an effect (Huck & Zhang, 2021; Tarkar, 2020). Furthermore, in the interviews, most students reported a combination of negative experiences (e.g., more distractions at home, lowered motivation, fewer social interactions, higher stress, and missing in-school learning) as well as positive experiences (e.g., increased time management, access to resources, multi-tasking, organization, ability to shut out distractions, and time to sleep) that impacted their SDL abilities. Qualitative findings from this study extend prior research by providing student accounts of their experiences, including silver linings (Wilson et al., 2020).

Despite its limitations, this study revealed important exploratory findings about how students' SDL skills can develop across adolescence. Areas of convergence across qualitative and quantitative methodologies underscore the reliability of the study findings. There were also unique quantitative and qualitative findings that extend prior research and provide important implications for future research and practice.

Keywords: self-directed learning, self-regulated learning, development, adolescence, Montessori, COVID-19

Dedication

To Catherine Lepoutre, a.k.a. Mouf Mouf, my grandmother whose creativity, artistry, perseverance, determination, and self-directed learning inspired me in so many ways. You may have been denied a formal higher education, but that did not stop you from learning.

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Chapter 1: Introduction and Literature Review

Students who develop and apply self-directed learning skills have advantages in school (Betts & Knapp, 1981; Candy, 1991; Guglielmino, 1977; Schunk & Zimmerman, 2012). Self-directed learning (SDL) refers to an important set of learning processes and skills that enable individuals to become experts in their learning and excel academically (Zumbrunn et al., 2011). This is because SDL skills enable autonomous learning whereby students are aware of themselves as learners, can self-motivate, employ learning strategies, and monitor and evaluate progress toward their goals (Betts & Knapp, 1981; Knowles, 1976; Thomas et al., 1988; Zimmerman, 2002). Despite the importance of these skills, research has revealed that few adolescent students are consistently self-directed (Dent & Koenka, 2016; Zimmerman & Schunk, 2001). Because of the complex nature of SDL, it has been difficult to discern why this is the case. Researchers have called for dynamic systems approaches to understand the fused, context-dependent patterns by which SDL skills unfold (Hoyle & Dent, 2017). Multiple dynamic, interacting factors, such as maturation, environmental supports, and historical events, are expected to influence students' SDL developmental paths (Hoyle & Dent, 2017). To examine these factors, mixed methods and longitudinal methods are needed (Geldhof et al., 2013).

Accordingly, this study relied on a longitudinal convergent mixed-methods design to shed light on when, why, and for whom students' SDL skills develop across adolescence. Specifically, this study considered the influence of maturity, the learning environment, and a global pandemic on adolescent students' SDL development. Data for this study were gathered as

part of an evaluation study aimed at assessing self-directed learning as an outcome of a Montessori charter middle and high school. Adolescent students were followed for four years, allowing for the observation of the development of students' SDL skills in context and in real time. The school setting, a Montessori adolescent program that aims to cultivate SDL skills, provided an ideal setting to facilitate the observation of the development of SDL skills. In addition, a global pandemic occurred during data collection, providing a unique opportunity to observe and explore the potential influence of historical-temporal influences.

The following sections in this chapter define SDL skills and describe their benefits. Also, a review of the relevant literature proceeds, explaining what is known about SDL skill development, justifying why adolescence is a suitable stage in the lifespan for studying their development, and providing an argument for the need for the current study.

Self-Directed Learning

To examine the development of self-directed learning, we must first define it. Self-directed learning[1] is an autonomous learning process whereby students are metacognitively aware of themselves as learners and can motivate themselves, monitor, and evaluate their progress (Betts & Knapp, 1981; Knowles, 1976; Thomas et al., 1988; Zimmerman, 2000). Also,

[1] Several terms have been used to describe a similar set of processes related to self-directed learning. However, for research and practice purposes, these terms should be considered synonymous. Most notable in the literature is *self-regulated learning*. Several researchers have compared and contrasted *self-directed* and *self-regulated learning* identifying distinctions and areas of overlap (e.g., Pilling-Cormick & Garrison, 2013; Saks & Leijen, 2014). Overlaps between the constructs include subprocesses like defining goals, setting goals, planning, implementing learning strategies, and monitoring and evaluating progress (Saks & Leijen, 2014). Distinctions include the origin of the construct (i.e., education vs psychology) and the scope (i.e., self-directed learning comprises of self-regulated learning processes). However, the conceptual origins are not essential components when considering operational definitions or research programs. Further, more recently, the definition of self-regulated learning has expanded to include more of the elements once thought to apply only to self-directed learning (e.g., motivation and initiative; (Paris & Paris, 2001; Pintrich & De Groot, 1990). Therefore, self-directed and self-regulated learning should be considered the same construct. Throughout this paper, I use the term self-directed learning to refer to both the self-directed and self-regulated learning.

self-directed learners take responsibility for their learning. They are inquisitive, and as a result, they take the initiative in learning. SDL students set appropriate learning goals and use deliberate study strategies to achieve their goals. When needed, SDL students adapt their learning approach matching the learning task (Guglielmino, 1977; Knowles, 1976; Zimmerman, 1990, 2002). Taken together, SDL learners possess SDL skills, which include "multiple processes operating in concert" (Sitzmann & Ely, 2011, p. 421).

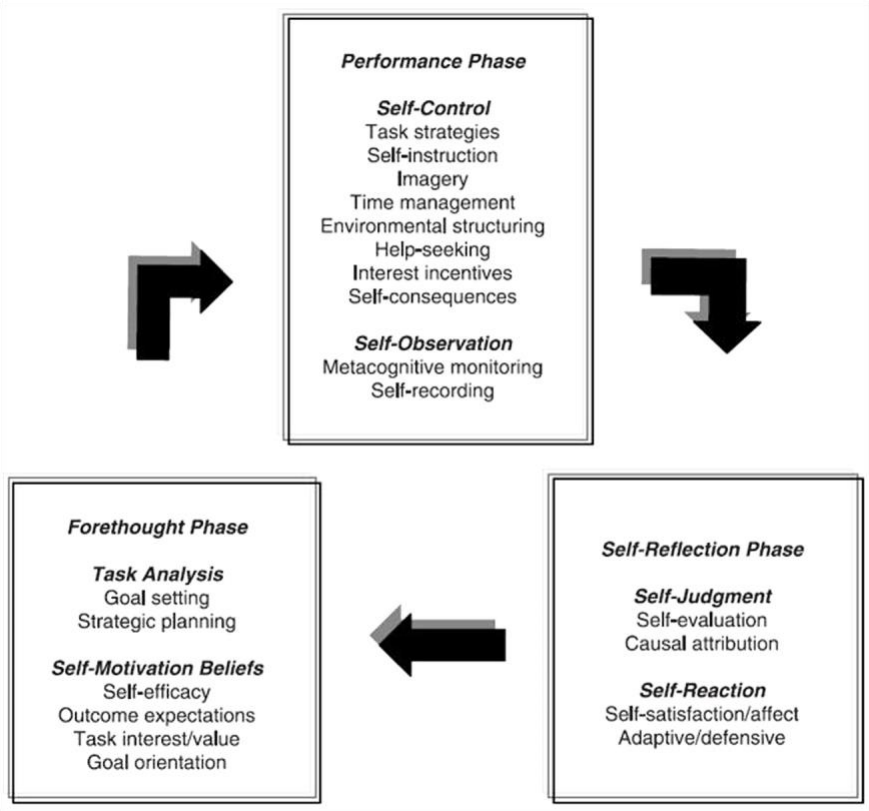
The multifaceted, complex nature of self-directed learning skills may help explain why so many conceptions of SDL learners and SDL skills have been proposed (see Boekaerts & Niemivirta, 2000; Paul, 2000; Winne & Hadwin, 1998; Zimmerman, 2000). Furthermore, many models describe self-directed learning as a dynamic process that includes elements of an individual's motivation, cognition, affect, and behavior directed toward achieving one's learning goals (Puustinen & Pulkkinen, 2001). Self-directed learners engage in a range of self-regulated behaviors, including exploration (Hardy III et al., 2014), self-motivation (e.g., self-efficacy; Corno, 1993; Wolters, 2003), meta-motivation; (Boekaerts, 1997, 1998; Vollmeyer & Rheinberg, 2006; Wolters, 2003, 2011), goal-setting (Lemos, 1999; Winne & Hadwin, 1998; Wolters, 1998), planning (Pintrich, 1999; Zimmerman, 2004; Zimmerman & Risemberg, 1997), appropriate learning strategies (Ryan et al., 2001; van den Broek et al., 2001; Winne, 1996), self-control (self-regulation; Corno, 1986; Harnishfeger, 1995; Kuhl & Beckmann, 1985; Winne, 1996), metacognition, including self-awareness (Schraw & Moshman, 1995; Zimmerman, 1990), and self-monitoring and evaluation (Butler & Winne, 1995; Pressley & Ghatala, 1990). Although each behavior is distinct, together they enable a student to be a self-directed learner (Hoyle & Dent, 2017). While some psychologists have attempted to identify which SDL sub-processes are most important to becoming a self-directed learner (Dent & Koenka, 2016), others have stated

that an important aspect of SDL is that it involves “interdependent processes that cannot be fully understood apart from each other” (Zimmerman, 1990, p. 6).

Researchers have studied SDL as both a learning event and a malleable skillset (Dignath & Büttner, 2008; Stoeger & Ziegler, 2008; Winne, 2010). In both conceptualizations, it is understood to be a process that not only involves the thoughts, feelings, strategies, and behaviors within an individual as an isolated event but also consists of dynamic interactions between individuals in their contexts (Schunk & Greene, 2017; Winne, 2010; Zimmerman, 1998). SDL also involves cyclical iterative phases of forethought, performance, and self-reflection (Zimmerman, 2000, 2002), whereby students plan, enact strategies, and monitor performance (see Figure 1). Early empirical research also suggests that contextual factors are likely to shape the development of SDL skills (Hardy et al., 2019). Accordingly, empirical work that examines the bi-directional and iterative nature of SDL development within contexts is needed. In summary, SDL is a complex, multidimensional process, and a nuanced approach to research is required to study it.

Figure 1

Zimmerman's model of self-regulated learning (Zimmerman, 2002).



Note: From B.J. Zimmerman and M. Campillo (2003), "Motivating Self-Regulated Problem Solvers." In J.E. Davidson and Robert Sternberg (Eds.), *The Nature of Problem Solving.* New York: Cambridge University Press.

Importantly, there are many benefits to self-directed learning. For instance, the ability to manage one's learning process supports problem-solving and learning transfer in and beyond school (Betts & Knapp, 1981; Candy, 1991; Guglielmino, 1977; Schunk & Zimmerman, 2012). In addition to supporting personal empowerment (see Freire, 1972), SDL has the potential to

equip students with the "skills and expectations to deal with potentially oppressive situations encountered in their daily lives" (Candy, 1991, p. 55). For instance, as SDL students take on more responsibilities, they learn how to evaluate conditions, make judgments, and seek appropriate help when needed. During the school years, "[SDL] leads to high levels of intrinsic motivation and task interest, and increases academic achievement and outcomes" (Boekaerts, 1997; Cleary & Zimmerman, 2004; Perry & Vandekamp, 2000; Zimmerman, 2002; as cited in Kindekens et al., 2014, p. 1983).

In addition, shifting some responsibility from the teacher to the student foreseeably benefits both parties (Candy, 1991). This way, students learn to be responsible for and take ownership of their learning, which can translate into feelings of autonomy, self-efficacy, and intrinsic motivation (Thomas et al., 1988). For teachers, there is also a time-saving advantage; they can divert more resources to support different types of learners and scaffold students individually. In short, having self-directed students frees up teachers' instructional time (Thomas et al., 1988).

Despite the many benefits of being a self-directed learner, research suggests these individuals are rare. Few students come to the classroom armed with SDL skills (Dent & Koenka, 2016; Zimmerman & Schunk, 2001), and teachers face many difficulties in helping their students become self-directed (Zimmerman, 2002). Even when students possess SDL skills, they may fail to enact them under certain circumstances (Dent & Koenka, 2016; Zimmerman & Schunk, 2001), and the "effectiveness of a strategy may change as a skill develops" (Zimmerman, 1998, p. 2). For example, for one student, the SDL strategy of studying for an exam using flash cards in a quiet library may be highly effective. In contrast, for another student, studying in a group and discussing the topic with peers may prove more useful. While younger

students may rely on more basic SDL skills, such as using mnemonic devices for memorization, older students may benefit from more complex SDL skills, such as integrating knowledge to write an essay. These examples also further illustrate the bi-directional and fused nature of the individual and their context for SDL.

A review of the relevant literature reveals that the rarity of SDL skills is a problem. Without these skills, students' educational preparation may fall short (Zimmerman & Risemberg, 1997). For instance, when students fail to be self-directed in their learning, they may miss opportunities to request help or clarify gaps in their understanding (Zimmerman & Martinez-Pons, 1986). Without a developed sense of self-awareness, which represents a core SDL skill, students are likely to overestimate or underestimate their abilities (Schunk, 2001), which can lead to poor test performance (Ghatala et al., 1989). Furthermore, without self-motivation, students may fail to sustain engagement during important learning exercises (Schunk & Zimmerman, 2012); they may set inappropriate learning goals or fail to effectively achieve them by not engaging in self-management (Zimmerman & Martinez-Pons, 1986; Zimmerman & Risemberg, 1997). Moreover, by not employing appropriate learning strategies, students may depend on external feedback instead of self-correcting (Zimmerman & Risemberg, 1997). In these cases, students are dependent on the teacher, who may not always have the time or resources to provide feedback. For these reasons, students with SDL skills are more likely to excel in their classroom than those who lack these skills.

Although educators largely recognize the benefits of having self-directed learners in the classroom, few know how to help students develop the requisite skills (Dent & Koenka, 2016; Zimmerman et al., 1996; Zimmerman & Schunk, 2001). As recent research suggests, this may be because SDL is a context-dependent, inter-individual, and intra-individual developmental

construct (Hoyle & Dent, 2017). Such complexity has been difficult to account for in research (Dent & Koenka, 2016; Hoyle & Dent, 2017; Lerner & Castellino, 2002). Most studies have examined SDL as a single event (Schunk & Greene, 2017; Zimmerman, 1990) or a static skill (Dent & Koenka, 2016; Winne, 2010). Even studies that have specifically examined the development of SDL have tended to be cross-sectional, identifying, for instance, the timing that subprocesses appear in children rather than the developmental trajectory of SDL skills over time (e.g., Brown, 1978; Paris & Newman, 1990; Ross et al., 2019).

To build on our current understanding of SDL, psychologists have argued that a dynamic systems perspective is needed (Hoyle & Dent, 2017). Even though the individual in context is rarely studied as a fused unit of analysis, theory and evidence suggest it should be (Dent & Koenka, 2016; Heater, 2005). Such a perspective would account for multiple interacting systems at different levels (e.g., individual behavior, classroom environments, school policies, historical events, and milestones of development) that may impact students' development of SDL skills (Hoyle & Dent, 2017). Additionally, relational developmental systems (RDS) approaches provide a framework that accounts for multiple levels of context. It considers "[how] mutually influential relations between individuals and contexts regulate the course of developmental change" (Lerner et al., 2011, p. 146). An RDS approach to SDL would focus on *how* the development of SDL skills unfolds and would consider the individual in context as the unit of analysis.

