UNDERSTANDING PATTERNS OF PRODUCTION IN UPPER ELEMENTARY WRITING

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A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

School Psychology – Doctor of Philosophy

2024

ABSTRACT

Educators often observe differences in students' writing productivity, with some students stopping early while others continue to write for the given time. This study demonstrates how planning and goal setting are related to these written production patterns. A Growth Mixture Model identified three groups of writers: the *Early Terminators* who stopped writing early, the *Decelerating Producers* who continued to write for the 15 minutes though at a slowing rate over time, and the *Steady Writers* who wrote at a constant rate across the task. Students who had an additional year of instruction and who created more structured plans to use as a writing goal were more likely to continue writing across the task, pointing to the importance of strong instruction in planning and goal setting for upper elementary writing.

For all of my teachers, young and old.
And especially for two of the best—Mom and Dad.

ACKNOWLEDGEMENTS

My learning and growth were supported by many people from multiple disciplines over the course of the dissertation and graduate studies. First, what an honor to have learned from and collaborated with Dr. Adrea Truckenmiller who always saw the potential in my ideas, even when I did not see it myself. Thank you to Dr. Sara Witmer, for your guidance and thoughtful perspective over the years. Dr. Eunsoo Cho demonstrated to me how a stellar methodologist thinks. A special thank you to Dr. Gary Troia for his support and expertise in writing and language development and whose fascinating data I used for several projects, including this dissertation. This research was supported in part by grant #R305A160049 from the U.S. Department of Education, Institute of Education Sciences, to Michigan State University. Statements do not necessarily reflect the positions or policies of this agency, and no official endorsement by it should be inferred.

Thank you to my school psychology cohort for the encouragement and motivation as I witnessed many children's lives changed since we started together in Fall 2019. I am endlessly grateful for my fellow WRITE labmates whose fierce advocacy for all children to develop literacy is contagious. Finally, thank you to my family who nurtured and inspired me to be where I am today. A special acknowledgement of the endless support of my husband, Uriel, who reminded me that every little step along this journey was worth celebrating. Here's to another!

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CHAPTER 1: INTRODUCTION

"I'm done!" "I don't know what else to say." "There's nothing else to write." These are likely familiar statements to adults who have worked with a young writer on an assignment, and this reaction to the challenging task makes sense. Young writers are confronted with a blank page and told to write for a certain amount of time or answer a prompt. They must balance demands of thinking about what to write, how to get those thoughts from their head onto the page, figuring out if what they have on the page is accurate or good enough, and deciding whether to continue with this recursive process or whether to stop and end it. The task is immense, and teachers respond to that. Though the vast majority (nearly 80%) of teachers in a national survey reported receiving little to no pre-service university training in writing instruction, most teachers report using evidence-based practices that might help students push through these moments of challenge during writing, including teaching planning procedures, setting writing goals, and teaching self-regulation to use during the writing process (Brindle et al., 2016). Still, questions about helping students persist in writing linger, namely, *who stops writing early* and *why*?

Writing is a task comprised of domain-specific processes related to writing (e.g., idea generation and transcription), knowledge and skills that contribute to these processes (e.g., topic knowledge and spelling), and self-regulatory and cognitive functions that facilitate the task (Kim & Graham, 2021). For writers of all levels, this complex task can be daunting, and it may be especially challenging for young writers who are simultaneously developing skills in spelling and transcription and knowledge of conventions such as punctuation, alongside more general cognitive skills (Berninger, 1999; Kim & Park, 2019; Limpo et al., 2014).

One response to the challenge of the writing task is to terminate writing early (Graham, 1990; Thomas et al., 1987). This could be attributed to a number of factors, including a cognitive capacity overload (McCutchen, 1996) or a lag in self-regulation (Zimmerman, 2008). There is evidence that developing writers and those that struggle with writing are more likely to terminate writing early (Thomas et al., 1987). Other research finds that students tended to produce the same amount of writing with both a 15-minute task and shortened 5-minute task, suggesting that without additional prompting or direction, students' rates of production slow with longer tasks (Ignacio et al., 2019). This is important because production, which is associated with the amount of time spent writing, is related to writing quality (Dockrell et al., 2015; Hayes & Nash, 1996; Kent & Wanzek, 2016; Kim et al., 2015). For example, when students with learning disabilities are prompted to continue writing, they generate additional content, leading to higher quality texts (Graham, 1990). When these prompts are structured to be specific to the genre, rather than genre agnostic or purely motivational, developing writers generate more content and spend more time on the task (Bakunas, 1996).

A written plan might be one tool writers use to cue themselves to continue writing through challenging tasks. There is some evidence that the presence of a plan affects writing behaviors. For instance, among graduate student writers, those whose writing process was characterized primarily by planning, as opposed to revision or a mixture of strategies, wrote more productively and found writing to be a less difficult task, suggesting the role that planning before writing can play in easing task demands (Torrance et al., 1994). Another study among college-aged writers found that students who engaged in structured planning by creating an outline spent more time engaged in the writing task than students in a comparison group who simply began drafting their compositions without an outline (Kellogg, 1987).

While pre-writing planning provides an explanation as to *what* might facilitate persistence in writing, it does not provide a possible explanation as to *how* this tool works. The goal setting literature may provide clarification. Goal setting is recognized as one of the most effective writing interventions (Koster et al., 2015; Santangelo et al., 2016). Students who set goals as part of the writing process write longer, more complete essays (Ferretti et al., 2009; Page-Voth & Graham, 1999). Effective, high quality goals are those that are specific, relevant to the task, and organized hierarchically (Schunk & Swartz, 1993; Zimmerman, 2008). Several theories seek to explain the way in which goal setting supports young writers, including freeing cognitive space by front-loading and externalizing idea generation and organization (McCutchen, 1996) and establishing a clear objective by which to measure progress toward a desired outcome (Zimmerman, 2008).

Planning and goal setting are connected, according to writing theories. Hayes and Nash (1996) describe planning as a way "to specify either the means for achieving a goal, or it may further specify the goal to be achieved; or, indeed, it may do both" (p. 30). These authors emphasize that planning can be used strategically to negotiate the complex process of writing: "Ill-defined tasks are very common in a variety of fields including writing…In ill-defined tasks, specifying the goal is often the most important function of planning" (Hayes & Nash, 1996, p. 31). This study builds on this idea that when students engage in high quality planning, they functionally engage in goal setting.

This study demonstrates a conceptualization of planning as goal setting, by drawing connections between the cognitive writing theories that describe planning and motivational theories of goal setting. Both written plans and goal setting rely on ideas, organization, and action. Beauvais et al. (2011) define planning in a way that aligns closely with goal setting.

According to these authors “Planning processes allow preparing the content of the text by retrieving ideas from the writer’s long-term memory or from the environment and by reorganizing these ideas if necessary. Planning processes also schedule writing by preparing action plans for composing” (p. 415). In comparison, goals have been described as the “aim of an action” (Locke & Latham, 2002, p. 705) and “a construct that organizes… previously distinct cognitive and affective factors” (Elliott & Dweck, 1988, p. 6). While young students rarely engage in explicit goal setting during writing (Gillespie & Graham, 2014), some research suggests that among younger writers, more broadly considering other forms of goal setting related to planning (such as idea generation and organization) captures the same function of developing a course of action and how to achieve it and can be more readily observed (López et al., 2019).

Most research investigating the effects of goal setting among younger writers focuses on the final product, including measures of quality and quantity (e.g., Graham et al., 2021; Llaurado & Dockrell, 2019; Santangelo et al., 2016); however, studies examining the writing behaviors of students during writing, such as when they stop writing (Graham, 1990; Thomas et al., 1987) suggest that exploring the role of goal setting through young writers’ plans may provide insight into helping students continue through challenging tasks.

Examining written production during composing may be one way to observe when students stop and start writing and how the characteristic of their goals (i.e., written plans) are associated with those patterns. More specifically, patterns of written production across the task can provide information about the rate of young writers’ production and the change in that rate as the writing task progresses, capturing when certain writers speed up, slow, and stop their writing. This study employs a unique methodology by applying a longitudinal modeling approach to a

15-minute writing task. Growth mixture modeling is used to identify classes of writers based on their patterns of production across the writing task, considering the characteristics of their pre-writing plan as a predictor of class membership.

CHAPTER 2: LITERATURE REVIEW

Early termination has been identified as a characteristic of the writing process for some learners in the upper elementary and middle school grades (Graham, 1990; Thomas et al., 1987). Graham (1990) found that students with learning disabilities stopped writing sooner than peers without disabilities. When students were prompted to continue writing, they wrote for longer and had higher quality and quantity in both writing and dictation conditions (Graham, 1990). Thomas et al. (1987) found that students with learning disabilities were five times more likely to end their writing earlier than peers without learning disabilities. The authors hypothesize that this "performance suggested difficulties in retrieval and using relevant schemata from memory that might sustain their thinking and writing in a generative way" (p. 28). Students who displayed early termination in their writing seemed to have trouble producing multiple ideas to write about and instead stopped writing after a single idea.

In contrast to early termination is persistence through the task. Persistence is defined as cognitive processes that influence behavior (e.g., goal-setting and self-monitoring) in pursuit of a goal (Butler & De La Paz, 2021; Graham et al., 2018). Persistence is tied to social cognitive theories of motivation that center on goal setting and strategic behaviors that increase a student's actions to accomplish the goal (Zimmerman, 2008). A student's level of commitment to their goal can rely on a number of motivational factors, including their self-efficacy, value for the task, and outcome expectancies (Alexander, 2003; Eccles, 2020; Zimmerman, 2008). Persistence also invokes a relationship to time, as it is used in the writing literature (Piazza & Siebert, 2008). While this may sometimes be considered a construct related to engagement or time on task, persistence goes beyond behavioral engagement by acknowledging behaviors are directed and sustained in the pursuit of a goal, often in a challenging context (Drake et al., 2014).