Key components of RDS metatheory that are important for the study of SDL development include *relationism*, *plasticity*, *intraindividual differences and interindividual differences in intraindividual changes*, and *integrated actions* (Lerner, 1991, 1998, 2007). *Relationism* refers to the idea that variables and developmental systems interact in bidirectional,

reciprocal, or fused ways. For SDL development, this involves the interplay of multiple interacting factors from different systems, including the student's classroom culture, teacher, and age or maturity. Furthermore, *plasticity* refers to an individual's ability to change throughout their lives. In the context of SDL, plasticity may imply that a student of any age has the capacity to learn SDL skills regardless of prior developmental experiences. *Intra-individual* and *inter-individual differences* represent the natural variability occurring from the fused interaction of biology and the environment such that no two people are alike; individuals develop in different ways. This highlights the individual differences and variability that can occur in SDL development. Finally, *integrated actions* suggest that individuals are actors in their contexts and their development in a bi-directional person ← → context relationship. For SDL, integrated actions could involve students as critical actors in selecting and influencing their developmental experiences, further illustrating the bi-directional nature of SDL. In summary, this theoretical lens can help us account for how an individual's behavior and development are influenced by self, maturity, the classroom environment, and temporal events such as a global pandemic.

Development of Self-Directed Learning during Adolescence

Despite the limitations noted above, research has provided educators with evidence of how SDL skills develop across ages. Although children can enact learning strategies and engage in metacognition, developmental research suggests it is not until mid-to-late adolescence that self-monitoring and self-management behaviors, central to productive self-directed learning, are spontaneously produced (Brown, 1978). The developmental pattern of SDL skills across childhood and adolescence represents a steady progression from non-strategic to strategic learning rather than a stage-like shift, as proposed by Piagetians (Beilin, 1992; Piaget, 1926).

Brown and colleagues (1983) described the pattern as "development [that] involves the systematic consolidation, and growing conviction of the appropriateness of the mature strategies, combined with the rejection of plausible but less efficient habits" (p. 49). In other words, although young children may display cognitive and metacognitive behavior essential for self-directed learning, they are inconsistent and simplistic compared to their older counterparts. It also must be prompted.

From a brain development perspective, the growth of the pre-frontal cortex during adolescence suggests these years are likely to be an important time for developing SDL skills. In addition, adolescents gain self-awareness and control over executive functions, which are important for SDL (Weil et al., 2013). Moreover, middle and high school teachers often encourage students to take ownership of and responsibility for their learning (Eccles & Roeser, 2004). Taken together, research suggests that adolescence is a reasonable time for developing and implementing SDL skills; therefore, it is also a suitable time to examine them. As such, the present study followed adolescent students over time, directly observing the unfolding of their SDL skills.

Developmental Contexts and Strategies

While age-related timing is critical in SDL development, we also know that SDL skills are malleable; in other words, they can be taught (Stoeger & Ziegler, 2008; Zimmerman, 2002). However, teaching these skills is challenging (Zimmerman, 1990). Even teachers who desire to support self-directed learners still struggle to do so (Dent & Koenka, 2016; Treffinger & Barton, 1979; Zimmerman, 2002). Over time, many instructional models have been proposed to support the acquisition of SDL skills; they all share similar features, especially the fact that they all follow a cyclical and iterative process (Schunk & Zimmerman, 1998). That is, as students

experiment with strategies, they continuously update their abilities, expanding their repertoire of SDL skills (Hoyle & Dent, 2017). Often, through iterations, there is a gradual transfer from other-regulated behaviors to self-regulated behaviors (Berger, 2011).

In addition, there are specific strategies and environmental learning contexts that are most likely to facilitate the teaching of SDL skills. Specifically, the literature suggests that opportunities to practice SDL skills are necessary if students are to develop this skill set (Thomas et al., 1988; Zumbrunn et al., 2011). Equally, the learning environment should be mastery-oriented, with personal, non-competitive conditions that emphasize learning rather than performance (Thomas et al., 1988). Similarly, rather than focusing on norm-referenced performance, grading should emphasize improvement (Zumbrunn et al., 2011). In summary, SDL is more likely to be prevalent in a classroom that supports it. These contextual supports are aspirational but often difficult to implement in the classroom. However, an alternative approach to education, Montessori, offers a learning environment designed to nurture and support self-direction among its students. Therefore, it was selected as the context for the present study.

Montessori. Developed by Dr. Maria Montessori, the Montessori method is an alternative approach to schooling where students are encouraged to be independent, conscientious, and critical thinkers (Hainstock, 1997). The Montessori Method's key concepts align with SDL-supportive contexts (Lillard, 2017). For example, Montessori schools foster deep engagement through "freedom and discipline" (Rathunde, 2009, 2014). This Montessori concept translates to students who are granted a relatively high degree of choice regarding the content, focus, and approach to their daily studies; simultaneously, the classroom culture calls for high expectations and continuous engagement with self-discipline viewed as a natural process of development (Andrews, 2012). In other words, students organize their open time, pick their

study topics, and choose how long to spend on each lesson with in-built expectations for self-discipline around sharing time, space, and resources with peers and being focused and engaged throughout the school day. Another Montessori principle is blocks of uninterrupted work time throughout the school day. During this time, students have complete control over their studies and what they work on. In these ways, students' learning is inherently student-directed.

The pedagogy also includes methods for self-monitoring and self-evaluation. These opportunities encourage students to take part in determining whether or not they have mastered a concept. In addition, students typically lead parent-teacher conferences. Although the responsibility for learning lies with students, the Montessori Method offers scaffolding and appropriate demands. For instance, teachers clarify what students should learn from the lesson and offer meaningful follow-up tasks to ensure their learning takes hold. Montessori teachers also highlight student responsibilities and help summarize learning (Thomas et al., 1988). As students get older, they are given more responsibility; adolescent-aged students are tasked with planning outings, organizing events, and even running a businesses (Montessori, 1948). When students are younger, they are constantly offered feedback through didactic materials; when they are older they receive feedback through one-on-one meetings and detailed written evaluations (Hainstock, 1997). Finally, students are given opportunities to take responsibility for their learning through open work time, setting their own deadlines, and dispensing their own rewards. In summary, SDL skills are likely to be fostered in the Montessori learning environment.

These postulations are not only theoretical; emerging empirical work has demonstrated that the Montessori Method may help develop SDL skills. For example, a three-year study comparing Montessori to non-Montessori students from similar backgrounds found that Montessori students demonstrated more consistent growth and more self-regulation, an important

SDL skill (Ervin et al., 2010). Having said that, it is important to note that key data and the analysis approach were not reported, so it is impossible to know if these differences were meaningful. However, at least one other study involving Montessori and non-Montessori schools concluded that in adolescence, student-directed learning was linked to greater intrinsic motivation and enhanced learning (Rathunde & Csikszentmihalyi, 2005). In this study, it is important to note that the schools were specifically chosen with the purpose of having pupils with similar demographics and parents with similar backgrounds and parenting styles. Taken together, these studies show the potential of the Montessori environment to foster self-directed learning skills; however, more research is needed to support these emerging findings. The current study addressed this need by examining the development of SDL skills in a Montessori middle and high school.

Historical contexts. In addition to the classroom environment, temporality is also an important context to consider (Lerner & Castellino, 2002). Although students develop SDL skills over time, in some cases, historical events can significantly impact their development (Lerner & Castellino, 2002). For example, war, natural disasters, and global pandemics are likely to disrupt normal school or classroom functioning, and these events could also influence SDL skill development. However, these contextual factors are rarely considered when studying the development of SDL skills among youth due to their unpredictability and disruptions. The longitudinal and mixed-methods research that accounts for these kinds of historical events could shed light on how teachers can most effectively help students when they are impacted by such events.

In conclusion, research has identified important developmental and environmental factors that can impact SDL skills. However, these factors are rarely considered together. To build on

our current understanding of SDL development, research that takes an RDS perspective and considers the individual within their context is needed.

The Need for Mixed Methods and Longitudinal Research

To examine various interacting and developmental contextual factors in the same study, methodological approaches that align with the RDS frameworks are needed. Longitudinal and mixed-methods approaches can be especially useful in research on development (Geldhof et al., 2013). Longitudinal research, for example, can shed light on the developmental trajectories of SDL skills over time (Schunk, 2008), something that few studies have done (Hoyle & Dent, 2017). Also, longitudinal studies, especially those with cross-sequential designs, can account for both cohort and developmental effects. Without such research, confidence in conclusions regarding the foundations of development is limited (Crano et al., 2015; Little, 2018). For example, a cross-sectional study found that some SDL skills, such as self-regulation, declined across adolescence (see Pajares & Valiante, 2002); however, a longitudinal study found that SDL skills were stable from 6th through 8th grade (Heater, 2005). To resolve this discrepancy and others, longitudinal research that captures development in real time is needed.

Furthermore, mixed methods approaches are also justified because they are best suited for multi-faceted, complex research problems (Creswell & Plano Clark, 2018). In contrast, mono-method approaches may fall short given the many skills that contribute to SDL expertise, the cyclical nature of SDL, and the many factors that are likely to shape SDL development. In addition, mixed-methods approaches have the potential to resolve discrepancies by balancing out the strengths and weaknesses of each approach (Johnson & Onwuegbuzie, 2004). For instance, longitudinal quantitative studies are important for shedding light on the developmental trajectory

of SDL while accounting for interacting variables. However, they are unable to provide key information on why and how those changes occur. On the other hand, qualitative studies can provide important, individualized and well-rounded accounts of the phenomenon, but they cannot test important relationships among variables. In mixed-methods studies, the person↔ context relationship can be investigated both ideographically and nomothetically by combining the two methodologies (Geldhof et al., 2013). In addition, findings from qualitative and quantitative approaches can build on one another and support more robust and complete conclusions (Bryman, 2006; Creswell & Plano Clark, 2018). As such, the present study featured a mixed methods design. Together, mixed methods and longitudinal approaches can provide critical insights for educators who need to know when, how, and for whom to introduce SDL skills to students in their classrooms. However, although studies like these are rare, they are needed to yield crucial information regarding how educators can help instill and support these critical learning skills in individuals across settings and over time. By examining the development of SDL skills using mixed methods over time and considering person↔ context relations, the present study provides much-needed information to educators and practitioners to better support the development and use of SDL skills.

Chapter 2: Current Study

Despite the clear benefits of SDL skills, we know very little about how SDL skills develop in students dynamically within context and over time (Dent & Koenka, 2016; Hoyle & Dent, 2017). Since adolescence appears to be an optimal time for students to gain sophisticated SDL skills, more research is needed to explore what SDL skills entail during this stage (Dent & Koenka, 2016; Heater, 2005; Schweder & Raufelder, 2019). As such, the present study sought to investigate the development of SDL skills within teens. Consistent with an RDS framing, this study used the individual in context as the unit of analysis. The study was conducted in an environment supportive of SDL skill development to maximize the chances of encountering students who had or were developing SDL skills. Hence, this study focused on students enrolled in a Montessori school (Lillard, 2017). During data collection, COVID-19 occurred, and schools were required to make changes to keep students healthy. Collecting data amidst a global pandemic provided a unique opportunity to examine the effects of a significant historical event on the development of students' SDL skills.

In conclusion, the current study aimed to provide a systematic investigation of the development of SDL skills during adolescence, taking into account important contextual and developmental influences and individual pathways. Specifically, the current study used RDS-aligned methodology to follow adolescent students attending a Montessori school in Southern California for four years. This study considered how individuals, learning environments, and historical factors influenced the development of adolescent students' SDL skills. A growth-curve analysis of the longitudinal trajectories of change investigated within-person changes over time while accounting for contextual effects that interacted with individual characteristics. Also, a thematic analysis of the qualitative data allowed themes to emerge that shed light on which

factors impacted individuals' subjective experiences with SDL. Finally, collating and weighing the results and findings from each data source (Greene et al., 1989; Morse, 1991) in a convergent mixed-methods design (Johnson & Onwuegbuzie, 2004) allowed for a deeper understanding of SDL development, leading to more nuanced, actionable information for researchers and educators (Creswell & Plano Clark, 2018).

Philosophical Assumptions

For mixed-methods research, evaluating the underlying philosophical assumptions or worldviews that provide the foundation for each approach is important. Quantitative and qualitative research approaches are based on opposing philosophical perspectives. However, the basic underlying paradigm that guides most mixed-method studies, including this one, is pragmatic (Creswell & Plano Clark, 2018). A *pragmatism* worldview focuses on the questions asked and identifies the data collection tools or methods that best inform the problem under investigation. In this way, pragmatism sets aside the ontological split associated with quantitative or qualitative methods and accepts reality as both subjective and objective. Moreover, the investigative approach combines inductive and deductive analyses to address the research questions. As such, using a pragmatic worldview, the following research questions and hypotheses (when appropriate) guided this current investigation:

Table 1.

Research questions by methodological type with methodological approach and hypotheses

Type of Question	Research Questions	Methodological Approach and Hypotheses
Integrative	*Do students' self-reported SDL skills change across adolescence, from 7th through 12th grade, and if so, what does the change look like?*	I assessed this question through a mixed-method integration of the quantitative results and the qualitative findings
Quantitative	*1A. Do adolescent students' SDL skills increase, decrease, or remain stable throughout middle and high school?*	This question was examined using students' quantitative survey responses. Previous research is mixed. Some studies found these skills increase across adolescence (Reio & Ward, 2005), whereas other studies found they remain stable (Heater, 2005). Still, others found a decline in the related self-efficacy for SDL (Pajares & Valiante, 2002). Linear and quadratic shapes were also found across studies. Accordingly, since the current study measured SDL skills (not self-efficacy for SDL), it is hypothesized that students' SDL skills either increased, decreased, or remained stable across adolescence.[2]
Qualitative	*1B. How do students explain changes in their SDL skills across adolescence?*	Qualitative interviews allowed me to explore this question. Patterns around how students talk about the improvement, stability, and possible decline of their self-directed learning skills were explored.
Integrative	*In what ways do factors such as students' grade level and the learning environment impact SDL development?*	I assessed this question through a mixed-method integration of the quantitative results and the qualitative findings
Quantitative	*2A. To what extent do grade level and the Montessori classroom environment impact the development of SDL skills over*	These associations were tested using quantitative student survey data. Previous research suggests the Montessori classroom environment may impact SDL development; therefore, it is

[2] The shape of the trajectory (linear, quadratic, or cubic) was not tested due to limited power because of the small sample size.

	time? If there are effects, in which direction and to what extent do they shape SDL skills?	hypothesized that in the current study, the Montessori learning environment had a significant effect on students' SDL skills. Moreover, since the Montessori pedagogy is well-aligned with approaches that foster SDL skills, it is also hypothesized that students who have participated in Montessori programs for longer would have higher SDL skills than students who have been in Montessori programs for less time.
Qualitative	*2B. How do person ← → context relations, including maturation and the Montessori environment, play a role in the inter-individual and intra-individual differences in students' SDL development?*	Qualitative interviews were analyzed to explore how students describe intra-individual differences in the development and use of their SDL skills, including students' bi-directional role in shaping their contexts and SDL development, as well as when and why maturation and elements of the Montessori environment, like autonomy support, open work time, and others may be important for the development of students' SDL skills. I also looked for patterns of inter-individual differences across student interviews.
Integrative	*Have changes in the learning environment associated with COVID-19 shaped the development of students' SDL skills? If so, how?*	I assessed this question through a mixed-method integration of the quantitative results and the qualitative findings
Quantitative	*3A. Is there a significant change in students' SDL skills before and after the onset of COVID-19 and subsequent educational adaptations? If so, in which direction and to what extent is there an impact on students' SDL?*	I used quantitative student survey responses from before and during COVID-19 to answer this question. Since there is no previous theory or research on the impact of a global pandemic, this is an exploratory question without clear hypotheses.
Qualitative	*3B. According to students, how have educational changes associated with COVID shaped the development of their SDL skills? Why have these changes unfolded?*	These exploratory questions were considered using student interviews. I analyzed patterns from students' responses regarding the perceived impact of the global pandemic on aspects of their self-directed learning, like their motivation, independent learning, and sustained attention.

Chapter 3: Methods

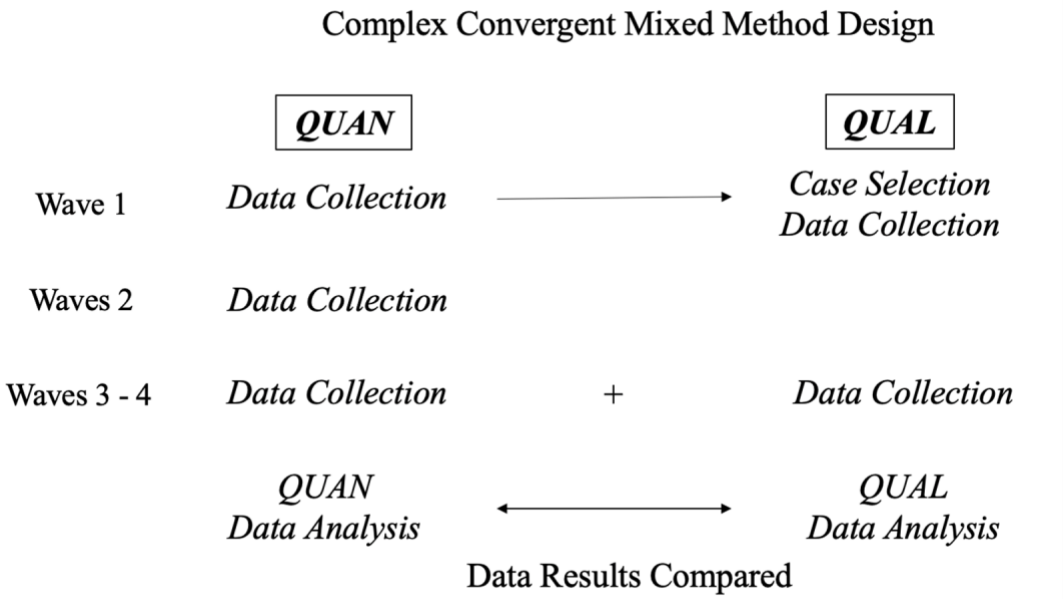
To address the overarching research questions, the present study used survey and interview data collected over four years (2018-2021) as part of an evaluation study with a middle and high charter Montessori school assessing student outcomes. The present study featured longitudinal survey data from an accelerated longitudinal design (ALD; a.k.a., cross-sequential design). The ALD involves following multiple cohorts of students across time and repeatedly enrolling new individuals in the study (Little, 2018). The ALD design has several advantages over a single cohort design, including its ability to examine a longer developmental age span (e.g., 7th through 12th grade) within a shorter period (e.g., four years; Galbraith et al., 2017) and to handle missing data and smaller sample sizes (Little, 2013).

In addition to surveys, this study also featured semi-structured interviews conducted over the same period. Semi-structured interviews involves asking participants a set of open-ended questions in a flexible manner, allowing the interview to be guided by the researchers' questions as well as explore topics raised by students (Creswell & Poth, 2018). Open-ended questions with a subsample of cases yielded data that were examined for trends within and across individuals.

When combined, qualitative and quantitative data sources provided complimentary and discrete information about students' SDL skills and development over time. Figure 2 depicts how the data were used in the convergent mixed-methods design. In addition, surveys and interviews, collected simultaneously, were analyzed separately then together to address the relevant guiding research questions (Creswell & Plano Clark, 2018).

Figure 2

Convergent Design adapted from Creswell et al. (2003).



Note: QUAN = Quantitative, QUAL = Qualitative

Participants

The current study featured a sample of students in grades 7-12 from a southern California public charter Montessori middle and high school, where self-directed learning is intentionally fostered (Lillard, 2017). The school setting was selected to maximize the likelihood of detecting SDL skills. Starting in 2018, students were invited to complete an annual survey about their self-directed learning skills and to provide demographic information (e.g., age, gender, race/ethnicity). All 214 students in middle and high school in 2018 were invited to participate in the study. Students who returned parental consent forms and provided their assent were given class time to take a survey about their SDL skills. In each subsequent year, all middle and high

school students, with parent permission, were invited to participate in the study, meaning new participants were added at each wave of data collection.

Wave 1 of data collection occurred in the spring of 2018 and included 136 responses (18 responses were removed due to missing data); Wave 2 took place in the spring of 2019 and included 144 responses (1 response was removed due to missing data); Wave 3 was recruited in the spring of 2020 and included 44 responses (14 responses were removed due to missing data), and Wave 4 was recruited in the fall of 2020 and in the spring of 2021 to increase the sample size due to lower participation during COVID-19; wave 4 included 142 responses (33 responses were removed from the data set due to missing data; 33 responses were removed from the data set due to repeat entries[3]). Students who participated year after year responded to the same surveys. Table 2 describes the cleaned sample for each wave of data collection, while Figure 3 depicts the number of students in each grade level across waves of data collection.

Across waves of data collection, each student responded to the survey between one and four times (n = 284). One hundred and forty-three students responded to the survey only once, 62 responded twice, 22 responded three times, and eight responded four times. To achieve 90% power, 50 participants at each data collection point, or 200 measurements, are needed in an accelerated longitudinal design (Galbraith et al., 2017). Although the number of participants with at least three responses to the survey in this study was fewer than 50, the total number was considerably higher than 200. Moreover, the current analyses are robust to missing data (Little, 2018). Taken together, the parameters suggest this sample size could sufficiently examine the

[3] Due to the way Wave 4 data were collected, students could have responded to both the fall and the spring survey administrations. A repeated measures t-test found students' responses for the two data collection times were not statistically different ($M_{Wave\ 4}$ = 3.66, $SD_{Wave\ 4}$ = 0.46; $M_{Wave\ 5}$ = 3.65, $SD_{Wave\ 5}$ = 0.42; p = 0.820). Therefore, for students with two responses, only their first response was included in the study.

relationships and changes under investigation.

Figure 3

Number of Survey Participants by Grade Level and Data Collection Wave

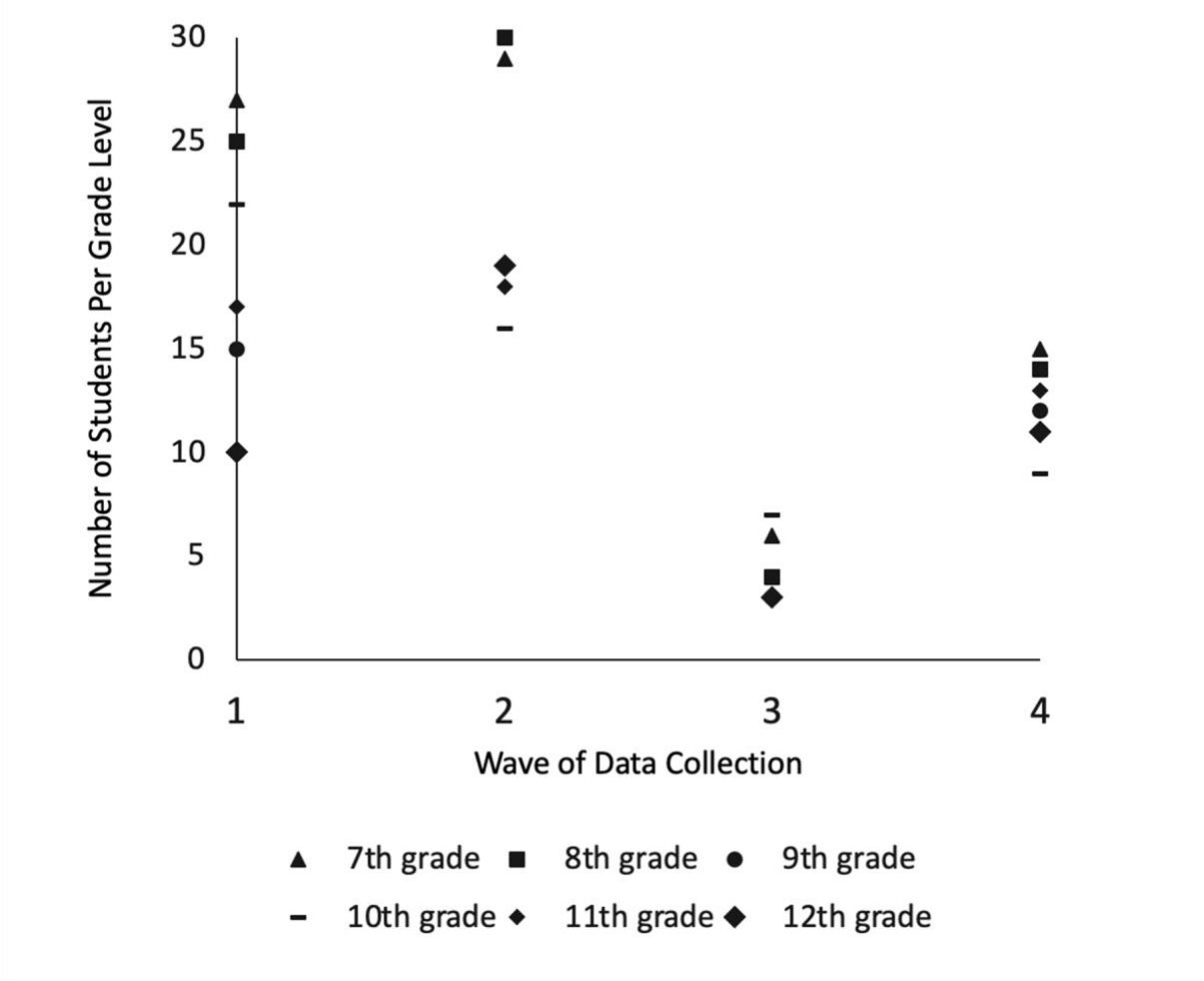


Table 2.

Survey Sample Description Table by Data Collection Wave

	Wave 1 n = 118		Wave 2 n = 143		Wave 3 n = 27		Wave 4 n = 77	
	N	*%*	*N*	*%*	*N*	*%*	*N*	*%*
Sex								
Female			81	56.6%	17	65.4%	46	62.2%
Male			59	41.3%	7	26.9%	24	32.4%
Other			3	2.1%	2	7.7%	4	5.4%
Race/ethnicity								
White			77	54.2%	16	61.5%	52	70.3%
Hispanic or Latino/Latina			23	16.2%	6	23.1%	8	10.8%
Black or African American			3	2.1%	0	0.0%	1	1.4%
American Indian or Alaska Native			0	0.0%	0	0.0%	0	0.0%
Asian			11	7.7%	1	3.8%	3	4.1%
Native Hawaiian or Pacifica Islander			0	0.0%	0	0.0%	0	0.0%
More than one race/ethnicity			28	19.7%	3	11.5%	8	10.8%
Other			0	0.0%	0	0.0%	2	2.7%
Grade Level								
7th grade	27	23.3%	29	20.3%	6	23.1%	15	20.3%
8th grade	25	21.6%	30	21.0%	4	15.4%	14	18.9%
9th grade	15	12.9%	31	21.7%	3	11.5%	12	16.2%
10th grade	22	19.0%	16	11.2%	7	26.9%	9	12.2%
11th grade	17	14.7%	18	12.6%	3	11.5%	13	17.6%
12th grade	10	8.6%	19	13.3%	3	11.5%	11	14.9%
Number of Years in Montessori								
1-3 years	41	35.3%	52	36.9%	6	23.1%	23	31.1%
4-6 years	22	19.0%	26	18.4%	7	26.9%	10	13.5%
7-9 years	9	7.8%	6	4.3%	3	11.5%	5	6.8%
10-12 years	24	20.7%	34	24.1%	4	15.4%	23	31.1%
13 + years	15	12.9%	23	16.3%	5	19.2%	13	17.6%

Note: Wave 1 data were collected in the spring of 2018, Wave 2 data were collected spring of 2019, Wave 3 data were collected spring of 2020, and Wave 4 data were collected fall 2020 and spring 20201.*

**Sex and Race/ethnicity were not collected in Wave 1 because it was determined that they were not pertinent to the evaluation questions under investigation at the time.*

For the interviews, students were selected using a purposeful, stratified sampling strategy. Participants with a range of SDL skills were included (Patton, 2015). The aim was to follow a few students with average (within one standard deviation of the mean), above average (one standard deviation above the mean), and below average (one standard deviation below the mean) SDL skills over time to explore developmental patterns. As such, only students with at least two interviews were included in the current study. In order to determine their SDL skill level, students' scores from the SDL survey were compared against the mean SDL survey score from the first wave of data collection (M = 3.53, SD = .46). As with most longitudinal studies, attrition was a problem. Of the sixteen students who were initially invited to participate in the interviews (6 average, 5 above average/high, and 5 below average/low), seven students participated in all three interviews and four participated in at least two interviews. This yielded a total of 11 cases and 29 interviews. The 11 cases represented a range of ages, from 7th through 11th grade (median grade at time one = 8), and an equal number of male and female (50%) participants. Table 3 provides a full description of the cases at each interview time point. Notably, four interview participants left or graduated from the Montessori school before the end of the study; however, they were still included in the analyses because they had participated in the Montessori program for a significant length of time, thereby having ample time to be immersed in the self-directed, Montessori pedagogy. At the time of the initial round of data collection, the interviewed participants had been enrolled in Montessori schools for an average of 7.73 years.

Table 3.

Interview Sample Description Table by Data Collection Timepoint

Characteristics	Time 1 n = 11		Time 2 n = 10		Time 3 n = 8	
	N	*%*	*N*	*%*	*N*	*%*
Sex						
Female	5	45.5%	5	50.0%	2	25.0%
Male	6	54.5%	5	50.0%	6	75.0%
Grade Level						
7th grade	2	18.2%	0	0.0%	0	0.0%
8th grade	4	36.4%	0	0.0%	0	0.0%
9th grade	2	18.2%	1	10.0%	0	0.0%
10th grade	2	18.2%	5	50.0%	2	25.0%
11th grade	1	9.1%	2	20.0%	3	37.5%
12th grade	0	0.0%	1	10.0%	2	25.0%
Post-secondary	0	0.0%	1	10.0%	1	12.5%
Number of Years in Montessori						
1-3 years	4	36.4%	1	10.0%	1	12.5%
4-6 years	0	0.0%	1	10.0%	1	12.5%
7-9 years	2	18.2%	1	10.0%	1	12.5%
10-12 years	4	36.4%	3	30.0%	3	37.5%
13 + years	1	9.1%	4	40.0%	2	25.0%
SDL Scores from Time 1						
High SDL	5	45.5%	4	40.0%	3	37.5%
Average SDL	3	27.3%	3	40.0%	2	25.0%
Low SDL	3	27.2%	3	30.0%	3	37.5%

Note: SDL = Self-Directed Learning; Time 1 interviews were collected in the spring of 2018, Time 2 interviews were collected spring of 2020, Time 3 interviews were collected spring of 2021.

Measures

Quantitative Measure

Students responded to a survey for the original evaluation study that measured students' self-directed learning skills. The classroom environment was also measured in the survey by having students indicate the number of years they had attended a Montessori school. Similarly, students indicated their current grade level in the survey. Other demographic variables (e.g., sex, race/ethnicity) were collected starting in Wave 2.

Self-Directed Learning Skills. The Self-Directed Learning Rating Scale (SDLRS) was used to measure students' self-directed learning skills (Guglielmino, 1977; Appendix A). The SDLRS is a closed-ended, 41-item scale, and respondents were asked to rate each item on a 5-point Likert scale ranging from (1) "Almost never true of me" to (5) "Almost always true of me." Sample items from the scale included, "if there is something I want to learn, I can figure a way to learn it" and "I try to relate what I am learning to my long-term goals." The scale has a Pearson's split-half reliability of .94 (Guglielmino, 1988b, as cited in Guglielmino, 1989). The SDLRS was not designed to be used with adolescents or longitudinally; however, it demonstrated high internal consistency with the current sample (Wave 1 α = .893, Wave 2 α = .908, Wave 3 α = .944, Wave 4 α = .925).