The current study examines how a self-regulatory behavior (i.e., goal setting through written planning) contributes to the motivational outcome of persistence across a writing task. First, I will describe the general goal setting literature before illustrating its application to writing. Next, I will provide examples of writing theories that connect goal setting to planning in writing. These theories are backed by empirical evidence that suggest a developmental pattern in planning sophistication that aligns with the development of high quality goals. After establishing planning as a form of goal setting, I will suggest several theories that can help explain why goal setting (via planning) might contribute to persistence throughout a writing task.

Goal Setting

Goals are an important element in persisting through a challenging task. Goal theory originated in response to strict readings of behaviorist psychology that did not allow for the role of consciousness, deliberation, or choice in action (Locke & Latham, 2002). Since then, goal setting has been described from various perspectives. Locke and Latham (2002) describe the entity that is the goal itself: "A goal is the object or aim of an action, for example, to attain a specific standard of proficiency, usually within a specified time limit" (p. 705). A social cognitive perspective adds how the goal is used by identifying its role as comparison of effort and outcomes; a goal is "what one is consciously trying to accomplish, provides a standard against which people can gauge their progress" (Schunk, 1990). Finally, self-regulation's role has been suggested through how a "goal may be a construct that organizes…previously distinct cognitive and affective factors" (Elliott & Dweck, 1988, p. 6). Goal setting theory was integrated into learning and educational literature that explains how goals might be used in the academic domains, particularly when students encounter challenges like figuring out what to write next or maintaining engagement during a writing assessment.

One way goal setting may affect persistence is through facilitating motivational processes. Zimmerman (2008) describes four motivational effects goal setting has on academic behaviors. Goals influence attention toward goal-related activity and away from goal-irrelevant activity. They influence the affective response to outcomes such as increased feelings of satisfaction through accomplishing a goal. In the midst of the writing process, goals can influence the level of effort and ultimately the persistence a student shows through the writing task.

Goal setting's relationship to persistence has been investigated through the effect that goal setting has on learning behaviors. Learners who work toward a more difficult goal tend to spend more time on the task to meet that challenge than learners with a goal that is easily achievable or those with no goal (LaPorte & Nath, 1976). This persistence through challenge is ultimately related to performance; those who persist (i.e., spend more time in order to complete challenging tasks) have increased learning outcomes or task performance (LaPorte & Nath, 1976; Samuels & Dahl, 1975).

Notably, a goal's effectiveness depends on its quality and characteristics (Zimmerman, 2008). Schunk and Swartz (1993) identified three factors that contribute to a goal's effectiveness: specificity, proximity, and difficulty. Specificity refers to the precision of language used to articulate the goal that helps provide clear, focused plans and monitoring of progress toward the goal. The proximity of a goal refers to the direct relevance and immediacy of the plan to the required task. Third, a goal's difficulty or level of challenge must promote high levels of performance and engagement in the task, while still ensuring attainability. Zimmerman (2008) added to this list, emphasizing that effective goals are often hierarchical in nature. That is, they recognize short and long-term and general and specific targets.

Goal Setting in Writing

In writing, goal setting has been seen as the mechanism that drives the process throughout its various stages, from planning through revisions and publishing or sharing (Flower & Hayes, 1981). In their cognitive model of writing Flower and Hayes connect writing and goal setting:

> The act of composing itself is a goal-directed thinking process, guided by the writer's own growing network of goals…Writers create their own goals in two key ways: by generating both high-level goals and supporting sub-goals which embody the writer's developing sense of purpose, and then, at times, by changing major goals or even establishing entirely new ones based on what has been learned in the act of writing (p. 366).

While good writers tend to revisit their goals and use them throughout stages of writing (Flower & Hayes), writers with lower quality writing may not effectively use plans and goal setting; this is particularly evident among students with learning disabilities (Thomas et al., 1987).

Goal Setting is an Effective Writing Intervention. Goal setting's role in writing is further illustrated by its effectiveness as an intervention. In writing, goal setting interventions have some of the highest effect sizes in upper elementary writing. One meta-analysis of 32 writing intervention studies in upper elementary school demonstrated that goal setting had the highest effect size (*ES*= 2.03) when compared to categories of interventions, including strategy instruction (*ES*=0.96), text structure (*ES*=0.76), and peer assistance (*ES*= 0.59; Koster et al., 2015). These results are tempered in that all effects of goal setting included in the analysis came from a single published study that included multiple measurements (i.e., Schunk & Swartz, 1993). Even still, other meta-analytic evidence supports goal setting interventions among the

most effective. Another meta-analysis examining self-regulation interventions in writing found that goal setting interventions had an average weighted effect size of 0.73 on writing quality, representing a moderate magnitude of change (Santangelo et al., 2016). Still another meta-analysis, this time examining the effect of writing interventions for students with learning disabilities, identified goal setting interventions as having statistically significant positive effects on writing quality with an average weighted effect size of 0.57 (Gillespie & Graham, 2014). These authors note that the goal setting interventions included in their meta-analysis highlight goal setting as a feasible, relatively quick process to integrate into writing instruction that has benefits for students who struggle with writing.

Effects of Goal Setting on Writing Behavior. The goal setting theories regarding motivational effects, persistence, and quality described above map on to goal setting in writing. Goals are associated with increased motivational beliefs in writing. A study of high school aged writers found that students who participated in a feedback and goal setting intervention demonstrated increased confidence and self-efficacy for the use of self-regulation during writing (Wilson et al., 2022). Students who set goals are also more likely to engage more deeply and thoroughly to address the identified objective. For example, students who set goals about using a certain strategy during writing, spend longer engaging in each step of that strategy (Torrance et al., 2015). Finally, the quality of goals that are established to guide the writing process can influence the goal's effectiveness and the quality of the writing outcome. Studies of goal setting in writing have frequently compared groups of students receiving general goals for revision (e.g., "write a persuasive paragraph" or "make this essay better") versus specific revision goals (e.g., "include all the elements of a persuasive paragraph"). These studies generally find that revisions improve with specific goals (De La Paz et al., 1998; Graham et al., 2021; Midgette et al., 2008).

For example, a study by Graham and colleagues (2021) provides support for the importance of specific, content-related goals. Students who received specific goals related to revising made a greater number of revisions, more meaningful revisions, and higher quality revisions (Graham et al., 2021). Furthermore, feedback and coaching can be an effective method to help students calibrate and create their own writing goals that are more specific, proximal, and appropriately challenging (Wilson et al., 2022).

Process and Product Goals. One important distinction in the goal setting for writing literature is the question of what type of goal is most effective. Goal setting in writing can involve setting both process and product goals. Process goals in writing tend to focus on using strategies ("I will use the steps I learned to compose a descriptive paragraph"; Schunk & Swartz, 1993). Product goals focus on the specific outcomes intended, such as a number of pages to be written or following a specific structure for a descriptive paragraph (Torrance et al., 2015).

While some research suggests that process goals are ultimately the most sophisticated and effective for increasing writing quality (Schunk & Swartz, 1993), other research shows that instruction for early writers in setting product goals can lead to just as much improvement in writing quality (Page-Voth & Graham, 1999) and may help increase their efficiency (Torrance et al., 2015). Torrance and colleagues examined the effect of setting process goals versus product goals among upper elementary school writers. The researchers found improvements in writing quality of students in both conditions and found that students in the product goal condition completed the writing task more quickly than those who were engaged in a process strategy. Students in the process condition did spend more time in writing process activities (e.g., planning) than those in the product goal condition; however, because they improved just as much

as students in a product goal group, teaching students to set effective product goals may be sufficient at this stage.

How has goal setting typically been conceptualized in writing research?

Many studies of goals and writing have examined students' *use* of assigned goals, rather than goals students set for themselves. Often times these come in the form of writing prompts during the pre-writing stage that are designed to control the qualities of the goal (e.g., a general goal versus a specific goal) in an experimental design (Ferretti et al., 2000, 2009; Page-Voth & Graham, 1999; Schunk & Swartz, 1993). Other times, goals have been assigned to students during revision in order to guide revising behaviors (Graham et al., 1995, 2021; Midgette et al., 2008). These studies have helped to clarify that writing quality, writing completeness, and writing behaviors are associated with the qualities of a goal, especially specificity, and that when students are assigned a goal that identifies specific criteria to incorporate into their writing product, their writing improves.

While these experimental study designs are often considered investigations of goal *setting*, this may not be an accurate representation of how students go about creating their own goals for writing. Descriptive and naturalistic studies of these processes are few, and those that measure the quality of students' writing goals do so in the context of goal setting instruction. Broadly, these studies suggest that students can learn goal setting strategies and use them in their writing process, though they may not often occur spontaneously.

Wilson (2022) examines goal setting from the perspective of goal development and found that this skill is associated with overall writing quality. Wilson's sample consisted of 56 female students in grades five through eight. In order to support students in developing appropriate and high quality goals, students selected process goals from a list of options related to areas to

improve in their writing and were provided guidance on typical growth in the case of product goals. These scaffolds were designed to help students calibrate their goals to an appropriate and feasible level of challenge. After engaging in the intervention, students had improved in the calibration of their goals and writing quality and reported increased self-regulation related to the writing process.