Qualitative Measure

Three semi-structured interview protocols were created for the original evaluation study. Each protocol included open-ended questions (Creswell, 2013) that explored students' (1) motivation and experiences with SDL, (2) their current skill level with SDL, and (3) contexts and factors that may have influenced their SDL abilities. The questions regarding students' SDL skills were also developed to account for the skills related to the forethought, performance, and

self-reflection phases in Zimmerman's (2000; 2002) model of self-regulated learning. Also, the second and third interview protocols included additional questions designed to probe changes in students' SDL skills over time as well as any impact on their SDL abilities from changes in the learning modality associated with COVID-19. The interview protocols for each wave can be found in Appendix B. Interviews were conducted by trained graduate students in-person or over Zoom. All interviews were audio recorded and transcribed. They lasted an average of 52 minutes.

Data Analyses

The following analyses were used to explore the development of students' SDL skills over time and to address the above research questions.

Quantitative Analyses

First, data were prepared (e.g., reverse-coded items were addressed, and composite variables were created). Then the normal distribution was assessed (by examining the skew and kurtosis for the variables of interest, including SDL, grade level, and years in Montessori). Next, two-tailed Pearson's R correlations were examined for the predictor and criterion variables at each data collection wave.

To answer research questions 1A and 2A *(1A, do adolescent students' SDL skills change throughout middle school and high school; 2A, to what extent does grade level and the Montessori classroom environment have an impact on the development of SDL skills over time? If there are effects, in which direction and to what extent do they shape SDL skills)*, descriptive analyses and a multilevel model (MLM) growth curve analysis were completed using the "ggplot," "nlme," and "panelr" packages in R Studio. First, the data were prepared by combining

each wave of data collection into a single dataset and transforming the format from short to long. Next, SDL, as the outcome variable, was centered around the grand mean to support interpretation. To make the intercepts easier to understand and to lessen the possibility of biased estimates at Wave 1, grade level was also centered so that grade seven (the first grade in middle school) was equal to zero (Kreft et al., 1994; Mehta & West, 2000). Next, the data were visually analyzed to explore within- and between-person patterns. Using the ggplot package in R, two spaghetti plots were created. One plot included the data collection waves on the x-axis, representing the passage of time, while the second plot included grade level on the x-axis, representing the developmental passage of time of interest for this study. These visual inspections are used to approximate the developmental trajectories and differences between within-person and between-person variability. As another indicator of within- and between-person variability, an intraclass correlation (ICC), was calculated.

Next, a series of MLM analyses using the nlme and panelr packages in R was completed to explore developmental patterns in students' SDL skills. First, the nlme package was used for the no-growth and unconditional growth models. However, upon close inspection of the output of the unconditional growth model, it was determined that the default function for nlme included participant responses with only one data point. This was an issue because the slope of a line (i.e., to measure growth) can only be calculated with at least two data points. Therefore, the panelr package in R was used for the unconditional and conditional growth models. The panelr package has a default function that only includes participants with at least two time points in the model. Model outputs from both packages were inspected closely to confirm similar results. There were only minor differences due to the unique calculations for the degrees of freedom in each

package. The growth model consisted of two levels with grade-level (Level 1) nested within individuals (Level 2). The equations that were used are presented below.

Level 1: $SDL_{ti} = b_{1i} + b_{2i}(grade\ level)_{2i} + u_{ti}$

Level 2: $b_{1i} = \beta_{01} + d_{1i}$

$b_{2i} = \beta_{02} + d_{2i}$

Levels 1 & 2 Combined: $SDL_{ti} = (\beta_{01} + d_{1i}) + (\beta_{02} + d_{2i})*(grade\ level)_{2i} + u_{ti}$

In addition, a growth curve analysis was planned to answer research question 2A: *To what extent do grade level and the Montessori classroom environment impact SDL skill development over time? If there are effects, in which direction and to what extent do they shape SDL skills?* The final planned model included the number of years a student had been enrolled in Montessori as a time-varying covariate, which could also be examined in interaction with students' grade level. The equations for the planned analysis are presented below.

Level 1: $SDL_{ti} = b_{1i} + b_{2i}(grade\ level)_{2i} + u_{ti}$

Level 2: $b_{1i} = \beta_{01} + \beta_{11}*(years\ in\ Montessori)_i + d_{1i}$

$b_{2i} = \beta_{02} + \beta_{12}*(years\ in\ Montessori)_i + d_{2i}$

Levels 1 & 2 Combined: $SDL_{ti} = (\beta_{01} + \beta_{11}*(years\ in\ Montessori)_i + d_{1i}) +$

$(\beta_{02} + \beta_{12}*(years\ in\ Montessori)_i + d_{2i})*(grade\ level)_{2i} + u_{ti}$

However, this final model was not tested due to a non-significant unconditional growth model, which is discussed further in the results section below.

Finally, a repeated measures ANOVA test was performed to answer research question 3A: *is there a systematic change in students' SDL skills from before and after the onset of COVID-19 and subsequent educational adaptations? If so, in which direction and to what extent is there an impact on students' SDL?* This analysis allowed the researcher to examine students'

SDL scores before and after the onset of COVID-19. Because the onset of COVID-19 and subsequent changes educationally were time-bound and grade was used as a proxy for time, the effects related to COVID-19 could not be examined in the growth model. Instead, student responses on the survey were grouped into "pre-COVID-19" and "post-COVID-19" as the independent variables for the ANOVA analysis. This way, the potential developmental effect of grade level was controlled since students were at varying grade levels in both the pre-and post-measurements. To create "pre" and "post" COVID-19 variables, students' scores were included if they only had one response for pre or post. For students with more than one "pre" or "post" COVID-19 response, their SDL scores were averaged. The dependent variable was students' scores on the SDL measure. The data was kept in a wide format, and the analysis was conducted using SPSS.

Qualitative Analyses

The qualitative data analysis in the present study was done using a case study approach. According to Creswell (2018), case study research is a form of empirical inquiry that investigates a phenomenon in depth and within its real-life context. Participants were treated as cases and were purposefully selected to represent a range of SDL skills. Analysis of these cases featured both idiographic and nomothetic approaches (Johnson & Onwuegbuzie, 2004). While idiographic analyses focused on understanding intra-individual changes over time, nomothetic analyses focused on identifying patterns and trends around SDL development across participants (Runyan, 1983). Both approaches to analysis were inductive, meaning a priori codes did not govern analysis; instead, themes and patterns were allowed to emerge from the dataset. Analysis within and across cases also yielded exploratory insights into the development of SDL skills.

Furthermore, thematic analysis was used to code the interviews. Thematic analysis is a flexible approach to coding qualitative data that involves reading transcripts and identifying patterns within and across participants (Braun & Clark, 2006). It is widely used to analyze qualitative data in psychology, and it is particularly useful for studies, such as this one, that seek to identify patterns in the data. Accordingly, I read and coded all transcripts to become familiar with the data. Next, I re-read the transcripts by case and began the initial coding process, in which I looked for themes relevant to each qualitative research question. Next, consistent with thematic analysis, I collaged the codes with supporting data, meaning I grouped the passages related to each code. Following this, codes were grouped into themes, and themes were revised, merged, and removed to ensure the best fit for the data (Glaser & Strauss, 1967). This process unfolded until transcripts were fully coded.

Mixed Method Integration

Once the surveys and interviews were analyzed separately, findings were integrated to draw inferences across the two methods (Creswell & Plano Clark, 2018). Concepts from each analysis that were analogous across methods were identified and compared. The extent to which the two methods could be used to elaborate on or enhance the findings of each other was also considered (Greene et al., 1989). The results from this data integration are visualized in a joint display and discussed in the following section.

Chapter 4: Results and Findings

Quantitative Results

The descriptive and correlation results for the variables included in the study are reported by waves in Tables 4 and 5, respectively. An examination of the descriptive statistics revealed that the variables were normally distributed. Skew and kurtosis for each variable fell within an acceptable range of -3 and 3. Also, the correlation tables showed that SDL for each wave was moderate to strongly correlated (.57-.89), grade level for each data collection wave was also highly correlated, between .87-1.00, and the number of years in Montessori was highly correlated to other waves (.77-.98). In addition, grade level and the number of years in Montessori were only moderately correlated in wave 1 (.30), which provided evidence that there was likely no multi-collinearity between grade level and the number of years in Montessori. Finally, SDL was sometimes slightly to moderately correlated with the number of years in Montessori across waves (.17-.50) but was not correlated with grade-level waves.

Table 4.

Descriptive Statistics for SDL, Grade Level, and Years in Montessori by Wave

Measures	*n*	M	SD	Skew	Kurtosis
Wave 1					
1. SDL	116	3.55	0.45	0.240	0.042
2. Grade Level	118	10.06	1.63	0.262	-1.159
3. Years in Montessori	113	6.76	4.70	0.363	-1.363
Wave 2					
4. SDL	143	3.53	0.51	-0.011	-0.075
5. Grade Level	143	10.15	1.68	0.350	-1.095
6. Years in Montessori	141	6.88	4.75	0.277	-1.387
Wave 3					
7. SDL	26	3.74	0.58	-0.310	-0.576
8. Grade Level	27	10.26	1.68	0.032	-1.144
9. Years in Montessori	26	7.08	4.71	0.379	-1.312
Wave 4					
10. SDL	74	3.50	0.46	0.074	-0.073
11. Grade Level	77	10.30	1.76	0.151	-1.36
12. Years in Montessori	77	7.55	4.99	0.101	-1.337

Table 5.

Correlation Table of SDL, Grade level, Years in Montessori by Wave

Measures	1.		2.		3.		4.		5.		6.		7.		8.		9.		10.		11.
Wave 1																					
1. SDL	--																				
2. Grade Level	.09		--																		
3. Yrs in Montessori	.37	**	.30	**	--																
Wave 2																					
4. SDL	.83	***	-.19		.19		--														
5. Grade Level	.01		.94	***	.16		.14		--												
6. Yrs in Montessori	-.01		.31		.77	***	.11		.22		--										
Wave 3																					
7. SDL	.63	***	-.10		.33		.89	***	-.22		.12		--								
8. Grade Level	.02		.94	***	.00		-.10		1.00	***	-.07		-.01		--						
9. Yrs in Montessori	.30		.03		.89	***	.29		-.15		.94	***	.17	*	.00		--				
Wave 4																					
10. SDL	.68	***	-.21		.46	*	.78	**	-.36		.45		.57	***	-.03		.21		--		
11. Grade Level	-.08		.87	***	-.03		-.33		1.00	***	-.34		-.02		.99	***	-.13		-.04		--
12. Yrs in Montessori	.50	*	-.10		.83	***	.46		-.48		.92	***	.20		-.16		.98	***	.24	**	-.04

* $p < .05$, ** $p < .01$, *** $p < .001$.

Note: SDL = students' SDL scores; Grade level = the grade students were in each Wave; Yrs in Montessori = the cumulative number of years students were enrolled in Montessori.

To answer research question 1A, *do adolescent students' SDL skills increase, decrease, or remain stable throughout middle school and high school?* The spaghetti plots were first visually inspected. Both spaghetti plots for SDL scores by data collection wave (see Figure 4) and SDL scores by students' grade levels (see Figure 5) depicted high within- and between-person variability. Figure 4 uniquely depicts the drop-off in student responses during COVID-19 (after Wave 2). Figure 5 shows that for some students, their SDL skills increased; for some, they decreased; and for others, they remained relatively stable across middle and high school grades. Changes in SDL levels among students tended to be dramatic across the middle school and more gradual across the high school.

Figure 4

Spaghetti Plot of Students' SDL Scores by Data Collection Wave

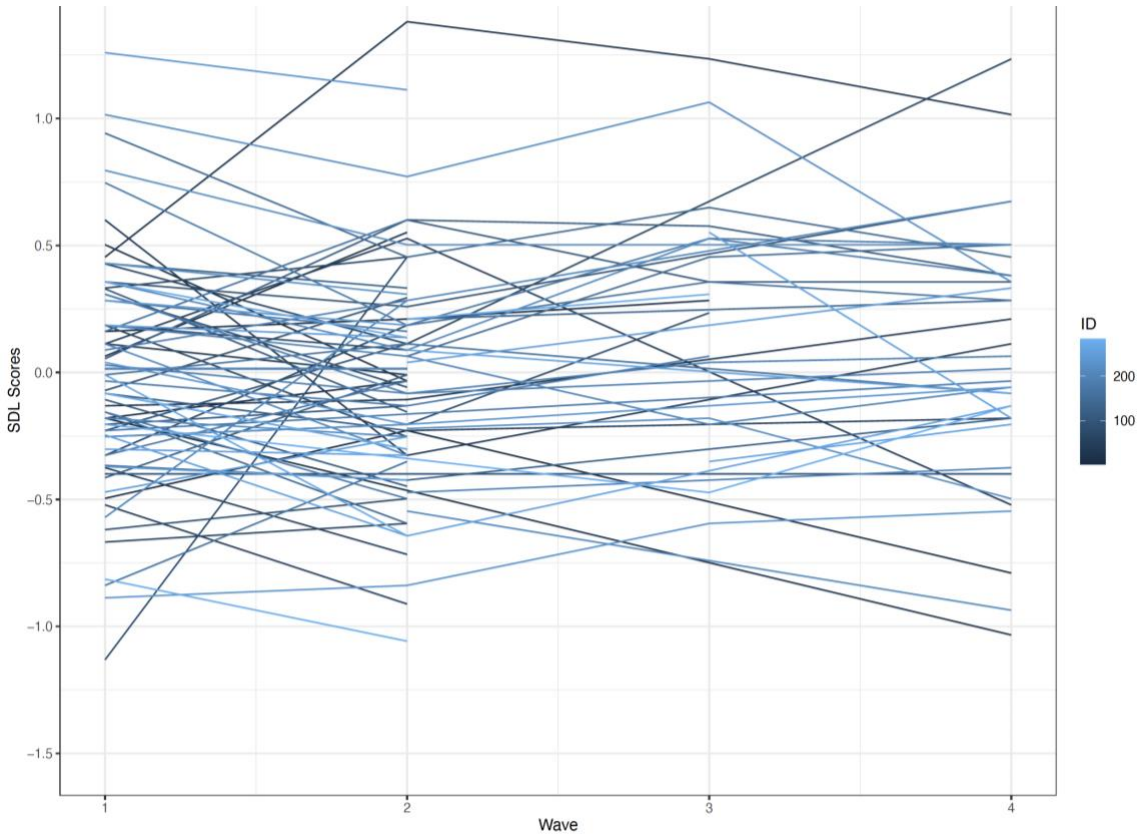
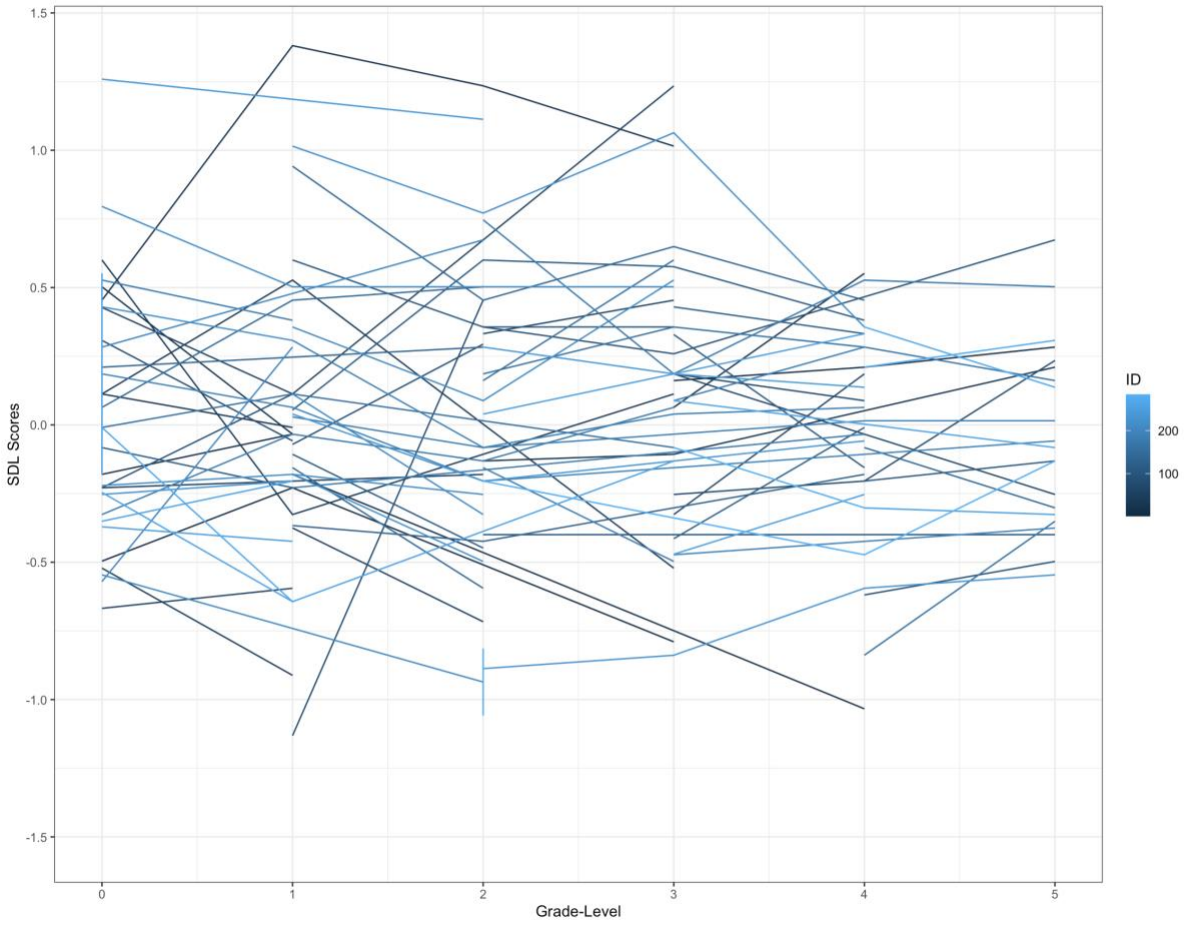


Figure 5

Spaghetti Plot of Students' SDL Scores by Students' Grade Level



Next, the intraclass correlation (ICC), which is a ratio of the random intercept variance (between-person variability) over the total variance (between-person + within-person variability), was calculated. ICCs are used to indicate how much individuals within a group are similar to one another (Singer & Willett, 2003). Growth modeling, which examines within-person changes over time, is only appropriate when there are differences within individuals. Results from this study demonstrated that the between-person variability was 70%, and the within-person variability was 30%, meaning there was a moderate to high between-person variability and a low to moderate

within-person variability in the sample. In other words, there was sufficient within-person variability (30%) to warrant a growth model investigation.

Next, to examine the data inferentially, a no-growth model was first tested. This allowed the researcher to eliminate the null hypothesis that there was no change in students' SDL skills over time (Grimm et al., 2016). The no-growth model was non-significant (Table 6), meaning the individual and mean intercept scores differed. In other words, the non-significant no-growth model indicated that SDL scores varied over time, and a growth model might better fit the data. An unconditional growth model with grade level (a proxy for time) was tested next. The results from this analysis are also presented in Table 6 and indicated no significant effect of grade level (time). In addition, the fit indices, which allow for model comparisons, can be found in Table 7. Models with lower AIC and BIC numbers are thought to have a better model fit. Despite the model indicating no growth in students' SDL scores over time, the unconditional growth model demonstrated the best model fit. This model also explained a large portion of the variance in students' SDL scores (R^2 = .65).

Table 6.

Multilevel model results

	No Growth Model					*Unconditional Growth Model*				
	b	*(SE)*	*df*	*t*	*p*	*b*	*(SE)*	*df*	*t*	*p*
Fixed effects										
Intercept	-0.03	(0.03)	127	-0.80	0.424	0.01	(0.08)	91	0.07	0.95
Grade level	--	--	--	--	--	0.00	0.03	92	-0.12	0.91
Random effects										
Intercept		*(0.41)*					*(0.36)*			
Slope										
Residuals		0.27					0.27			

* $p < .05$, ** $p < .01$, *** $p < .001$.

Table 7.

Multilevel regression model fit statistics

	AIC	*BIC*
No growth model	*421.53*	*433.18*
Unconditional model with grade level	*211.59*	*228.47*

Results from this study suggest that students' SDL skills vary with time. However, the non-significant unconditional growth model implies that grade level may not be the best temporal indicator for capturing developmental trends in SDL. It is also possible that the sample size was insufficient to detect change over time as measured. In addition, the results from this set of analyses demonstrated high between-person variability and moderate to low within-person variability, which suggests that students can vary greatly in their SDL skills (at least in terms of the outset of this study). Yet, once on a developmental path, the changes for any student tended to be more moderate. Furthermore, the inconsistencies in descriptive plots across students' SDL trajectories in middle school, when compared to their descriptive plots in high school, might suggest a pattern that early adolescence is an experimental period for SDL development and that by later adolescence, students settle into SDL abilities. Investigating this trend may be an important area for future research to focus on so that interventions to support students' SDL growth can be targeted and aligned to students' developmental stage.

The next research question (2A) was: *Is the number of years spent in the Montessori classroom environment related to changes in students' SDL skills? If so, in which direction and to what extent?* The planned full growth model including the number of years students spent in the Montessori program as a time-varying co-variate was not calculated due to the non-significant unconditional growth model. Full model analyses, which include co-variates as a predictors of change, are only appropriate when change occurs and the unconditional growth

model is significant (Singer & Willett, 2003). Due to the small sample size and limited power to detect effects, more research with larger data sets are needed to draw conclusive findings.

Finally, research question 3A asks: *"is there a significant change in students' SDL skills from before to after the onset of COVID-19 and subsequent educational adaptation" If so, in which direction and to what extent is there an impact on students' SDL*?" These questions were addressed using repeated measures ANOVA. Results are presented in Table 8. There were no measured significant differences between students' SDL scores prior to and after the onset of COVID-19. This finding may indicate that students were only nominally impacted by the events of COVID-19, or it may be that these kinds of impacts were not captured by the measures used in the present study. The latter explanation seems most likely given that other research consistently finds that COVID-19 has had significant effects on student learning (Huck & Zhang, 2021; Simpson, 2020; Tarkar, 2020; Wilson et al., 2020). Qualitative findings from the present study offer additional insight into this issue.

Table 8.

Results for repeated measures ANOVA

Measures		Pre-COVID-19		"Post"-COVID-19				
	n	*M*	*SD*	*M*	*SD*	*F*	*df*	*p*
SDL Scores	28	3.62	0.42	3.66	0.53	.224	1	.640

* $p < .05$, ** $p < .01$, *** $p < .001$.

Qualitative Findings

The qualitative findings are presented below by research question. Bands are provided to represent the frequency with which findings emerged across cases. As such, "all" means *all* the cases said something was coded this way, "most" means more than half (6 or more) of the

students said something was coded this way, "several" means between two and five of the students said something was coded this way, while "only one" means that one student said something was coded this way.

Patterns of SDL Skill Change Over Time

For research question 1B, *"how do students explain changes in their SDL skills across adolescence*?" three themes emerged. Throughout the research study, students stated that their SDL skills improved, declined, or remained stable. These themes were not mutually exclusive for individual students. For instance, throughout their interviews, students sometimes reported growth and stability, and at other times, they reported declines. However, growth was the most commonly reported change in SDL skills by students, such that *all* students reported growth at some point in their interviews. For example, when an 11th-grade boy who began the study with average SDL skills was asked about how his SDL skills had changed over time, he reported: "I think it's been something that's more recently come to me because personally, I've been getting involved in a lot . . . of small things and managing my time a lot better than in the past" (JG_2021). Similar responses about growth in their SDL skills were reported by all students.

In addition to an increase in SDL skills, several students also reported a decline. For those students, the decline was always associated with the changes in the learning context related to COVID-19. In his third interview, for example after the onset of COVID-19, a 10th-grade boy with high SDL skills noted, "during the distance learning I was a bit, I was probably less of a self-directed learner than the years before" (BAP_2021). While less common, several students indicated a similar loss in their SDL skills around the time of COVID-19.

In addition, most students also reported stability in their SDL skills throughout the study. The rationale students gave for the stability in their SDL skills was typically due to the student

having learned the skill when they were younger. For example, an 11th-grade girl who began the study with low SDL skills reported, “I felt like I've just always kind of been that way” (SLB_2020). Another 12th-grade boy who had low SDL skills reported a similar sentiment when asked about his SDL skills around goal setting:

> Student: I think usually I do meet the goals that I've set, sometimes I aim a little bit too high, but typically I'm able to meet goals 'cause I see them as guidelines.
>
> Interviewer: Is this something that's changed or stayed the same for you as you've gotten older?
>
> Student: I think it's stayed the same, pretty much the same. Maybe I've gotten a little better at it, but I think it's stayed pretty much the same. (KDM_2021)

Again, across cases and interviews, the experience of growth, decline, or stability was not mutually exclusive. Most students experienced at least two types of change, and several experienced all three throughout the study. The reason for this overlap is related to the second theme described below.

The second theme that emerged involved the intra-individual development of students’ SDL skills. Students described changes in some SDL skills but not in others. For example, students might have described improvements in help-seeking when they encountered obstacles but not in their ability to set and regulate goal pursuit. For example, an 11th-grade boy with average SDL skills described improvement in many abilities, including goal setting and goal pursuit: “I think I've been getting a lot better with giving myself direct goals that I can work towards, and I end up completing” (JG_2021). On the other hand, when asked if he knew how he learned best, he replied: “Oh, absolutely not. . . . I think maybe as I get older, I will start to understand how I learn a bit better. But for right now, it's just kind of . . . I don't think I really

have anything set in stone yet" (JG_2021). Such developmental uniqueness of each SDL skill was apparent in all of the student interviews.

The third emergent theme was the type of growth that students described. Students described their growth as either increasing in quantity or becoming more sophisticated, as in something qualitatively different, or both. This type of growth varied depending on the SDL skill students discussed. All students described quantitative, or incremental, growth in their SDL skills, while several cases reported qualitative growth, or increases in the level of sophistication, in their SDL skills. An example of incremental growth comes from a 10th-grade boy with high SDL skills. When asked how he became responsible for his learning, he reported: "I started self-regulating, so whenever there's something that had to be done, I'd just start doing it before mom and dad would tell me to. . . . I've definitely become more organized, more analytical, and more responsible" (LSC_2020). The way this student described the growth of his SDL skills over time was most common among the students interviewed. Yet, other students also talked about their SDL skills becoming more sophisticated over time. This sophistication played out when students either applied the SDL skill in a new way or adapted the skill to a new situation. For example, the skill might have started as a student's awareness of their interests—what topics they are drawn to or how they are able to stay engaged in topics they find intrinsically motivating. As the skills transforms or becomes more sophisticated, a student may be able to self-motivate themselves to learn about a topic that they are not intrinsically drawn to by identifying adjacent elements related to the topic that they are interested in. This is best illustrated through the example of an 8th-grade girl with high SDL skills who discussed how interest and goal setting were motivating to her: "I think it is definitely when I am interested in the topic . . . and when I set that goal . . . I feel like I am really engaged and focused. . . . . [I] usually can achieve it"

(JM_2018). This example demonstrates an early stage of the SDL skill. However, when the same student was interviewed two years later, her understanding of interest had become more sophisticated. She could cultivate interest even when it was not there intrinsically. “I try to find something interesting in it, I guess, that I can enjoy, and see if I can find passion [and] work on it through that” (JM_2020). This type of sophistication of SDL skills also appeared when students applied the skills that they learned in one context to another. For example, a sophomore in college who started the study in eleventh grade with average SDL skills described transferring her skills across settings: “I was taking more STEM classes when that clicked for me, and then I feel like I was able to apply that skill to other things” (LNB_2021).

In summary, when commenting on the changes in their SDL skills over time, all students reported growth in at least some SDL skills. At the same time, several students reported declines in at least some SDL skills, and most students reported stability in some other SDL skills. These findings offer a possible explanation as to why the literature has previously been mixed across studies (e.g., Heater, 2005; Pajares & Valiante, 2002; Reio & Ward, 2005). This is because a student can experience instances of growth, decline, or stability in their SDL skills over time. It is also because each SDL skill can develop along a unique trajectory. Depending on the methodological approach used to examine SDL skill development, a study may only capture one aspect of the various ways SDL skills develop, ultimately painting an incomplete picture. Moreover, additional quantitative and qualitative changes in SDL growth are subtle and nuanced (e.g., skill sophistication), and these changes could have been missed in other types of studies.

Reasons for Changes in Students’ SDL Skills Over Time

The next research question explored *how* a *person's ←→ context relations, such as maturation and the Montessori environment, played a role in the inter-individual and intra-*

individual differences in students' SDL development. In other words, to what reasons did students attribute changes in their SDL skills? Themes were explored for each type of change: growth, decline, and stability. For growth in students' SDL skills (as reported by all eleven students), three overlapping themes emerged. Most students attributed the growth in their SDL skills to the passage of time or their increasing age. In other words, most youth felt their SDL skills improved due to maturity. When asked when he had acquired an SDL skill, an 11th-grade boy with low SDL skills fully attributed his growth in skills to his age: "I think it's been a little easier to recognize that now as I've gotten older. I might not have been able to see it when I was like, 10, but now I'm a little bit more self-aware" (KDM_2020). In addition to attributing the growth of some SDL skills to maturity, all students also attributed the growth in SDL skills to their educational experiences. For instance, an 8th-grade boy with average SDL skills reported, "I think I've been a lot more self-aware recently. I think honestly doing this at-home learning has really helped me learn what my learning habits are" (JG_2021). Regarding the types of environmental features that students most reported supported their SDL skills, all students referred to a variety of factors that were explicitly or implicitly associated with the Montessori method, including open work time, autonomy support, teacher support, scaffolding, and opportunities to be self-directed. For example, a freshman in college, who began the study in 11th grade with average SDL skills, reported:

> I felt like my high school education taught us that, because we had more open-ended projects . . . I had to actually do something for myself too, and that you couldn't just leave it all to the teacher. . . . I think that that independence in having to choose when you want to do stuff and then take the responsibility for doing it, is definitely something I've improved on. (LNB_2020)

This finding supports the fairly robust literature on the strategies that promote SDL (Thomas et al., 1988; Zimmerman et al., 1996b; Zumbrunn et al., 2011) and extends the research on Montessori teaching practices that has been sparse to date. All students also reported receiving social support outside school, especially from parents and siblings, which helped them improve their SDL skills. Surprisingly, most students only mentioned direct instruction as important for their SDL skill development when they were specifically asked. Finally, all students reported a variety of other factors that influenced the likelihood of their being SDL at any given time, such as interest, self-efficacy, distractions, fatigue, relevance, application, or value to the real world. These in-the-moment factors are important because they could have a compounding effect over time, ultimately influencing the trajectory of students' SDL skills.

The third theme addressing the research question revealed a relationship between students' developmental maturity and their environment. According to students, aging and environmental factors contributed together in support of their SDL skill development. In other words, a student's maturity unlocked their readiness to assimilate a new skill, while the context provided an experience from which lessons could be gleaned. Most students reported instances of this interaction. For example, when asked about how he thought he had changed as a learner and why, an 11th-grade boy with average SDL skills reported,

> I think it did have something to do with my age 'cause I realized when I currently was at school during that time of the trip, I hadn't really thought about my future . . . and I hadn't really thought about how important education is. . . . And so, by seeing how important education is in these other countries and seeing just how different it is to our own, really helped me put things in perspective and really helped me to want to work harder. (JG_2021)

As illustrated in this example, the extent to which a student may be 'ready' to learn a new skill or have a takeaway from an experience may be a factor of the student's age.