Torrance and colleagues (2015) also implemented a goal setting intervention with sixth grade students in Spain. Their study compared the writing behaviors and quality of students in three treatment conditions. One group was taught a procedure for setting a product goal related to expository writing. In this condition, students learned a mnemonic to highlight the important elements of this genre and compared exemplar essays to understand how this applied to writing, from which they based their own product goal development in their writing. A second group learned the same product goal setting strategy but also took part in explicit process-related instruction in which the teacher taught strategies to guide the planning and revision processes. This was designed to influence the quality of product and process goals these students would incorporate into their writing. Finally, a control group was not taught a strategy for setting a product goal; their instruction resembled more closely typical writing instruction with practice writing and teacher feedback on elements of writing. Results of this study suggested that students could effectively learn and incorporate goal setting strategies into their writing. This resulted in an increase in the time spent writing, especially for students in the product-and-process group, and an increase in writing quality. As noted above, there was no difference detected in the post-test writing quality of students engaging in process-strategies, so their writing was identified as being less efficient than those in the product-only group.

Finally, López and colleagues (2019) employed a unique think aloud methodology in order to capture the natural goal setting processes of upper elementary students during argumentative writing. In order to combat the challenges of describing one's own thinking processes and to lessen the disruption the writing process, students wrote essays in pairs and were trained to talk through their thoughts and processes as writing with one another. The researchers captured the oral commentary and found that students engaged in very little explicit goal setting. In this case, goal setting was defined as "elaboration of objectives to be achieved by the text ('*I want to make a good text'*)" (López et al., 2019, p. 313). Goal setting occurred most frequently in the beginning of the writing time, and while students spent an average of just five seconds on goal setting, almost half of the pairs engaged in this process during writing. On the other hand, one hundred percent of students engaged in some sort of planning process, including idea generation, organization, and goal setting. The general measure of planning lasted an average of nearly four minutes across pairs. This suggests when goal setting is considered more broadly as planning prior to writing, researchers can capture more student engagement in this process. López and colleagues did not find any evidence that engagement in certain subprocesses during writing (e.g., planning, goal setting, revision) predicted writing quality. While the authors provide some justification that their novel think aloud method did not disrupt the writing process for students, it is still plausible to critique this technique in that students are typically not taught to plan and set goals for writing verbally. Second, these authors did not measure quality of that goal or plan, which may explain differences in writing quality (Wilson et al., 2022). Measuring quality of a more typical measure of planning or goal setting, such as evaluating a written plan or graphic organizer may provide additional insight into how student-set goals influence the writing process and writing quality.

These studies represent the small body of research that measures the quality of student-set goals in writing. One reason to explain this paucity may be that few students engage in goal setting on their own (Gillespie & Graham, 2014), though the studies reviewed above provide support for the integration of goal setting into the writing process. By broadening the definition of goal setting, researchers can capture more students engaging in this process (López et al., 2019). Furthermore, this literature suggests that goal setting instruction is both effective in improving students' use of goal setting and their resulting writing quality (Wilson et al., 2022). While process goals are shown to improve the process-related strategies students use in writing (Torrance et al., 2015) and process-related strategy instruction is identified as the most effective form of instruction for struggling writers (Gillespie & Graham, 2014), product goals may still help students increase in their writing quality while maintaining efficiency in writing (Torrance et al., 2015). The next section of this literature review explores how structured planning can be considered a type of product goal that influences how students engage with writing.

Planning is Goal Setting

According to Flower and Hayes (1981), goal setting begins with planning, and the goal is revisited and attended to in a recursive process throughout writing as the plan helps a writer focus and maintain progress in a directed way. They further describe planning as having three main functions: idea generation, organization, and goal setting. As Flower and Hayes highlight the recursive nature of the writing process, their model recognizes that a written plan can serve multiple functions at once. For example, a single written plan can demonstrate idea generation and organization and can be used as a goal for the task.

Development of Planning

Understanding the developmental trajectory of planning may shed light on its role in goal setting. As with goal setting (Wilson et al., 2022), planning for writing can improve with instruction and become more sophisticated over time (Limpo et al., 2014; Llaurado & Dockrell, 2019). Less sophisticated plans may not serve all three functions of idea generation, organization, and goal setting. Early writers may only engage in planning as idea generation (Llaurado & Dockrell, 2019). These plans might look like lists of words or pictures. A slightly more sophisticated plan could begin organizing this collection of ideas by adding structure to the content. Organized and structured plans help writers identify relevant ideas and avoid compositions that include too few or too many details (Chai, 2006). Finally, a well-developed plan serves the function of a well-developed goal and includes characteristics of strong goals (e.g., specificity, proximity, and difficulty; Schunk & Swartz, 1993).

Online Versus Offline Planning

Planning has been seen as a main cognitive component of the writing process. The concept of "online" planning describes the internal idea generation and organization that occurs during the translation portion of writing (Berninger & Swanson, 1994). The presence of this internal process is evident through studies that have not explicitly measured written planning and have still found that stronger writers have a longer "pause" before beginning to write (Beauvais et al., 2011; Ferrari et al., 1998). This suggests that even when planning is not written down, idea generation, structuring, and goal setting may be occurring internally.

Alternatively, written plans provide an opportunity to understand goal setting's role in the writing process in a uniquely observable way. A written plan constructed prior to writing is considered an "offline" plan and provides an external representation of the cognitive schema that

will form the intended composition (Berninger & Swanson, 1994). Students show variability in the amount of time spent engaging in offline planning and the quality of their plans which has effects on the quality of their writing (Kaplan et al., 2009; MacArthur & Graham, 1987; Thomas et al., 1987). For a young writer, offline planning provides support and structure both cognitively and socially. When planning is expressed externally, it may lessen cognitive load and help a writer hold and manipulate multiple ideas at once (McCutchen, 1996). Researchers have used this observable quality of written plans to understand the role of planning as idea generation, organization, and goal setting in writing, described below.

Planning as Idea Generation (Knowledge Telling)

Idea generation relies on a student retrieving information from long-term memory (Flower & Hayes, 1981). This is illustrated through the challenge of idea generation among students with learning disabilities. Thomas et al. (1987) found that one of the most common reasons writers with learning disabilities terminated writing early was "difficulties generating multiple ideas related to a topic… [It was] as though they had dumped all of their knowledge at once, and in doing so, had exhausted their ideas on a given topic" (p. 26). Idea generation is essential in that it provides content that will make up a composition (Chai, 2006). Though when planning exclusively involves idea generation, the writer risks a composition of unconnected and underdeveloped facts, what Bereiter and Scardamalia (1987) identified as *knowledge telling.* Bereiter and Scardamalia caution against labeling all knowledge telling compositions as low quality, and they offer a developmental view that knowledge telling (idea generation) is a necessary base from which other types of more organized and sophisticated writing emerge (p. 29). Knowledge telling compositions are more common among younger writers and students with disabilities (Graham, 1990; López et al., 2019; Thomas et al., 1987). Written compositions

made of these unorganized and unstructured lists of ideas are lower quality (Chai, 2006; Llaurado & Dockrell, 2019).

Planning as Idea Structuring (Knowledge Transforming)

In order to develop writing beyond unstructured strings of ideas, organization of content is necessary. An organized plan helps a writer adhere to genre-specific structures and increase their efficiency in ensuring that all relevant ideas can be included in a composition (Brown et al., 1983). When doing this, writers move beyond knowledge telling and into *knowledge transforming* (Bereiter & Scardamalia, 1987). Knowledge transforming builds on knowledge telling through organization of ideas into logical categories and structuring categorized ideas into a genre-based schema. As a result of this process, the writer formulates both text and knowledge as writing turns into a goal-directed problem solving process.

Brown and colleagues (1983) found evidence of the development of planning from sentence-based knowledge telling into more efficient categorization of ideas into short words or phrases. The sample in their study included writers in upper elementary school, middle school, high school, and college. Students were given time to learn six folk stories and were later asked to summarize each story in a set number of words. The authors controlled for the efficiency of word use and established an indicator of categorization of ideas by providing a limit to the number of words that could be used in the summary. Critically, students who did not plan before writing their summary engaged in knowledge telling, ran out of room, and were not able to include all relevant pieces of the story, whereas students who did engage in paper-based planning were able to more often incorporate all details provided the limited space. Older students were more likely to plan than younger students, but even younger students that planned demonstrated similar levels of efficiency to college-aged writers. This suggests that part of the knowledge

transforming process during planning involves the group of ideas as needed in order to address a particular goal or prescribed structure.

Other evidence regarding planning as knowledge transforming is found in studies more specific to genre-based compositional structures. Planning can take a variety of shapes in order to represent the intended text structure, including drafting content of a written response, pictorial or graphical representations of content, and outlining content (Llaurado & Dockrell, 2019; Thomas et al., 1987). Early writers in grades 1 and 3 tend to create more linear, single word, and genre-agnostic plans than older writers (Llaurado & Dockrell, 2019). As children's writing skills develop, planning becomes more complex in structure and may include genre markers. Llaurado & Dockrell found that students in grade 5 expressed more hierarchical relationships between content in the plans. Stronger writers develop plans and compositions that represent more varied structures with genre-specific rhetorical devices (Ferrari et al., 1998; Llaurado & Dockrell, 2019; Thomas et al., 1987), and the quality of a goal or plan that involves text structure may be dependent on a student's genre knowledge (Ferretti & Fan, 2016; Wilson et al., 2022).

Are idea generation and organization distinct functions of planning? While this system of classification provides a developmental framework from which to understand planning, the two functions of text generation and organization are likely interdependent and may overlap. One example from a content analysis of planning in elementary school writers found that students who used drawings, figures, and diagrams in their plans instead of words produced higher quality writing (Llaurado & Dockrell, 2019). One explanation for this this may be related to organization of ideas; use of non-word representations of ideas may be associated with higher level abstract thinking and ideas. Alternatively, the use of non-word representations

may be a way to bypass written language constraints on idea generation such as spelling, punctuation, and mechanics, allowing for faster generation of content (Ferrari et al., 1998).

Bereiter and Scardamalia (1987) also consider this potential overlap in their knowledge telling and knowledge transforming framework. These authors note that the act of generating ideas and putting these ideas into words (knowledge telling) likely involves knowledge transforming to some extent as authors "thematicize" and access knowledge from long term memory and move it into language. That is, in order to engage in knowledge telling (idea generation), knowledge transforming (organization) is necessary to some degree.

On the other hand, some have described the relationship between these processes as the reverse: idea organization is dependent on idea generation. Chai (2006) studied specific features of written plans and their relation to expository writing of students in grades 4, 7, and 10. Results showed that the most sophisticated plans had structure, but they also had substantial details to allow for elaboration on the topic. Idea generation was necessary to include elaborative details and write a more fleshed out argument in the composition. According to Chai, this led to "a 'Goldilocks' conclusion (a 'not too many' and 'not too few' or 'none at all', but just right amount of idea units) to commence essay writing" (p. 213). Once students engaged in deeper idea generation, they could move into organization which served the purpose of structuring and selecting an appropriate number of details to include. Despite potential ambiguity between knowledge telling, knowledge transforming, idea generation, and organization, it is a valuable framework to consider in developing writing.

Planning as Goal Setting

The broadest function of planning is goal setting (Beauvais et al., 2011), and high-quality written plans share many characteristics with high quality goals. A written plan lays out

actionable steps and provides cues to maintain focus throughout the task (Chung et al., 2021). Written plans are focused and specific (Schunk & Swartz, 1993). The written plan in writing also serves the same regulatory function as a goal. A plan provides an external representation of a goal that writers can return to frequently throughout the process to re-focus or assess progress toward the goal (Flower & Hayes, 1981; Schunk, 1990). When the written plan indicates the desired structure of the composition (such as an outline), it can be considered a product goal.

It should be acknowledged that goals fall along a continuum of quality, and both lower and higher quality plans can help a writer achieve some sort of goal. Bereiter and Scardamalia provide an explanation of how idea generation (knowledge telling) and organization (knowledge transforming) are both forms of goal setting. Each represents a different level of sophistication or concreteness of the goal. These authors conducted a think-aloud analysis of children and adults engaging in planning before writing. The child's planning was made up almost exclusively of content that could be directly used in the composition (idea generation). The adult's planning consisted mostly of comments to themselves and problem-solving statements to develop content tied to a compositional goal (knowledge transforming). According to Bereiter and Scardamalia (1987):

> What the adult displays fits a definition of planning as working through a task at an abstract level in advance of working through it at a more concrete level… [The child] is working through the task at approximately the same level of concreteness as in the actual carrying out of the writing task. (p. 21)

Though both children and adults are engaged in planning and working toward a goal, the quality of the goal differed based on the character of the planning-- idea generation or organization.

Summary of Planning Literature

To summarize, the planning literature conceptualizes this process as serving the functions of idea generation, organization, and goal setting (Flower & Hayes, 1981). The development of planning suggests that as the sophistication of the plan increases, its utility as a well-developed goal increases. This sophistication can be captured through measuring the quality of a written plan's content and structure. Plans that include mostly content with little structure are associated with *knowledge telling* (Bereiter & Scardamalia, 1987). This category includes plans that are drafted text that can be applied directly to a written composition and is more common in younger writers and those with disabilities (Bereiter & Scardamalia, 1987; Graham, 1990; Llaurado & Dockrell, 2019). Plans that categorize, organize, or structure ideas provide evidence of a writer engaging in *knowledge transformation.* These plans include outlines, structural reminders, and graphic organizers, and are evidence that the writer is engaging in planning as a strategic writing behavior (Graham et al., 2017) and are associated with a higher quality writing product in upper elementary and middle school (Chai, 2006). Finally, if goal setting is to be understood as a function of planning, it makes sense to consider the many shared characteristics between high quality plans and high quality goals, including specificity and relevance to the task. Students who create a high quality plan may be seen as having a well-developed goal that can direct behavior toward a desired outcome.

Why might goal setting explain persistence?

It is well-documented that effective planning and goal setting skills lead to higher *quality* in writing (Beauvais et al., 2011; Chai, 2006; Llaurado & Dockrell, 2019; Santangelo et al., 2016); however, the present study seeks to understand the relationship between goal setting and persisting across a writing task. Most studies examining planning and goal setting in writing

measure outcomes based on the final writing product (e.g., amount of writing produced at the end of a task or the quality of a final product), while this study captures the amount of production throughout a continuous task. López and colleagues (2019) took a similar approach to modeling process writing; however, their study did not take into account the *quality* of goal setting, which may influence its relationship to production across a writing task.

There are several possible theoretical explanations for this potential relationship between goal setting and persistence in a writing task. Cognitive theories explain goal setting through planning as a tool that frees cognitive resources otherwise spent on simultaneously generating and transcribing ideas, allowing the writer to engage more deeply and for a longer period with the task (McCutchen, 1996). A social cognitive view of self-regulated learning posits that goal setting provides a measuring stick with which a writer can monitor their progress toward goal attainment (Zimmerman, 2008). When writers engage in this reflective practice, their self-efficacy increases, and they are more likely to continue with a task and persist. Each are described in the context of planning for writing below.

Cognitive Capacity Theory of Writing and Persistence

A cognitive capacity theory may emphasize the tendency of a writer to lessen cognitive load and engage efficiently with cognitive processes involved in writing (McCutchen, 1996). As a complex multi-component process, writing places a great strain on cognitive resources (e.g., working memory), particularly for developing writers who have not yet established fluency in transcription (Kim & Graham, 2021; Limpo & Alves, 2013; Olive & Kellogg, 2002). McCutchen's theory explains that children engage in knowledge telling behaviors because those are the most efficient. Early writers allocate their cognitive resources to the content generation and transcription fundamentals of creating a written text and forego complex and taxing

processes such as planning or specific structuring (i.e., knowledge transforming) based on cognitive demands. As transcription becomes more automatic, especially in the upper elementary grades (Limpo & Alves, 2013a), this frees working memory and allows writers to devote those resources to more complex processes such as idea structuring.

McCutchen (1996) extends this theory by describing the role of planning in facilitating cognitive efficiency. Writers with higher working memory capacities tend to produce better plans, which leads to higher quality compositions (Kellogg, 1990). On the other hand, planning can lessen the cognitive demands of writing by providing an external framework and allowing working memory to be allocated elsewhere (McCutchen, 1996). It is therefore plausible that through creating a higher quality plan, writers free up cognitive resources that allow them to engage in the writing task for longer. In other words, writers who plan, persist.

Self-Regulated Learning in Writing and Persistence

A possible alternate explanation to explain the connection between goal setting, strategy use, and persistence behaviors in writing is self-regulated learning. Goal setting has been described as contributing to the "management" of the multi-faceted writing process by establishing a plan to follow, which suggests its connection to self-regulation (Beauvais et al., 2011). Zimmerman (2008) developed a three-stage model of self-regulation that describes a cycle of processes during learning and task performance. The first stage, *forethought*, includes goal setting and other strategic preparatory processes that take place before a task. In writing, this looks like the use of developing process (e.g., selecting a strategy to guide writing) and product goals (e.g., outlines) that occur during planning. Second is the *performance stage,* which includes actions that take place during task performance. In writing, this might look like the composing of the essay. Finally, the third stage is a *self-reflection* stage, which contributes to the

cyclical nature of these stages as a student reflects back on efforts and outcomes during the overall process. In writing, this self-reflection can occur as a writer pauses composition to look back at a written plan or evaluates at the end of writing whether the writing goal was addressed as part of revision. Self-reflection can also be a time in which motivational beliefs (e.g., self-efficacy) are developed or reinforced as a student evaluates their process or performance. This is shown in research among students with learning disabilities. Schunk (1985) found that participating in a goal setting exercise was associated with higher expectations of goal attainment. Relatedly, students with higher self-efficacy also had higher performance on the task. In writing, students with higher self-efficacy persisted longer in a writing task and demonstrated higher self-regulation throughout the process (Bouffard-Bouchard et al., 1991).

How do we measure persistence in writing?

Examining written production as it unfolds rather than simply a final product may facilitate understanding the role of persisting across a writing task and aligns with the construct's close relationship to time (Piazza & Siebert, 2008; Vandermeulen et al., 2020). Researchers have used both low- and high-tech methods to understand production across one writing task. Though few studies have specifically considered persistence across a writing task as an outcome of interest, there are several examples of measuring production during writing that provide support for understanding how a writer gets to the final product. This body of literature is driven in part by the development of technologies that have allowed researchers to examine the writing process. These range from rougher estimations of production rate across the writing task and modifications of transcription tools to more precise measures of bursts and pauses in writing. Together, this research provides support for measuring writing across a task and highlights how this information can be used to support developing writers.