In addition to growth, some students reported that their SDL skills decreased. For the several students who experienced a decline in their SDL skills, they attributed it to only one cause. A decline in SDL skills was always linked to an environmental change, specifically the move to online learning due to the global pandemic. For example, a 10th-grade boy with high SDL skills noted, "During the distance learning . . . I was probably less of a self-directed learner than the years before. . . . During COVID, school for me was more of just, get it done" (BAP_2021). Interestingly, while the cause of a decline in students' SDL skills was always associated with COVID-19, some students also had positive experiences associated with COVID-19, which will be discussed in more detail below.

Finally, some students reported that their SDL skill level remained stable throughout the study period. These students identified two reasons for this. The first was a ceiling effect. That is, students felt they had already fully developed their SDL skillset, and additional growth was not possible. This phenomenon was evident in the following statement from an eleventh-grade boy with high SDL skills: "So I was taught to be independent, and self-directed at a very young age... and then I just carried [it] over to my academic growth" (LSC_2020). The second reason had to do with students' awareness of themselves as a learner. Students with less awareness of themselves as a learner coul miss opportunities to reflect on and grow their SDL skills. As such, an awareness of self as a learner may be a necessary component of developing SDL skills. A boy who began the study in 9th grade struggled with this. He had low SDL skills throughout the study.

> I have trouble with [teaching myself] a lot of times 'cause it's hard for me to recognize where I need improvement generally. . . . I usually need an outside source as a mark, to make it clear… what I'm doing [right] and where I am doing it wrong. . . . I've never noticed the pattern, which is kind of annoying 'cause . . . then I can't do it by myself, like when there is something I need to learn on my own. . . . I haven't noticed one certain thing that's worked for me. (KDM_2020)

Interestingly, in this case, the student is aware of himself as a learner and knows he needs external guidance to help him self-evaluate, but he is not aware of how to address this challenge.

In summary, according to some students, growth in their SDL skills was related to developmental maturity, environmental supports, or a combination of the two. Some students noted that the stability in their SDL skills was the result of having mastered the SDL skillset at a younger age, and students who experienced a decline in SDL skills over the course of the study linked that decline with changes in their environment related to COVID-19.

Changes in SDL Skills Related to COVID-19

Qualitative findings are presented next for research question 3B*: According to students, how have educational changes associated with COVID shaped the development of their SDL skills? Why have these changes unfolded?* Most students reported a combination of negative and positive experiences associated with the global pandemic. Students who spoke about the pandemic as a hindrance to their SDL skills often pointed to distractions at home, lowered motivation, fewer social interactions, higher stress, and missing the school learning culture. For example, a 12th-grade girl with high SDL skills said,

> [During COVID] it just was harder for me, 'cause there were so many distractions and other things. When you're at school, it's like you're at school for school. Of course, you

> have friends and you can talk to them and stuff, but there's not a TV there or a bed where you can sleep… and you didn't have that set of time for here's this class, here's this class. You have a lot of structure. And with COVID, it was not a lot of structure. (KB_2020)

On the other hand, most students also made positive or at least neutral statements about the shifts in their ability to be self-directed during the pandemic. For example, one girl who began the study in 8th grade said, "especially after COVID and having to do a lot of my school from home. I would say I'm much more of a self-directed learner than I ever was before" (JM_2020). However, she was not alone on this, as many students reported benefiting in some way from the pandemic. Others also identified silver linings. Some of these positive experiences were related to improved time management, access to information, multi-tasking, organization, the ability to shut out distractions, and more sleep time. For example, one boy who began the study in the 8th grade with high SDL skills reported,

> I think [the pandemic] made it easier, 'cause thinking back to in-person, I would have a folder and I would just put all of my homework in it, and it would just get cluttered--all types of classes, a whole bunch of different books. But now… it's all on one device, I can click through Google Classroom, find my work. I think it's more organized and I think that's helped a lot for me, because being able to even do a command search for specific assignments, I can always do that, bookmark it. . . . I've [also] kinda become more of a multi-tasker. (VM_2020)

In summary, students reported a combination of positive and negative experiences being self-directed during the pandemic. Unfortunately, prior research on this topic is limited. Moreover, most of the few studies that have examined the effects of the pandemic on learning

from the student perspective have reflected the unpleasant experiences for students (e.g., Simpson, 2020; Wilson et al., 2020).

Integration of Quantitative Results and Qualitative Findings

In a several areas, qualitative and quantitative findings led to similar conclusions; in others, they led to different conclusions. To facilitate the comparison of results between these two methods, the main results and findings for each method are presented side-by-side in an integrative analysis in Table 9 and discussed below.

The first integration research question that combined quantitative and qualitative findings was, *do students' self-reported SDL skills change across adolescence, from 7th grade through 12th grade, and if so, what does the change look like?* Quantitative results and qualitative findings diverged in some ways and converged in others. While the non-significant no-growth model converged with qualitative findings to suggest that students' SDL skills changed over time, the non-significant growth model diverged from qualitative findings and indicated students' SDL skills did not change over time. The divergence may be due to an underpowered quantitative analysis that failed to detect change. This potential conclusion is supported by the fact that some of the quantitative results converged with the qualitative findings that found that students' SDL skills changed over time. In addition to the non-significant no growth model, correlations and descriptive spaghetti plots added to the evidence suggesting that students could experience a combination of growth, decline, or stability in their SDL skill development across adolescence. Importantly, this set of findings provides a possible explanation as to why findings from previous studies have been mixed. For example, findings from one study demonstrated students' scores increased during adolescence (e.g., Reio & Ward, 2005), while another

demonstrated they decreased during adolescence (e.g., Pajares & Valiante, 2002). Still, another study demonstrated no change in students' SDL skills over time during adolescence (e.g., Heater, 2005). Each of these studies found only one developmental pattern, while the convergent findings from this study pointed to all three patterns within and across students' SDL skill development. That is, students could experience instances of growth, decline, and stability in their SDL skills over time. Despite the small sample size and partial divergence in findings in this study, the areas of convergence across qualitative and quantitative methodologies point to a potentially important developmental pattern in students' SDL skills that may have been missed by monomethod studies. In other words, depending on the methodological approach used to examine SDL skill development, a study may only capture one aspect of the various ways SDL skills develop, ultimately painting an incomplete picture.

In addition to the concurrent findings, each methodological approach extended the findings of the other. Qualitative interviews, for example, revealed that each SDL skill developed on its own timetable. While one SDL skill might have improved over time, other SDL skills declined or stayed the same. For example, a student's metacognitive ability may have increased, but their attention control and ability to inhibit distractions may not have. Scientists have debated whether SDL skills are a collection of skills greater than the sum of their parts or a set of related skills that should be understood separately (Sitzmann & Ely, 2011). While this finding indicates each SDL skill can develop separately, more research is needed to understand how these skills might interact, if at all.

Quantitative patterns also extended qualitative findings. Specifically, the visual plots of students' SDL scores across grade levels may suggest a greater degree of fluctuation in changes in middle school grades compared to high school grades. This visual pattern aligns with research

on SDL skills, which found that younger teens were less consistent in their SDL use compared to older teens and young adults (Brown, 1978; Brown et al., 1983). While results from this study point to a similar pattern, they are not conclusive, given the descriptive nature and power limits. Inferential statistical analyses would be needed to determine if the differences in slope in the middle school grades compared to the high school grades were statistically significant.

In summary, there was quantitative and qualitative evidence that indicated that individual SDL skills increased, decreased, or remained stable across middle and high school grades. Furthermore, while more research is needed, quantitative results and qualitative findings from this study suggest there may be greater variability in the development of SDL skills in middle school compared to high school. Findings also suggested that individual SDL skills can have distinct developmental trajectories.

Table 9.

Mixed-method integration matrix

	Quantitative Results	Qualitative Findings	Mixed-Method Integration
Patterns of SDL skill change over time	Quantitative results were contradictory. The non-sigificant growth model indicated that students' SDL skills remained stable over time. On the other hand, the non-significant no-growth model and descriptive spaghetti plots indicated that students' SDL skills increased, decreased, or remained stable across adolescence. There was also evidence for greater between-person differences than within-person differences. A visual inspection of the patterns over time suggested there may be greater rates of change and more negative slopes during the middle school grades compared to the high school grades.	Across all cases, there was evidence of students' SDL skills growth. Furthermore, specific SDL skills grew more than others. Most cases reported stability in some (but not all) SDL skills. Several cases experienced a decline in certain (but not all) SDL skills.	**Divergence:** Non-significant growth model indicated that students SDL skills did not change over time while qualitative findings indicated in addition to stabilility, students could experience growth and decline in their SDL abilities across adolescence. **Convergence:** The quantitative and qualitative results and findings converged in detecting and observing changes in students' SDL skills across adolescence from 7th through 12th grade. There was also evidence that students' SDL skills could increase, decrease, or remain stable. **Extension:** The qualitative interviews extended the quantitative results revealing that the change in students' SDL skills may be unique for each type of SDL skill. On the other hand, the quantitative results also extended the qualitative findings by detecting a pattern of a greater degree of fluctuation in changes in students' SDL skills in the middle school years compared to the high school years.

Reasons for changes in SDL skills over time	Within correlations, there was slight evidence of a positive relationship between the number of years a student has been in Montessori and their SDL skills. Additional quantitative analyses were not possible due to the small sample.	Across cases, all students reported a variety of supports for the growth in their SDL skills. There was also evidence of coaction between age and students' environment, such that it was sometimes difficult to discern unique contributions from one another. All students reported a positive impact on their SDL skills from being a Montessori student, from factors that could or could not be related to Montessori (e.g., teacher support, autonomy support, scaffolding, opportunities to be SDL). A decline in students' SDL skills for several cases was related to changes in the environment, like the shift to online learning, due to the global pandemic. Stability in students' SDL skills for several cases appeared to be related to previously developed SDL skills or a lack of self-awareness as a learner.	**Convergence:** Quantitative patterns and qualitative findings converged to suggest an impact of the Montessori classroom environmental supports on students' growth in their SDL skills as well as an interaction between students' age and environmental factors, which were often inextricably tied in the interviews. **Divergence:** While this study was unable to determine if a student's grade level was a significant factor for the development of students' SDL skills in the quantitative results, developmental maturity was an important factor in the development of students' SDL skills noted in the interviews. **Extension:** The qualitative findings supplemented the quantitative results by identifying key features of the Montessori approach that supported SDL development. Qualitative findings also point to the coaction of students' maturity and their learning environment in the devleopment of SDL skills.

Changes in SDL skills related to adaptations in the learning environment as a result of COVID-19	There was no quantitative evidence of a change in students' SDL abilities as a result of adaptations in the learning environment due to COVID-19.	Across most cases, students dominantly reported negative experiences in their SDL related to COVID-19. Most cases also had positive or neutral changes in their SDL as it related to COVID-19. Many students benefited in some ways (not all) from the online learning adaptations.	**Divergence:** While quantitative results indicated no change in students' SDL skills during COVID-19, findings from the qualitative interviews found students' SDL skills improved, declined, or remained stable during COVID-19.

The second integration research question was, *what roles do contexts like grade level and the Montessori learning environment play in SDL development?* Combined evidence from qualitative and quantitative findings suggest the Montessori classroom environment may support the growth of students' SDL skills. Specifically, positive correlations aligned with emergent qualitative findings regarding the benefit of the Montessori experience for students' SDL skill development. Students' average SDL skills were weakly yet significantly correlated with the number of years a student had been in a Montessori program across waves ($r_{\text{Wave 1}} = .37$, $r_{\text{Wave 3}} = .17$, $r_{\text{Wave 3}} = .24$). In addition, all students who were interviewed attributed their growth in SDL skills to factors associated with the Montessori environment.

In addition to convergence, the qualitative findings supplemented the quantitative results by identifying key features of the Montessori approach that supported SDL development. This finding, which suggests that open-work time, scaffolded opportunities to be SDL, autonomy support, and supportive teachers support students' SDL development, aligns with prior research that identified pedagogical practices that most directly support students' SDL skill development (Thomas et al., 1988; Zimmerman et al., 1996b; Zumbrunn et al., 2011). In addition, qualitative findings extended the quantitative results by identifying other environmental factors that support students' SDL development (e.g., interest, fatigue, parents, siblings, and other out-of-school factors). Equally, RDS theories imply that various levels and layers of context are likely to influence development (Cantor et al., 2021; Lerner et al., 2015), and these findings support that claim. Moreoever, qualitative findings also point to the potential coaction of students' maturity and their learning environment in the devleopment of SDL skills. Specifically, most students reported instances when their SDL skills grew as a result of their maturity and the school learning environment. For example, some students reported that they had improved their goal-

setting ability because they got older and had also learned it from a teacher who taught them about goal-setting. This finding also aligns with the RDS theoretical premise that the individual and context operate in a dynamic, bi-directional, and fused way to impact development (Geldhof et al., 2013; Lerner, 1998; Lerner & Castellino, 2002).

In sum, converging quantitative and qualitative findings indicate that the Montessori learning environment supported students' SDL development. Findings from this study also suggests that SDL development may occur through combination of maturity and environmental learning supports. This set of findings provides supporting evidence for the premises made by RDS theories (Cantor et al., 2021; Lerner et al., 2015); namely, that development involves the coaction of the individual with their environment. In addition, qualitative findings highlighted open-work time, scaffolded opportunities to be SDL, autonomy support, and supportive teacher support as features of the Montessori school that were particularly useful in supporting SDL development.

The final integration research question was: *have changes in the learning environment associated with COVID-19 shaped the development of students' SDL skills? If so, how?* On this topic, quantitative results and qualitative findings differed. Quantitative results indicated no significant differences in students' SDL skills before and after the onset of COVID-19 (p = 0.640), implying that adjustments in the educational environment caused by the pandemic did not affect students' SDL skills. Although the quantitative results from this study failed to detect any indirect effects of the impact of COVID-19 on students' SDL, qualitative findings found that such changes in the learning environment impacted students' SDL in meaningful ways, both negatively and positively. Most students reported a combination of negative experiences (e.g., more distractions at home, lowered motivation, fewer social interactions, higher stress, and

missing in-school learning) as well as positive experiences (e.g., increased time management, access to resources, multi-tasking, organization, the ability to shut out distractions, and time to sleep). Given the recent nature of COVID-19, research on how those impacts affect students' SDL learning is limited. According to a cross-cultural study, COVID-19 had a detrimental impact on various SDL skills, including students' autonomy and self-awareness (Wilson et al., 2020). Also, lowered motivation and difficulty having social connections were reported in the cross-cultural study as challenges for learning during COVID-19. Other COVID-19 research indicates that COVID-19 negatively impacted students' learning in general (Huck & Zhang, 2021; Tarkar, 2020). While it may be possible that COVID-19 did not impact the students in the present study, it seems more likely that the quantitative instrument was not suitable for measuring such changes. Moreover, the qualitative findings in this study noted above align with and extend the findings from these two prior studies that examined the impact of COVID-19 on student learning.

In summary, despite the divergence between the quantitative results and qualitative findings regarding the impact of changes in the learning environment due to COVID-19 in this study, it is more likely that students' SDL was impacted. All the students in the interviews reported that their SDL skills were negatively impacted, yet some students also had more favorable experiences, which aligns with early research findings.