Persistence as Writing Time

The Writing Dispositions Scale (Piazza & Siebert, 2008) was developed to measure the affective views elementary and middle school writers bring to the writing process. Factor analysis identified four items that fall into a persistence scale. These items ("I take time to try different possibilities in my writing", "I would like to write more in school", "I am willing to spend time on long papers", and "I take time to solve problems in my writing") all relate to writing time and engagement in the recursive process of writing. Wilson and Czik (2016) used this scale in a study among eighth grade students and found that students who received teacher feedback on their writing agreed more strongly that they "take time to solve problems" during writing. Behaviorally, this scale item was supported by these students completing more drafts of an essay than peers in a control condition, which Wilson and Czik attributed as a form of persisting through challenging tasks.

Production Rate

In an effort to gauge writing speed across a task, one study divided the number of words produced by the allocated writing time to calculate total words written per minute (Ignacio et al., 2019). The authors found that students in a shorter writing condition (5 minutes) had a faster calculated writing rate than students in the longer writing condition (15 minutes); however, a major limitation in their findings arises from no accounting for possible (and likely) early termination in the 15-minute writing task. Without considering this, the metric assumes all students wrote for the entire writing time and relies on a calculated average that may not represent the varying and recursive nature of the writing process (Flower & Hayes, 1981; López et al., 2019). Regardless, the authors' proposed implications of understanding writing rate in curriculum-based measures for writing, including identifying for whom shorter writing tasks may

be more accurate and when teachers should redirect student attention during assessment, are important. This suggests that a more complete analysis of student writing patterns to account for persistence and stopping time is warranted.

López and colleagues (2019) measured production across time in a more finely grained manner that captured engagement in writing-related activities and when these occurred. As described above in the goal setting section, this study used a unique methodology by pairing elementary aged writers together and asking them to co-write an argumentative essay by talking aloud to one another. Based on this modified "think aloud," researchers coded time spent on activities and calculated the probability of student engagement in various parts of the writing process (e.g., planning, translation, and revision) across the 30-minutes of the writing task. Contrary to their hypothesis, researchers found no relationship between time spent engaged in any part of the writing process and the quality of the essay, even when models considered when during writing those occurred. It is possible that examining a measure of production measured across time (e.g., Total Words Written) might explain differences in quality.

Early Modifications to Transcription Tools

Other studies manipulate the transcription tool to indicate differences in writing across time. Some researchers have timed students who handwrite an essay, asking students to switch to different colors of pens at regular intervals in order to provide rough timing estimates that correspond to written production (Ferrari et al., 1998). This study, among 48 junior college students, found that stronger writers waited for a longer period of time before beginning writing, suggesting they engaged in more planning prior to writing. These strong writers wrote longer, more organized, and more complete essays. This might suggest that measuring time writers spend engaging in processes can provide information about the quality and structure of the final

composition. This study also demonstrates that students who engage in planning also write higher-quality compositions.

Another study measured the components of the writing process (e.g., planning before writing, planning during writing, revision during writing) through a live observer coding writing behaviors and their duration across one minute intervals paired with an audio recorder set up to capture the sound of a pen scratching on paper to measure when transcription occurred (Perl, 1979). Though no robust conclusions can be drawn from the observational case studies presented, this study is another early representation of measuring written production during a composing task. The authors highlight the recursiveness of composition, especially noting how writers frequently paused their composing to reference the plan they created in the beginning. While these early studies captured differences in writing production across time intervals of a writing task, their measurements are cumbersome and may be disruptive to the process, compromising the generalizability of findings to typical tasks in the classroom.

Measuring Burst Length

More recently, advancements in technology have helped to lessen the intrusion on the writing process while still capturing in-the-moment data. The Livescribe (Limpo & Alves, 2017) transcription tool uses a pen with a camera embedded in the pen tip that measures bursts of motoric writing activity and the pauses in between these bursts. The measure of burst length is similar to persistence in that it is a measure of activity during the translation and transcription parts of writing and can be an indicator of production across a writing task, which may be related to writing quality (Alves & Limpo, 2015; Connelly et al., 2012).

Studies on burst length have found variation between low and high skilled writers' production. Generally, lower skilled writers produce texts in shorter bursts and with longer

pauses (Alves & Limpo, 2015; Connelly et al., 2012). Connelly and colleagues (2012) studied this among 99 children, including a large sample of children with a specific language impairment (*n*=33) who were matched by age and language development. The authors found that the length of pauses in between writing bursts had a negative relationship to text quality and burst length. That is, students who paused longer during writing tended to produce a lower quality composition and write in shorter bursts throughout written production. Despite this, there were no differences detected between groups in the number of bursts on the five-minute writing task. Alves and Limpo (2015) shared similar findings among a Portuguese sample of students in grades 2-7, regardless of grade, suggesting that as writers develop, their composing becomes more consistent and more efficient across a task. Writing in the opinion genre consisted of shorter bursts and longer pauses for all grades, which may mean that efficiency in this genre lags behind the more practiced story genre.

Burst length studies are also relevant to persistence through identifying the role of higher order skills that may influence whether a student stops writing early. In a study of 177 second grade students, Kim (2022) found both an indirect (via transcription) and direct effect between attentional control and burst length. Students with greater attentional control had longer bursts (i.e., wrote more during each burst). Working memory was indirectly related to burst length through transcription. The longer bursts were described as "mechanisms by which writers direct and establish agency over the process of writing" (Graham, 2021, p. 53), and Kim's work clarifies that students with greater domain-general attentional control and working memory can persist through increasing the lengths of bursts of writing.

Overall, burst length studies provide examples of understanding written production during a writing task. In relation to persistence, they indicate that less skilled writers' production

changes across the task, suggesting more effort taking place at different points in the composition (Limpo & Alves, 2017). This potential increase in cognitive effort may be indicated by longer pauses and results in less production in the task. Burst length is also related to executive functions (e.g., attention control and working memory; Kim, 2022), which likely help students persist through directing attention to a task and facilitating the transcription process (McCutchen, 1996).

Keystroke Logging

Finally, typed composition has been examined through various studies using keystroke logging as a measure of composition rate and engagement during writing (e.g., Baaijen & Galbraith, 2018; Vandermeulen et al., 2020). These high-tech instruments have focused on microlevel data that provides insight into bursts of writing that may be closely aligned with cognitive processes that contribute to the act of translating and transcribing ideas onto a page.

One critique of keystroke data is the complexity and meticulous nature of so many data points (Vandermeulen et al., 2020); however, recent work has shown the utility of using this process data for providing feedback to students (Bowen et al., 2022; Vandermeulen et al., 2020). Broadly, their findings suggest that goal setting as prompted by feedback affects writing behaviors. In one study among Thai undergraduate students enrolled in an English language composition course (n=34), students typed essays in four genres across a semester using a keystroke logging software. This software captured data such as production across the task and revision behaviors that were shared in a report provided to instructors and students. Students in the process-feedback intervention group wrote higher quality essays and more words than the control group. Additionally, they reported an increased awareness and use of strategies such as planning and goal monitoring (Bowen et al., 2022).

Using keystroke logging process data to inform teacher feedback has also been studied at the secondary level (Vandermeulen et al., 2020, 2023). Vandermeulen and colleagues (2023) provided a feedback intervention to 65 Dutch students in grade 10 who wrote informational texts. Students received feedback based on data shared in a report generated from keystroke logging data. This report included graphs and narrative explanation of components of the writing process, including the number of words typed across intervals of a 50-minute writing task, time spent writing, and time spent consulting reference sources. Students in two conditions were provided self-reflection activities and exemplars of writing processes from which to compare their data. One group of students received exemplar process reports of a similarly performing student, while a second group received example process reports of a higher performing writer. The most notable process-related findings of this study are that students in both feedback conditions spent more time in the sources, suggesting they had increased engagement in planning, and wrote more fluently in the writing task. Interestingly, students in both feedback conditions spent less time actively writing than peers who did not receive the feedback intervention. The baseline control group results showed that students increased in the amount of time spent actively writing as their general writing skills developed. That is, students in grade 12 spent more time writing than students in grades 10 and 11. The difference in writing time between treatment and control groups might be explained by the production fluency effect observed in the feedback group who may have completed writing sooner because of higher fluency. This is important, as it suggests students who are receiving “business as usual” writing instruction show a developmental trend of increasing active writing time (persistence) as their skills grow.

Summary of Research Measuring Persistence and Production Patterns in Writing

The definition of persistence that emphasizes engagement across time (Piazza & Siebert, 2008; Wilson & Czik, 2016), even in a challenging task such as writing, is one that aligns with the body of research on the process of writing. The studies reviewed above demonstrate how researchers can understand patterns of written production during composition, as opposed to simply a final product or completed essay. These studies illustrate how advances in technology can help researchers observe patterns in production while minimizing intrusion on the composition (e.g., Alves & Limpo, 2015; Vandermeulen et al., 2020). The development in measurement technologies has led to increased precision in understanding the written production, such as measuring burst length. Burst length studies provide support for examining the rate of production beyond a calculation of words written per minute (speed) or fluency (speed and accuracy). This metric seems to be a promising way in which to understand the role of component skills in writing to the overall quality of the product. Though some express concern that burst length may not provide more meaningful information about a student's writing quality than simpler metrics such as word count (Connelly et al., 2012), computer-based measurements might provide effective feedback for secondary level students to modify their writing process (Vandermeulen et al., 2020, 2023). Additionally, understanding differences in students' writing persistence more generally across a writing task may provide insight into which students stop writing early.

Perhaps the most important conclusions from the research base in understanding patterns in written production point to the practical implications of this research for young writers. Findings from the above suggest that research in persistence and production can help identify how the length of a writing task and time spent writing might be related to the quality of the final

composition (Ferrari et al., 1998; López et al., 2019). This literature also clarifies that time spent planning is related to writing fluency during composition (Ferrari et al., 1998; Vandermeulen et al., 2020, 2023) and that disruptions to the writing process may affect composition quality (Alves & Limpo, 2015; Kim, 2022; Perl, 1979). Ultimately, this information can be used by educators to provide effective feedback to students (Bowen et al., 2022; Vandermeulen et al., 2020, 2023) which leads to increased persistence and engagement throughout writing (Wilson & Czik, 2016).

Modeling Persistence through Rate and Shape of Written Production

This study builds on previous research on written production during composition by exploring the amount of cumulative text written during a common classroom assessment (i.e., curriculum based measure in written expression). Modeling students' written production over the course of a single task provides insight into their persistence in writing, indicating when they start, stop, and slow their production. Understanding change over time comes from a body of growth modeling research (Grimm et al., 2017) and measures the rate and shape of production. The rate of a student's writing in this study will be defined as the cumulative amount of text produced at specified intervals across a writing task. Often, this is measured as Total Words Written (TWW) across minutes of writing and can be understood as a linear slope. The "shape" of the written production, that is, how the rate of writing changes over time, can reveal more about a writer's patterns of production during composition. The rate a student writes may vary from interval to interval. It is not uncommon among school-age writers to stop writing before the allotted time is reached ("early termination"). This is captured by shape and can be visually represented by plotting a measure of writing production (e.g., Total Words Written) over writing time, allowing the rate (slope) to vary across intervals. As a function of potentially changing rates, shape may be best represented by a nonlinear curve (e.g., quadratic).

Considering Revision

Revisiting the recursive nature of the writing process (Flower & Hayes, 1981), it should be acknowledged that multiple subprocesses (e.g., revision) take place during the production phase of writing that could result in a writer stopping written production. While this could have potential implications as to the interpretation of the rate and shape of production as modeled across a writing task, developmental consideration of upper elementary writers assuages this. In López and colleagues' (2019) study among 6th grade writers, students spent an average of 59 seconds out of a 30-minute writing task engaged in revision. Revising behaviors took place almost exclusively in the final minute of the writing process, and the majority of writers engaging in revisions (82%) spent time re-reading their writing, as opposed to making changes to text. This aligns with other findings that developing writers rarely revise writing and that these revisions tend to not substantially alter the content or quality of the product (Graham et al., 2021; Limpo & Alves, 2013a; Shen, 2022). Therefore, it is plausible to assume that changes to rate and shape of written production in this task are more aligned with early termination of writing, rather than revision behaviors that momentarily stop production.

Considering Planning Quantity on Essay Quantity and Quality

While most studies score planning according to a rubric which accounts for structure or sophistication as opposed to quantity (e.g., De La Paz & Graham, 1997; Limpo et al., 2014; Whitaker et al., 1994), questions about the relationship between quantity of planning and written production remain. Of the studies that measure quantity of ideas in a pre-writing plan and essay, a higher number of ideas occur in compositions than in plans. For example, one study that accounted for the number of ideas included in a pre-writing plan found that even after targeted planning instruction, the number of ideas students included their pre-writing plans was small (

ranging from 2 to 5; De La Paz & Graham, 1997). In this multiple baseline design with 3 fifth grade participants, researchers found that after receiving strategy instruction in planning, two of the students increased modestly from baseline in the number of ideas they included in their pre-writing plans, one from 0 idea units to 2.7 and the second from 0 to 5.0. The third student did not engage in any pre-writing planning, even after the intervention. In contrast, all three students engaged idea generation during writing, as indicated by increases in the number of ideas in their written compositions *not present* during planning and transformations of their ideas and text that occurred during composition.

Other research finds evidence that higher quantities of planned content do not correspond to more ideas in a final composition. Ong (2013) conducted a study involving 152 pre-university Chinese students classified as English as a Second Language students found that students who were given no time to plan their writing produced the highest number of ideas in their essay writing, when compared to students who were given a typical planning time period (10 minutes) and an extended period (20 minutes). As students were given less time to plan, they produced more ideas in their final essays. Additionally, this study found that the rate of ideation was significantly higher during essay composition than during planning. Ong suggests that this is evidence that transcription may account for more variance in idea generation than planning, as this transcription during composition is more practiced and less cognitively demanding than planning. Ong posits that during composition, ideas may be retrieved more quickly and, thus, generated in greater quantities.

Additional findings suggest that there may be such thing as too much idea generation during planning, which hinders writing quality. In Ong's 2013 study, while students produced the most ideas in an extended planning time, the quality of the ideas in their final essay was

lower than students in the typical planning and no planning conditions. This contrasts with findings from Chai (2006) in a study of 1,797 writing samples from grades 4, 7, and 10. Though Chai's study did not measure quantity of ideas in the final written product, Chai found that students who elaborated with more details in their pre-writing plan wrote higher quality essays; however, when looking more closely at levels of responses, Chai found a "Goldilocks effect" that indicated high quality essays had not too few and not too many ideas. This aligns with Ong's (2013) that students who were given extended amounts of time to plan may engage in over planning. According to Ong, after generating a large number of ideas, these students may have been unable to effectively use their plan during composition. One possible explanation Ong provides is a language proficiency challenge, in which these students were unable to develop their ideas beyond planning. Ong attributed this to this sample's classification as English as a Second Language writers who were planning and composing in English. While Ong's population is among Chinese pre-university students with developing English skills, this may also relate to younger writers who are developing language skills alongside component skills of writing.

Finally, some guidance on considering the relationship between planning quantity and writing quality exists in a review by Hayes and Nash (1996). These authors provide a review of planning studies and caution against reading correlational results as causation. They provide an alternative of using partial correlations between three factors in a study (e.g., planning quantity, essay quality, and time-on-task) to provide a sort of control and statistically hold one factor constant. Hayes and Nash give several examples of calculating partial correlations that indicate no strong claims for a relationship between planning quantity and final text quality and note that much of the variation in writing quality can be related to time-on-task.

This analysis also provides support related to the present study; Hayes and Nash advocate that researchers pay attention to students' time-on-task during writing. They note patterns of students ending writing early and state that these students "will fail to face and solve the writing problems their writing assignments pose. Thus, writing instruction will suffer. Researchers need to pay much more attention to motivation than they have in the past. We need to understand better how to engage students in writing tasks" (p. 53).

Identifying Groups of Writers Based on Planning

The rate (slope) and shape (quadratic) of production during a writing task may be one way to model how planning and goal setting are related to persistence and production in young writers. The literature identifies three types of plans (no planning, knowledge telling, and knowledge transforming) which can be understood through this modeling of rate and shape. In general, the production of better planners is anticipated to be characterized by a steeper linear slope, represented by a larger coefficient. The shape of stronger planners will be represented by a narrower quadratic parabola, indicated by a negative coefficient farther from zero. The three hypothesized classes based on type of plan are described below.

Early Terminators. First, are the students who do not plan. Graham (1990) identified these "early terminators" as the students who stop writing before the allotted time. Because these students do not engage in planning before writing, they exhaust their ideas, use significant cognitive resources (McCutchen, 1996), and do not have plan from which to evaluate their progress (Zimmerman, 2008). Their production modeled across time is characterized by a low slope, indicating a slow rate of production and a wide quadratic shape, indicating a great number of early terminators whose production "flatlined" early on.

Knowledge Tellers. The second group of planners ("Knowledge Tellers") are described as those who draft text that can be used directly in composition (Bereiter & Scardamalia, 1987; Brown et al., 1983). Their shape and rate of production are characterized with a slope that is slightly steeper than Early Terminators, as they begin writing more quickly due to some level of advance planning; however, Knowledge Tellers' shape of production is also characterized by a plateau effect indicating termination after their ideas are composed in the essay. Because Knowledge Tellers have a steeper slope while they are composing than Early Terminators, the shape of their quadratic parabola is more narrow.

Knowledge Transformers. Finally, the third group of planners are the Knowledge Transformers. These students engage in transforming ideas categorizing and structuring ideas in their plans. These plans may look like short, efficient words or phrases (Brown et al., 1983) or may include structural reminders, such as outlines or bullet points (Llaurado & Dockrell, 2019). Knowledge Transformers' patterns of production are characterized by a steeper slope, due to their preplanning of ideas. This slope is more linear, as they are less likely to engage in early termination. The shape of production is represented by the most narrow quadratic parabola.

Why study this with informational writing?

The cognitive processes used to structure a text are dependent on the genre of writing (Troia et al., 2020). When writing more familiar narrative texts, writers rely on a discourse schema accessed through oral language experience and retrieval of ideas from long-term memory (Bereiter & Scardamalia, 1987). This knowledge telling schema is less applicable to informational writing in which a writer is prompted to "teach" a reader about a particular topic. Teaching someone through writing necessarily calls for an awareness of audience and requires an element of persuasion that relies on more than simply the facts a writer knows about a topic.

Writers engaging in informational writing must employ skills that are more sophisticated than knowledge telling, rather they engage in knowledge transforming (Beauvais et al., 2011; Bereiter & Scardamalia, 1987). This transformation of knowledge into complex genre-specific communication may require more cognitive resources and, as a result, more self-regulation strategies such as planning (Graham & Harris, 1997). In line with this, Beauvais and colleagues (2011) found that while narrative writing quality was not dependent on planning, argumentative writing quality was related to planning time; writers who spent more time on planning had higher quality argumentative writing. This suggests that this relationship is genre-dependent and may be more prominent for expository (informational or persuasive) genres.