Chapter 5: Discussion

Learning *how* to learn may be one of significant lessons one can learn in life. Self-directed learning is an important set of learning processes and skills whereby individuals learn to become experts in their learning and excel academically (Zumbrunn et al., 2011). However, research shows that SDL skills are rare in childhood and adulthood (Dent & Koenka, 2016; Zimmerman, 2002; Zimmerman & Schunk, 2001), and the complex coactions of the person↔environment contribute to the difficulty in studying how they develop. As a result, researchers and practitioners have called for research that investigates how SDL skills can be promoted from a relational developmental systems perspective and corresponding methodology (Hoyle & Dent, 2017; Thomas et al., 1988; Zimmerman et al., 1996b; Zumbrunn et al., 2011). This study investigated these matters from with an RDS-aligned approach and methodology. Theory and research suggest that adolescence is an appropriate time for SDL skill development; therefore, this study focused on that time period (Brown, 1978; Brown et al., 1983). Similarly, Montessori schools intentionally aim to cultivate SDL skills (Lillard, 2017; Rathunde, 2009, 2014). Therefore, to maximize the likelihood of finding self-directed students, a Montessori middle and high school provided the context for this study. Moreover, given that historical factors can also influence SDL skill development, the impact of COVID-19 and the corresponding move from a school-based to a home-based learning context were also a focus of this study. Finally, this study followed students over time to observe the development of SDL skills in real time. In addition, this chapter reviews and discusses key findings from the study, contextualizes them in the literature, and notes their implications for research and practice. Limitations and future directions are also discussed, followed by concluding remarks.

Discussion of Key Findings and Implications

Patterns of SDL Skill Change

Results and findings from this study revealed insightful takeaways despite the underpowered quantitative analysis and small sample. Regarding the developmental trajectory of SDL skills during adolescence, this study found that the skills did not follow a consistent trajectory within or across students. Instead of steady or consistent growth, students' SDL skills could increase, decrease, or remain stable over time within and across students. Moreover, in this study, students' SDL skills appeared to fluctuate up or down to a greater degree in middle school than in high school.

Another area of variation in the developmental trajectory of students' SDL skills was that each skill seemed to develop independently. As previously discussed, researchers have long debated whether to consider SDL skills independently or collectively (Sitzmann & Ely, 2010). While one plausible conclusion from this study could be that SDL skills are independent and unrelated, more research would be needed before drawing such conclusions. Even if SDL skills develop independently, there are other important considerations. For example, there could be a compounding effect or sophistication that occurs when SDL skills work in concert. In other words, the Gestalt principle may apply such that the whole may be greater than the sum of its parts. Still yet, there may be a meta-SDL skill that helps students know when, where, and why to apply certain skills over others. More research is needed to understand these nuances and before drawing firm conclusions about the independence or 'Gestaltedness' of SDL skills.

Taken together, this set of findings also extends prior research and explains why findings across previous research studies were mixed. For example, findings from one prior study found that students' SDL skills increased during adolescence (e.g., Reio & Ward, 2005); another found

that SDL factors decreased during adolescence (e.g., Pajares & Valiante, 2002); and still another found that SDL skills did not change during adolescence (e.g., Heater, 2005). However, it may be the case that each of these prior studies captured only a part of the developmental picture. In contrast, the present study found that students' SDL skill development can include a combination of growth, decline, and stability, and that each SDL skill can develop on its course. To this author's knowledge, findings from this study are the first of their kind demonstrating these important nuances of SDL development. These subtle patterns were observed by utilizing a methodology that could account for within-person variation along with between-person variation.

In addition, this set of findings has a plethora of research and practical implications. From a research perspective, this study highlights the importance of including person-centered methods and measures that can account for the natural variability in students' SDL skill development (Cantor et al., 2021). While from a practice perspective, these findings suggest that it may benefit students to have tailored interventions that meet the student where they are developmentally, considering each SDL skill individually as well as all together. Also, identifying which SDL skills are less developed for each student could allow practitioners to provide targeted support for that skill specifically. Moreover, students may benefit from greater scaffolding, support, and direct instruction in early adolescence when they may be less consistent with their SDL skills compared to later adolescence.

Reasons for Changes in SDL Skills

Another set of findings from this study illuminated important factors that can contribute to students' SDL skill development. Namely, findings from this study revealed that a student's time spent in a Montessori program might, at least in part, influence the development of their

SDL skills. In addition, students identified features of the Montessori program such as open-work time, scaffolded opportunities to be SDL, autonomy support, and supportive teachers as conducive to their SDL development, which align with the literature (Zumbrunn et al., 2011). This finding also strengthens prior empirical work, which found cursory evidence for how Montessori schools support the development of SDL skills (Ervin et al., 2010). Findings from this study also suggest that a student's maturity interacts dynamically with the learning environment in supporting students' SDL skills. In other words, a student's maturity plays a role in SDL skill development, especially when environmental contexts are supportive.

Furthermore, due to the small sample size, conclusions from this set of findings should be moderate; nevertheless, they provide supporting evidence for relational developmental systems (RDS) theories. According to RDS theories, human development is a dynamic, integrated, relational, and bidirectional process in which individuals and their environments interact at all levels to shape development (Lerner et al., 2015). As such, "each person's life course [is] shaped by the specific features of these levels as they coact with a human being across time and place" (Cantor et al., 2021, p. 17). Together, findings from this study support the RDS meta-theory as an appropriate theoretical background upon which students and their SDL skills develop. As such, this study confirms and emphasizes the need for research approaches and methodologies that are aligned with RDS theories that are sensitive to evaluating the complex, dynamic, integrated, and relational factors that impact development (Cantor et al., 2021). Of note, this study was limited in scope and included only several people- and environment-related factors theoretically related to SDL development. Despite this, in the qualitative interviews, students raised several important additional people- and environment-related factors that impacted their

SDL development, like motivation, interest, perseverance, and support from parents and siblings. As such, future research should include additional factors like these in their investigations.

Additionally, this set of findings has implications for practice. In general, being autonomy supportive, providing students with opportunities to be SDL, giving explicit or implicit instructions on SDL, and modeling SDL strategies appeared to be important promoting factors for SDL. In other words, high amounts of support and personalized attention from teachers is important for SDL development; yet, can be challenging to implement (Reeve, 2009; Thomas & Rohwer, 1986; Zimmerman, 1990). These promoting factors involve not just highly skilled and trained teachers and positive beliefs about SDL (Kramarski, 2017; Lawson et al., 2019), but also a school culture and structure that provides teachers with the time and support they need to offer students individualized, scaffolded support (Zimmerman et al., 1996b). Therefore, students' SDL skills may benefit most from whole-school, structural, and system-wide interventions that address culture and practice as well as teacher skills and beliefs.

Changes in SDL Skills Related to COVID-19

Findings from this study also help us understand the influence of COVID-19 disruptions on the school environment and students' SDL skill development. When comparing differences in students' SDL scores before and during COVID-19, quantitative analyses were non-significant, implying that there was no impact. However, this finding was not supported by the qualitative portion of this study. In the interviews, students reported both negative and positive experiences with their SDL learning during COVID-19. Negative experiences included more distractions at home, lowered motivation, fewer social interactions, higher stress, and missing the learning culture that came with the change in location and school environment. On the other hand, positive experiences were almost just as common and included increased time management,

access to resources, multi-tasking, organization, the ability to shut out distractions, and more sleep time.

Furthermore, the pandemic significantly disrupted the structure and format of traditional in-school learning (Tarkar, 2020). The most apparent challenges in schools were related to the change to distance learning, which ultimately led to difficulties with technological, communication, social support, and mental health (Huck & Zhang, 2021). Yet, the personal effects of the pandemic on students' day-to-day learning are yet to be thoroughly investigated. Most of the literature to date has focused on understanding the impact of COVID-19 on educational institutions, teachers, society, or standardized test scores. There is limited research from student voices on how the pandemic affected students' experiences with learning. Therefore, findings from this study contribute to the literature by filling this gap. Importantly, out of the few studies that have examined the impact of COVID-19 on students' experiences, some have tended to highlight the challenges, barriers, and difficulties as opposed to possible bright spots or advantages. Hence, findings from this study, which illuminated silver linings also extended current research.

Moreover, this set of findings also has scientific implications. From a research perspective, the lessons learned from this study point to the importance of identifying appropriate instruments and study designs for measuring the impact of COVID-19 on student learning. While it is impossible to know from this study why there were no measured quantitative differences before and during the pandemic, a few explanations may be possible. It may be that the data collection time series was not appropriate to capture the change. It could also be that the SDL survey measure was not sensitive or appropriate for measuring the kinds of changes associated with the global pandemic. On the other hand, the experience of the pandemic could have altered

the way students responded to the measure of SDL and was, therefore, measuring something other than SDL. For example, the fact that students did not rate their SDL skills differently from before to during the pandemic in this study could be an artifact of their resilience. Alternatively, it could be a factor of self-preservation, whereby students were sympathetic and considered the extenuating circumstances in their self-ratings. When selecting instruments to accurately measure the impact of COVID-19 or other similar historical events in the future, it would be worthwhile to consider these alternative explanations. In addition, other methodologies may be considered. For example, a measurement-burst design or experience sampling method might be appropriate for measuring short-term or long-term impacts.

Finally, this set of findings also has practical applications for understanding which adaptations to school learning environments can reduce negative impacts and promote positive ones during a global pandemic. For instance, supporting students' SDL during distance learning might involve maintaining structure and consistency while communicating clear lesson plans so that students can set appropriate goals and manage their time accordingly. This will eventually reduce stress levels. Additionally, it may also be helpful to provide flexibility within assignments and deadlines so that students can have autonomy and self-pace their learning. Equally, it could also be helpful for teachers to provide many opportunities for social interactions, like group work, breakout rooms, or office hours.

Limitations

Despite the strengths and implications of the current study, there are a few limitations worth noting. Limitations of note relate to the sample size and measurements of SDL. Regarding the sample, while the occurrence of a historical event like the global COVID-19 pandemic made

it possible to include such an important developmental factor in the study, it also brought with it the difficulty of collecting consistent data. Many students disengaged when COVID-19 began, and as such, the sample size was drastically reduced. Despite selecting an analysis approach that is robust to missing data, the small sample resulted in a study that was underpowered for the quantitative research questions and analyses, limiting the ability to draw definite conclusions from the results. Moreover, the qualitative sample was also small, limiting saturation and comparisons across cases. Instead, the qualitative findings demonstrated possible variations of SDL development across adolescence; yet, there may be developmental experiences that were not captured in this study.

In addition to the small sample size, there were several limitations relating to the measurements used in the study. First, the survey measure of SDL that was selected as part of the original evaluation study may not have been appropriate for measuring change over time. Prior to this study, the SDLRS had not been used longitudinally; therefore, it was unknown if it would be able to detect change over time. However, as part of the preparation for the current study, the measure was evaluated and found to have high internal consistency across years, which provided important evidence for its reliability across time (Grimm et al., 2016). Moreover, relatively few measures exist that were designed specifically for longitudinal research and detecting change over time (Grimm et al., 2016). Despite this significant barrier to conducting longitudinal studies, prominent researchers have argued that this sort of research should continue until more appropriate measures are developed (Duckworth & Yeager, 2015).

Furthermore, the fact that only self-reported measures were included is another limitation. The quantitative measure of SDL, like the qualitative interviews, relied on students' self-reports of their SDL skills. Despite including multiple methods (quantitative surveys and

qualitative interviews), the inclusion of these measures without observational or other-report measures could not account for any potential self-report biases. That said, in the case of this study, the greatest threat to the validity from students' self-reports had to do with students' ability to comment on their SDL skills. Commenting on one's SDL skills involves cognitive processes that may be difficult to access. Because of this, it is possible that a student's ability to comment on their SDL skills is directly connected to their cognitive abilities. To minimize this threat to validity, the interviews included questions asking about students' SDL skills in two ways. Some questions asked students to comment directly on their SDL skills, while others asked students to simply describe their learning experiences.

A final limitation relating to measurement had to do with the time metric selected to observe changes in students' SDL development. Because this study used data gathered as part of an evaluation study, the assessment of students' annual SDL skills was neither theoretical nor scientifically determined. Also, choosing an appropriate time metric for what is being measured in longitudinal studies is key (Grimm et al., 2016). This is because the selected amount of time between each wave of data collection can either result in accurately capturing or completely missing changes over time. However, while some research has found that annual assessments may be appropriate for measuring some developmental phenomena, shorter intervals (e.g., every 6 months) may also have been developmentally appropriate (Geldhof et al., 2013).

Given the potential of SDL to help students thrive in varied academic settings and the relative infrequency and inconsistency of students with strong SDL skills, it is, however, vital that we learn *how* to support students in developing these critical skills. Despite its limitations, findings from this study provided important exploratory insights and illuminated useful patterns that can be used to guide future research and classroom practices.

Future Research

This study uncovered several important future directions for researchers to consider. First, a replication study with a larger and more diverse sample size, for example, could verify and expand on the patterns found in this study. Larger and more diverse sample sizes would not only increase the power to detect an effect but could also allow for more complex models to be tested, like a growth mixture model (see Bowers et al., 2011). Growth mixture models combine idiographic and nomothetic approaches identifying patterns of development that apply within and between individuals, ultimately distilling individual developmental trajectories into patterns or profiles that meaningfully map human development (Cantor et al., 2021; Geldhof et al., 2013; Rose & Fischer, 2011). Also, other theoretically important developmental contexts that can play an important role in students' SDL development, like parenting behaviors may be included in these models.

Furthermore, in addition to exploring the developmental patterns with a larger sample and more complex analyses, future research may benefit from considering how students apply and use their SDL skills across a variety of settings. Similar to previous research (Dent & Koenka, 2016; Zimmerman & Schunk, 2001), findings from this study pointed to inconsistencies in the implementation or use of SDL skills within students across settings. On the other hand, there was also evidence of students making connections or applying their learning and SDL skills across contexts. When students successfully apply their learning and SDL skills across settings, this phenomenon may be seen as a meta-SDL skill or a sophistication of SDL skills, which could benefit students and could be of worthwhile focus for future studies.

Moreover, an additional area for future research is the relationship between SDL and students' awareness of themselves as learners, as well as their interests or motivations for

learning. Evidence from this study suggest that awareness of self may be a key ingredient in SDL because of how it came up in the interviews. For example, when students described missed opportunities to be self-directed, it was most often due to a lack of self-awareness. A potential explanation of these findings is that awareness of self as a learner may be a foundational SDL skill upon which other SDL skills are built. Interest performed similarly. For example, even students who struggled to apply their SDL skills consistently were able to do so when they were interested in the topic. Therefore, interest may be key to unlocking the application of students' SDL skills. These patterns were emergent and only observed on a few occasions. As such, more research is needed to investigate the relationship between awareness of self and interest in SDL.

Finally, it could be worthwhile to explore the same phenomena and developmental patterns as explored in this study with a different student population. The Montessori environment was identified as the focus of this study because it increased the potential to observe SDL skills; however, exploring the same developmental patterns with students in other school settings might reveal greater variability in students' SDL. Such research could confirm findings from this study as well as illuminate a broader spectrum of SDL skill development.

Conclusions

Students learn in many ways, but by understanding how SDL skills develop, practitioners can better support higher-order thinking, deeper learning, and skill-building, which can then be transferred across contexts and support students' life-long learning and development (Candy, 1991; Knowles, 1976). To the author's knowledge, this is the only study of its kind that leveraged a mixed methods convergent longitudinal design to investigate the development of adolescent students' SDL skills in a Montessori school during a global pandemic. It contributes

to the literature by applying an RDS-aligned design and methodology to study how complex, dynamic, integrated person←→ environmental factors impact students' SDL development, illuminating *when* and *how* students' SDL skills are enhanced or worsened.

Specifically, according to the findings of this study, students' SDL skill development can vary within and across people, contexts, and time, and each SDL skill likely has its own developmental trajectory. Findings from this study also validate and describe how this aspirational set of skills can be nurtured and supported through external support as students mature. Moreover, this study is timely given the onset of a global pandemic, which has had large-scale effects on education. This study contributed to the field by describing students' needs and bright spots during the pandemic, which can be translated into practices to better support students in the future.