Summary of Literature and Current Study

Writing theorists have long viewed goal setting as a function of planning (Flower & Hayes, 1981), and both the goal setting and writing literatures have shown that changes in behavior can result from high quality goals (Graham et al., 2021; LaPorte & Nath, 1976; Page-Voth & Graham, 1999). When measuring goal setting through planning, one indicator of quality may be the character (i.e., idea generation and/or organization) of the plan (e.g., Flower & Hayes, 1981). According to Bereiter and Scardamalia (1987), plans can facilitate idea generation (knowledge telling), which often takes the form of composing sentences that can be directly applied to a composition. More sophisticated plans build on idea generation and organize ideas into categories or a genre-based structure (knowledge transforming). These structured plans share many characteristics of high quality goals, such as specificity and proximity to the task (Schunk & Swartz, 1993). Understanding that a structured plan serves as a high quality goal provides justification for the role of planning in changing writing behaviors such as persistence

and engagement in the writing task over time. Figure A1 provides an example of how each of these theories is applied to a planning measure used in the current study.

This study explores the variability in structured written plans and how the plan influences each student's production during the writing task. The following research questions will guide this investigation.

1. Are there distinct differences (classes) in students' writing production patterns during a 15-minute writing task?

   Hypothesis 1: I hypothesized that there are distinct differences in production across a 15-minute writing task.

   Rationale: Numerous studies have found differences in writers' production as measured as the length of the final text. These studies have found that composition length is typically shorter for younger writers and students with learning disabilities (Ferrari et al., 1998; Graham, 1990; Thomas et al., 1987). Differences in production across a writing task have also been detected, with more skilled writers and students who received targeted intervention writing more consistently in long bursts and with shorter pauses across a task (Alves & Limpo, 2015; Connelly et al., 2012; Vandermeulen et al., 2023).

   Analysis Plan: I proposed these differences in production could be observed through statistical modeling of production during composition. This was measured as the cumulative Total Words Written at several specified intervals across a 15-minute writing task. The classes of writers were identified through growth mixture modeling which estimates patterns of production based on a latent grouping variable. In order to understand how groupings are related to patterns of production, I compared each class's

mean estimates for both (a) linear slopes, indicating rate of production over time, and (b) quadratic slopes, indicating the change in this production rate over time (shape).

2. Is class membership dependent on the characteristics of a student's planning?

   Hypothesis: I anticipated the quality of a student's planning would predict their group membership.

   Rationale: Though no published studies could be identified that measure the effect of the quality of a written plan on patterns of production during writing, there is evidence that higher quality planning and specific goals are related to higher quality writing (Chai, 2006; Limpo et al., 2014; Midgette et al., 2008) or a longer final writing product (Agha et al., 2022; Chai, 2006). Some findings related to time spent on writing activities suggest that writers who spend more time planning write more complete, organized, and longer essays (Beauvais et al., 2011; Ferrari et al., 1998). In fourth grade writing, strategic behaviors such as planning and goal monitoring are related to writing quality (Graham et al., 2017). Finally, while planning's effect on patterns in written production has not been directly measured, there is evidence from goal setting research that higher quality goals affect strategic behaviors, specifically sustained engagement and persistence (LaPorte & Nath, 1976). Because planning is considered a mechanism for goal setting in the writing process and high quality plans and goals share similar characteristics, I applied these results to hypothesize that writers' group membership as defined by their writing production will be dependent on the quality of their written plans.

   Analysis Plan: A planning quality measure was entered as a predictor into a logistic regression comparing likelihood of classification into one class versus another based on the student's planning score.

3. Are upper elementary school writers' plans more aligned with knowledge telling or knowledge transforming?

   Hypothesis: I anticipated there would be more knowledge telling plans among this study's sample of students in grades 4 and 5; however, I also anticipated a large portion of students would not engage in any written planning.

   Rationale: Research on the development of planning shows that younger and less skilled planners engage in more concrete, unstructured plans, often in the form of drafting content that can be directly applied to a written composition (Bereiter & Scardamalia, 1987; Graham, 1990; Limpo & Alves, 2013a; Llaurado & Dockrell, 2019). Even more, it is common for young writers to not engage in written planning unless specifically instructed to do so (Limpo et al., 2014; Olinghouse & Graham, 2009).

   Analysis Plan: A theory-aligned rubric (see Figure A1) was used to asssess the character of each student's written plan and a sum of each type of plan was calculated.

CHAPTER 3: METHOD

Design

The study is a secondary data analysis of a subset of longitudinal data collected among three cohorts as part of a larger study. Data were collected from each cohort across a school year. The goal of the overall project was to investigate the relationship between writing instruction and writing outcomes in upper elementary students. Data for the current project were taken from a portion of this multi-year project in which student writing was measured across multiple genres. The informational genre was selected for the current study because of its unique structure that may be closely tied to planning (Beauvais et al., 2011). In the larger project, data were measured four times across the school year. For this project, the second data point for each cohort (taken in January and February of the respective school year) was selected. This decision was made because at this timepoint students would have had previous exposure to the assessment program, while minimizing potential assessment fatigue that may have occurred with the third and fourth testing sessions. This observational study takes a sub-set of that data and examines individual differences that define class membership and intra-individual patterns in production across a single writing task.

Participants

Data were collected from 228 students in grades 4 (n= 123) and 5 (n= 105) across two cohorts, one in January/February 2019 and another in January/February 2020 from different schools. Teachers and their students from 6 schools in the 2019 cohort and 15 schools in the 2020 cohort. Teachers in Michigan volunteered to take part in a larger study across the entire school year in which students' writing performance was measured at multiple timepoints within business-as-usual instruction. For writing instruction, nearly all the teachers (~90%) used a

modified version of the Units of Study in Writing (Calkins, 2013) which was developed with support of the Michigan Association of Intermediate School Districts. Demographic characteristics of participants are presented in Table A1.

Materials

Writing Prompts

Students were randomly assigned one of four informational writing prompts (see Appendix B). Each prompt was reviewed by a panel of experts and pilot tested to ensure equivalence across the four prompts per genre and consistency with expectations for grades 4 and 5 writing (Truckenmiller et al., 2020). Each informational prompt included a grade-level expository reading passage from online sources intended for student use and a question about the passage designed to elicit an essay. Permission was given by copyright holders to use and modify the passages for research. Passages were selected and adjusted based upon readability for grades 3 through 8 considering word count, Lexile, Flesch-Kincaid, and Coh-Metrix narrativity and syntactic simplicity score. To limit the effect of decoding, students also listened to the passage and the prompts read aloud. The writing prompt instructed students to "write an informative paper that will help others learn about the topic of the passage you read; be sure to use information from the article you just read to give reasons why it is important." The prompt also reminded students that informative essays include a clear main idea, an introduction and conclusion, and information from the article. After listening to the writing prompt, students were given three minutes to plan with these instructions read aloud to them through headphones: "Use this page to plan your response. Remember to use the process for planning that your teacher taught you to use."

Writing Architect 1.0

The Writing Architect is a web-based program that facilitates group administration of writing prompts and a scoring database for human raters and computer tallying. Students were guided through the writing assessment on the web, beginning with selecting their grade level and assigned prompt. After students selected a prompt, all instructions and informational reading passages were read aloud by a human voice recording. Students could follow along with the prompt and passage on the screen or a printed paper copy. Students were given up to three minutes to plan their writing on provided paper and 15 minutes to write their essay by typing in a textbox. During the planning period, a 3-minute countdown timer appeared in the bottom of the screen. Students could choose to end the planning period and move to the next screen at any time, or they could continue planning after the 3-minute timer if they wanted to. They then progressed to a screen with a large blank text box to write their essay. On this page, a one-minute warning was presented through an audible beep along with a visual message. Students could end the writing session and advance to the next screen if they finished writing early; the screen automatically advanced at the end of 15 minutes. Finally, the program prompted students to take a 90-second typing fluency test.

Measures

Total Words Written

Total Words Written (TWW) is a measure of text production commonly used to score CBM-WE. TWW is a tally of words produced regardless of spelling, syntactic accuracy, or punctuation (Jewell & Malecki, 2005). While TWW has the lowest criterion validity (r=0.37; Romig et al., 2017) when compared to other scoring procedures of CBM-WE that consider accuracy, TWW is a reliable indicator of production that is easily calculated and commonly used

to indicate fluency (Datchuk et al., 2022). In this project, the Writing Architect web-based application automatically computed the Total Words Written in the textbox at 3, 5, 7, 10, and 15 minutes of the writing task (or the time of submission if the student submitted before 15 minutes) by tallying each group of letters (or single letter) separated by a space.

Planning

Planning quality is used as an indicator of goal setting in the writing process. If a written plan shares the characteristics of a high quality product or process goal, then the written plan is an indicator of goal setting. High quality goals are specific, actionable, and can be used as a measure of progress toward an intended outcome or product.

A method of scoring planning (originally used by Troia et al., 2022) was developed to align with Hayes and Flower's (1981) tripartite view of planning (idea generation, organizing, and goal setting), Bereiter and Scardamalia's (1987) knowledge telling and knowledge transforming framework, and characteristics of high quality goals (see Figure A1 for summary table and Appendix C for planning rubic; Schunk & Swartz, 1993; Zimmerman, 2008). In this study, written plans were evaluated on a scale of 0, 1, 2, or 3. Students received a planning score of zero if they had no written plan. Students received a planning score of 1 if they only drafted text in sentence form, which indicated a basic version of idea generation that was limited to only the beginning of the essay. A planning score of 2 represented organization through the use of short words or phrases. This indicated their ideas were being placed into broader groups or categories but did not signal a plan for an overall essay structure. Finally, students received a planning score of 3 if they included structural elements, including outline form or graphic organizers. Students who use structural elements are engaging in goal setting through the

formation of a clear product goal. They demonstrate their intent to create a structured composition that will address the informational prompt.