Due to findings from this study, we now know that SDL skill development can vary uniquely for each student. Therefore, students are likely to benefit when teachers can get to know their students individually and can tailor their support and interventions to each student's needs, which requires a whole-school effort. In summary, this study highlighted important nuances in students' SDL skills development across adolescence and provided evidence-based recommendations for future research and practice so that more students can be supported to become self-directed learners.

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Appendix A: SDL Survey Instrument

Self-Directed Learning Rating Scale (SDLRS; Guglielmino, 1977)

Instructions: This is a questionnaire designed to gather data on learning preferences and attitudes toward learning. After reading each item, please indicate the degree to which you feel that statement is true of you. Please read each choice carefully and use the one which best expresses your feeling. The blanks on the answer sheet represent the following:

1. Almost never true of me
2. Not often true of me
3. Sometimes true of me
4. Usually true of me
5. Almost always true of me

There is no time limit for the test. Try not to spend too much time on any one item, however. Your first reaction to the question will usually be the most accurate.

Items:

1. I'm looking forward to learning as long as I am living.
2. I know what I want to learn.
3. When I see something that I don't understand, I stay away from it.
4. If there is something I want to learn, I can figure a way to learn it.
5. I love to learn.
6. It takes me a while to get started on new projects.
7. In a classroom, I expect the teacher to tell all class members exactly what to do at all times.

8. I believe that thinking about who you are, where you are, and where you are going should be a major part of every person's education.
9. I don't work very well on my own.
10. If I discover a need for information that I don't have, I know where to go to get it.
11. I can learn things on my own better than most people.
12. Even if I have a great idea, I can't seem to develop a plan for making it work
13. In a learning experience, I prefer to take part in deciding what will be learned and how.
14. Difficult study doesn't bother me if I'm interested in something.
15. No one but me is truly responsible for what I learn.
16. I can tell whether I'm learning something well or not.
17. There are so many things I want to learn that I wish that there were more hours in a day.
18. If there is something I have decided to learn, I can find time for it, no matter how busy I am.
19. Understanding what I read is a problem for me.
20. If I don't learn, it's not my fault.
21. I know when I need to learn more about something.
22. If I can understand something well enough to get a good grade on a test, it doesn't bother me if I still have questions about it.
23. I think libraries are boring places.
24. The people I admire most are always learning new things.
25. I can think of many different ways to learn about a new topic
26. I try to relate what I am learning to my long-term goals.
27. I am capable of learning for myself almost anything I might need to know.

28. I really enjoy tracking down the answer to a question.
29. I don't like dealing with questions where there is not one right answer.
30. I have a lot of curiosity about things.
31. I'll be glad when I'm finished learning.
32. I'm not as interested in learning as some other people seem to be.
33. I don't have any problem with basic study skills.
34. I like to try new things, even if I'm not sure how they will turn out.
35. I don't like it when people who really know what they're doing point out mistakes that I am making.
36. I'm good at thinking of unusual ways to do things.
37. I like to think about the future.
38. I'm better than most people are at trying to find out the things I need to know.
39. I think of problems as challenges, not stop signs.
40. I can make myself do what I think I should.
41. I'm happy with the way I investigate problems.

Appendix B: Interview Protocols

SDL Interview Protocol - Time 1

Interest and Engagement in School	- What are your favorite classes?
	  o Can you think about what it is that you really like about those classes?
	  o Is it the topic or the way the teacher teaches the class?
	- Think of your favorite class (pick one to reference in the following questions).
	  o What parts of the class do you enjoy most? Examples?
	  o What parts of the class do you feel the most engaged? Examples?
	  o What parts of the class do you feel you learn the most? Examples?
	- Think of a class that you are not very interested in.
	  o Are there parts of the class you are able to become engaged in? Why?

Autonomy Support	- Think about your favorite class. Tell me about that teacher's teaching style.
	  o What do you like about it?
	  ▪ Why?
	  o What could be better?
	  ▪ Why?
	- How much guidance or instruction does your teacher provide in that class?
	  o Does it vary based on the assignment?
	  ▪ Can you give me some examples?
	- How do you feel about open work time?
	  o What do you do when you have open work time?
	  o When are you most engaged in open work time?
	- Some students like a lot of guidance from the teacher when they give clear directions. Other students like to have more open-ended assignments where they get to pick what to work on, with whom, and how to go about it. Do you

	appreciate the guidance your teacher provides, or do you wish you had more or less freedom in how you complete assignments? (Some students think of this as a continuum.) - (Optional) Describe your perfect class day. o What would a day (hour) in that class look like?

SDL skills	- How do you feel about teaching yourself something?
	  o Do you like it or dislike it?
	  o Are you able to learn or have difficulty learning that way?
	- Think about a project (like a school assignment) that you recently completed on your own **OR** Can you share an example with me when you were in control of your learning toward a specific goal?
	  o Can you describe it to me?
	  o Did you feel like you knew the steps to take (or questions to ask) to complete it?
	  o How did you go about figuring out the next steps to take?
	  o Walk me through the process. What steps did you take?
	  ▪ How did you choose the topic?
	  ▪ How did you decide how to present it? (ask if applicable)
	  ▪ How did you know you were making progress/learning?
	  ▪ How did you know when you had mastered the topic?
	  ▪ Did your teacher support you? How?

Close	- Those are all my questions; do you have anything else to add that you think is important that I know?

SDL Interview Protocol - Time 2

Intro	- Warm up: What do you like about your school? What are your favorite classes?
	- What do you enjoy most about your classes? Examples?
	  o In what parts of the class do you feel most engaged in? Examples? Why?
	  o In what parts of the class do you feel you learn the most? Examples? Why?

Teacher support	- Tell me about your teachers' teaching styles.
	  o Is there a teacher who you like most with how they teach the class? What do you like about it? Why?
	  ▪ What could be better? Why?
	  ▪ How much guidance or instruction does your teacher provide in that class?
	  • Does it vary by assignment? What are some examples?
	  ▪ To what extent does this teacher enable you to make decisions on your own?
	  • E.g., you choose the content/topic of your learning, who you work with, set learning goals, plan, set deadlines, format to demonstrate learning/output
	  o Is there a teacher whose teaching style you least like? What do you like/not like about it? Why?
	  ▪ What could be better? Why?
	  ▪ How much guidance or instruction does your teacher provide in that class?
	  • Does it vary by assignment? What are some examples? What do you like about it?
	  ▪ To what extent does this teacher enable you to make decisions on your own?
	  • E.g., you choose the content/topic of your learning, who you work with, set learning goals, plan, set deadlines, format to demonstrate learning/output

Motivation to be SDL	- I'd like to ask you a few questions about yourself as a learner.
	- Is learning something you enjoy or does it feel more like a burden? Does it depend on the topic?
	- Some students like a lot of guidance from the teacher when they give clear directions. Other students like to have more open-ended assignments where they get to pick what to work on, with whom, and how to go about it. Do you appreciate the guidance your teacher provides, or do you wish you had more or less freedom in how you complete assignments? (Some students think of this as a continuum.)
	  o Can you tell me about a particular assignment where you had just the right amount of guidance?
	- How do you feel about teaching yourself something? Do you like it or dislike it?
	  o Are you able to learn or do you have difficulty learning that way?
	- Do you enjoy pursuing your own learning interests or do you prefer it when the teachers tells you what to learn?

SDL ability	- To what extent do you feel prepared/confident to have some responsibility for your own learning? Where did you learn that?
	  o How would you rate your ability to learn things on your own? How does that compare to others?
	- How do you typically respond/react when you come across an obstacle in your learning? Where did you learn that?
	- To what extent do you switch gears if you have some difficulty learning or do you force yourself to keep doing what you are doing? How did you learn to do that?
	- When there is something you need to learn, but are not particularly interested in learning about it, what do you do? How did you learn to do that?
	- Are you able to set your own learning goals or do you prefer it when the teacher creates goals for you?
	  o Can you describe an example when you created your own learning goals? Was it more or less successful that when the teacher set the goal?
	- To what extent do you usually complete the goals you set, revise them, or turn to new goals before completing the old ones? Please describe, provide examples.
	- If you need to memorize material, how do you go about it?
	  o Describe the strategies that you use? Do they vary depending on the material you are learning?
	  o How did you learn to do that?
	- Are you able to keep your concentration on your learning for as long as you need or do have difficulty staying focused on one thing for long periods of time? How did you learn to do that?
	- How aware are you of yourself as a learner? Do you feel like you know the best ways of how you learn? Please explain. How did you learn that?
	- How can you tell that you are learning something? How do you know if you have mastered a topic? How did you learn to do that?
	- As you are learning, does your mind go blank or do you find yourself thinking about what you know and don't know? How did you learn to do that?
	  o How often do you think about what you know and what you don't know? Can you give me an example?
	- As you are making progress in your learning, to what extent do you find yourself evaluating your thinking (thinking about how you're thinking)? How did you learn to do that?
	- When you've completed an assignment, to what extent do you think through what you've learned and what you haven't, what went well and what didn't, what was easy to learn and what was hard? How did you learn to do that?
	- How do you think your grade would be impacted if you were solely responsible for your learning?

SDL growth	- How have you changed as a learner since the last time we interviewed you, two years ago? - To what extent do you feel prepared to have some responsibility for your own learning now as compared to back then? Where did you learn that? o Do you feel like you could do a better job when it comes to being responsible for your own learning or are you satisfied with where you are at? Why? - How do you think you have learned how to take an active role in your learning?

SDL supports (general/ Teacher/ parent)	- To what extent do your teachers give you lessons on things like goal-setting, learning strategies, and self-evaluation?
	- What kinds of things do you need to make you feel more comfortable to be responsible for your learning?
	- What kinds of things have enabled you to become a more self-directed learner?
	  o How would you define what a self-directed learner is? Do you see yourself as a self-directed learner? Are there times when you are more easily self-directed as not? Why?
	- Who has supported you most in being able to be more responsible for your learning and why? How did they support you?
	  o In what ways, if any, have your teachers supported you in developing the skills that you might need to guide your own learning? (e.g., goal-setting, metacognition/knowing how you think, strategic planning, self-evaluation)
	  o In what ways, if any, have your parents supported you in developing the skills that you might need to guide your own learning? (e.g., goal-setting, metacognition/knowing how you think, strategic planning, self-evaluation)

Response to COVID-19	- How has COVID-19 impacted your learning experience?
	- In what ways, if any, have the changes in your classroom experience due to COVID-19 impacted the way you learn?
	  o How about your ability to be motivated to learn? Why?
	  o How about your ability to stay on track with your learning (i.e., complete goals)?
	- How did your teachers support you during COVID-19? What did they do that was helpful to your learning? What are they doing that is not helpful to your learning?
	- How about for your parents?

Close	- Those are all my questions; do you have anything else to add that you think is important that I know?

SDL Interview Protocol - Time 3

Intro	- Warm up: What do you like about your school? What are your favorite classes? - What do you enjoy most about your classes? Examples? o In what parts of the class do you feel most engaged in? Examples? Why? o In what parts of the class do you feel you learn the most? Examples? Why?
Teacher support	- Tell me about your teachers' teaching styles. o Is there a teacher who you like most with how they teach the class? What do you like about it? Why? ▪ What could be better? Why? ▪ How much guidance or instruction does your teacher provide in that class? • Does it vary by assignment? What are some examples? ▪ To what extent does this teacher enable you to make decisions on your own? • E.g., you choose the content/topic of your learning, who you work with, set learning goals, plan, set deadlines, format to demonstrate learning/output o Is there a teacher whose teaching style you least like? What do you like/not like about it? Why? ▪ What could be better? Why? ▪ How much guidance or instruction does your teacher provide in that class? • Does it vary by assignment? What are some examples? What do you like about it?

	▪ To what extent does this teacher enable you to make decisions on your own? • E.g., you choose the content/topic of your learning, who you work with, set learning goals, plan, set deadlines, format to demonstrate learning/output
Motivation to be SDL	- I'd like to ask you a few questions about yourself as a learner. - Is learning something you enjoy, or does it feel more like a burden? Does it depend on the topic? - Some students like a lot of guidance from the teacher when they give clear directions. Other students like to have more open-ended assignments where they get to pick what to work on, with whom, and how to go about it. Do you appreciate the guidance your teacher provides, or do you wish you had more or less freedom in how you complete assignments? (Some students think of this as a continuum.) o Can you tell me about a particular assignment where you had just the right amount of guidance? - How do you feel about teaching yourself something? Do you like it or dislike it? o Are you able to learn or do you have difficulty learning that way? - Do you enjoy pursuing your own learning interests or do you prefer it when the teachers tell you what to learn?
SDL skills	- To what extent do you feel prepared/confident to have some responsibility for your own learning? Where did you learn that? o How would you rate your ability to learn things on your own? How does that compare to others? - How do you typically respond/react when you come across an obstacle in your learning? Where did you learn that?

	- To what extent do you switch gears if you have some difficulty learning or do you force yourself to keep doing what you are doing? How did you learn to do that?
	- When there is something you need to learn, but are not particularly interested in learning about it, what do you do? How did you learn to do that?
	- Are you able to set your own learning goals or do you prefer it when the teacher creates goals for you?
	  o Can you describe an example when you created your own learning goals? Was it more or less successful that when the teacher set the goal?
	- To what extent do you usually complete the goals you set, revise them, or turn to new goals before completing the old ones? Please describe, provide examples.
	- If you need to memorize material, how do you go about it?
	  o Describe the strategies that you use? Do they vary depending on the material you are learning?
	  o How did you learn to do that?
	- Are you able to keep your concentration on your learning for as long as you need or do have difficulty staying focused on one thing for long periods of time? How did you learn to do that?
	- How aware are you of yourself as a learner? Do you feel like you know the best ways of how you learn? Please explain. How did you learn that?
	- How can you tell that you are learning something? How do you know if you have mastered a topic? How did you learn to do that?
	- As you are learning, does your mind go blank or do you find yourself thinking about what you know and don't know? How did you learn to do that?
	  o How often do you think about what you know and what you don't know? Can you give me an example?

	- As you are making progress in your learning, to what extent do you find yourself evaluating your thinking (thinking about how you're thinking)? How did you learn to do that? - When you've completed an assignment, to what extent do you think through what you've learned and what you haven't, what went well and what didn't, what was easy to learn and what was hard? How did you learn to do that? - How do you think your grade would be impacted if you were solely responsible for your learning?
SDL Development	- How have you changed as a learner since the last time we interviewed you, two years ago? - To what extent do you feel prepared to have some responsibility for your own learning now as compared to back then? Where did you learn that? o Do you feel like you could do a better job when it comes to being responsible for your own learning or are you satisfied with where you are at? Why? - How do you think you have learned how to take an active role in your learning?
SDL Skill Supports (general/ teacher/ parent)	- To what extent do your teachers give you lessons on things like goal setting, learning strategies, and self-evaluation? - What kinds of things do you need to make you feel more comfortable to be responsible for your learning? - What kinds of things have enabled you to become a more self-directed learner? o How would you define what a self-directed learner is? Do you see yourself as a self-directed learner? Are there times when you are more easily self-directed as not? Why? - Who has supported you most in being able to be more responsible for your learning and why? How did they support you?

	○ In what ways, if any, have your teachers supported you in developing the skills that you might need to guide your own learning? (e.g., goal setting, metacognition/knowing how you think, strategic planning, self-evaluation) ○ In what ways, if any, have your parents supported you in developing the skills that you might need to guide your own learning? (e.g., goal setting, metacognition/knowing how you think, strategic planning, self-evaluation)
Response to COVID-19	- How has COVID-19 impacted your learning experience? - In what ways, if any, have the changes in your classroom experience due to COVID-19 impacted the way you learn? ○ How about your ability to be motivated to learn? Why? ○ How about your ability to stay on track with your learning (i.e., complete goals)? - How did your teachers support you during COVID-19? What did they do that was helpful to your learning? What are they doing that is not helpful to your learning? - How about for your parents?
Close	- Those are all my questions; do you have anything else to add that you think is important that I know?