Written plans were scored by two trained graduate students. Inter-rater reliability for planning coding was calculated at 86.7% exact agreement with scores assigned after reaching consensus.

Typing Fluency

Typing fluency was included in the models because of its large influence on writing outcomes in the upper elementary grades (Truckenmiller et al., 2022). In these grades, writing quantity and quality are highly correlated (r=0.9) and closely linked to typing fluency (Truckenmiller et al., 2022). Typing fluency was measured through a 90-second paragraph copying task. The model paragraph was drawn from the copy task of the University of Washington Clinical Assessment of Writing Skills (Berninger & Whitaker, 1993). The Writing Architect program automatically tallied the number of letters and punctuation marks typed. A human scorer then counted the number of incorrectly typed letters and punctuation marks and subtracted the incorrect from the total typed to obtain a score of characters typed correctly.

Other Covariates

Student gender and grade are also included in the models. In upper elementary grade writing, there is a marked difference in writing performance, with girls outperforming boys. This pattern has persisted for decades, as indicated by a study examining writing performance from the 1980s to 2011 that found that across three decades boys were more likely to be classified on a national writing assessment as “below” proficiency in writing and girls more likely to be classified as performing in an “above” proficiency group (Reilly et al., 2019). Grade level was also included to account for potential developmental differences, though evidence suggesting

there are significant differences between writing performance in grades 4 and 5 is limited (Valentine et al., 2021).

Procedure

Administration of Writing Architect

Writing prompts were group-administered to students in the Writing Architect platform as part of a larger study that involved assessment in three genres of writing at four time points across a school year. The informational writing sample from the second administration of the school year (January/February) was selected for this study based on students having familiarity with the Writing Architect application while still maintaining a degree of novelty to prevent disengagement.

Students responded to a passage-based informational writing prompt through the Writing Architect application accessed through a netbook in the classroom or desktop computer in a computer lab. Students were also given a paper packet that contained printed versions of the reading passage, instructions, prompts, and planning space. They could refer to the passage and prompt at any time. Each student used a pair of headphones to listen to all instructions and passage read aloud. The Writing Architect program guided students through the reading passage, planning time, writing time, and typing fluency exercise as described above (See Appendix B for passages and prompts).

Analysis

Data Preparation & Descriptive Statistics

Missing Data. Little's MCAR Test indicated data were Missing Completely at Random, (χ^2) = 13.02, p = 0.876. As such, no imputation was deemed necessary. Missing data for the endogenous variables (TWW at each measured timepoint) were handled through full information

maximum likelihood (FIML) estimation in the MPLUS software. Missing data analysis of the exogenous variables (planning, typing fluency, gender, and grade) yielded 9 students with missing data. This small number (<5% of the sample) is considered to have a negligible effect (Dettori et al., 2018), thus listwise deletion was applied, resulting in a final sample size of 219 students.

Outlier Analysis. Following guidance from Tabachnick & Fidell (2020), five students were identified as potential multivariate outliers based on Total Words Written across each measured time point and the associated significant Mahalanobis distance scores (p <0.001); however, further visual inspection of the observed growth curves and student written responses identified these as appropriate production that fit within the hypothesized patterns. Two of these responses had very high typing fluency and typed quickly before ending their responses early and demonstrating a "plateau" of early termination. Two other responses demonstrated a "peaked" pattern that showed deletion of text across the writing time. The fifth potential outlier wrote steadily for the first half of the writing time, then increased their rate of production and wrote continuously for a full 15 minutes. These responses fall within plausible patterns of production and thus were kept in the analysis.

Descriptive Statistics. Descriptive statistics are reported in Table A2.

Growth Mixture Modeling

To answer research question 1, growth mixture modeling (GMM) was used to assess class membership based on a student's pattern of production during the writing task. As a mixture model, GMM assumes the presence of multiple subpopulations (or groups) in the data. GMM can be considered a version of multiple-group growth modeling in which the grouping variable is defined as an unobserved latent class that is identified *post hoc* (Ram & Grimm,

2009). As opposed to other forms of multiple-group growth models, GMM provides an advantage in that it does not require input to specify grouping structure. Because there is currently a lack of clear evidence from research for the shape of production across a single writing task and how student writing patterns might be grouped, the research question is exploratory and GMM provides the flexibility of using a latent factor structure in which the data determine the estimate and the grouping. As a growth model, GMM estimates intraindividual and interindividual changes in an outcome over time. It can be used to model both the rate and shape of that growth, including nonlinear patterns across time. Class membership was determined on the growth pattern detected across individual student's patterns of production.

Additionally, GMM allowed for the inclusion of predictors into the model. This addressed research question 2 regarding the influence of a student's planning score on their class membership. Though there has been some debate in the literature regarding the effect that predictors may have on the identification of class membership, Grimm et al. (2017) advocate for their introduction into the models after identifying the model based only on growth patterns. The suggested procedure for model building and including covariates is described in the following section.

Model Building Procedure

Model building followed a four-step procedure as recommended by Ram and Grimm (2009) described below.

Step 1: Problem Definition. The first step of the GMM model building procedure emphasizes rooting hypotheses in theory and exploratory data examination (Ram & Grimm, 2009). As part of this step, I specified research questions and their associated hypotheses and conducted initial data exploration with a subsample of the data (see Appendix D).

Step 2: Model Specification. A single class model of production (TWW) across each time interval in the 15-minute writing task was fit as a baseline model. Group comparison models systematically introduced additional classes. Because a 3-class solution was hypothesized based on theory and preliminary data exploration, models up to 4 classes were specified. All models included a linear and quadratic slope in order to capture hypothesized non-linear shape of production across the task.

Steps 3 and 4: Model Estimation and Selection. Models were run using Mplus Version 8 software (Muthén & Muthén, 2017). Parameter estimates and fit statistics (AIC, BIC, VLMR, BLRT) were recorded. These fit statistics were used for systematic model comparison, starting by comparing the baseline model to a simple 2-class solution, and then a 2-class solution to a 3-class solution, and a 3-class solution to the 4-class. Adequate entropy (above 0.8) and the number of cases per class was considered to establish confidence that cases were suitably classified (Ram & Grimm, 2009).

Covariates were added using the R3STEP approach. To investigate the role of planning and relevant covariates (typing fluency, gender, and grade), the R3STEP approach was used. This is a 3-step process that involves first identifying a latent grouping variable as in the growth mixture models. Second, the most likely class membership is identified for each row by selecting the class with the highest posterior probability and a rate of uncertainty is computed for each row. By incorporating this rate of uncertainty, the R3STEP approach allows for the error associated with class membership probabilities less than 1 and recognizes that latent class membership is not a known variable. Third, the auxiliary variables, most likely class variable, and uncertainty rates are incorporated into a multinomial logistic regression to estimate the odds

of membership in each class for each auxiliary variable. The logistic regression yields a comparison of individual classes in comparison to a reference class.

CHAPTER 4: RESULTS

Research Question 1: Identifying Classes of Writers Based on Rate and Shape of Production

Model Estimation

For the growth mixture model, unconditional models were fit to Total Words Written at each timepoint (3 minutes, 5 minutes, 7 minutes, 10 minutes, and submission). Growth factor loadings for time were specified to approximate different time intervals for each of the measured time points, with the intercept was centered at 7 minutes based on a visual inspection of data that suggested that was the timepoint before which most students stopped writing (slowed production). Mean estimates for intercept, slope, and deceleration (quadratic) were allowed to vary by class. Models allowing variance and covariance to vary by class failed to converge, so I decided to proceed with the means and class-invariant variances and covariances models. Residual variances for the first measured timepoint (Total Words Written at 3 minutes) and the last measured timepoint (Total Words Written at submission) were fixed to 0 across classes due to small (<|1|) negative residual variances in the first and final timepoints in initial models. This is considered an appropriate specification for small, negative residual variances (Farooq, 2022).

As a note on the decision to center the intercept at 7 minutes, this choice was made to aid interpretation and address a peripheral research question regarding the implications of CBM-WE test length. Visual inspection of TWW production curves across 15 minutes, showed that most students wrote the most (i.e., had the steepest slope indicating production) up to 7 minutes of the test. Approximately around this timepoint, visual analysis indicated that students' production began to slow or plateau. Comparison of the intercepts of each class at 7 minutes allows for interpretations of what production may look like if CBM-WE are shortened to a length at which

most students write for the duration of the allotted writing time. Centering at 10 minutes or more may obscure information about students who stop writing early and exacerbate detected gaps between high-production writers and low-production writers.

Model Selection and Class Identification

To compare models of different classes, unconditional models with no included predictors were examined. Ram and Grimm (Ram & Grimm, 2009) describe model selection as an "art" that accounts for both model-derived fit statistics and theory, and both were considered for determination of the final solution. Based on visual patterns observed in the initial data exploration (see Figure D1 in Appendix D), a three-class solution was hypothesized. To be comprehensive, 1-, 2-, 3-, and 4-class solutions are compared. Fit statistics were compared in a systematic process, starting by comparing an *n* class solution to the *n-1* class solution. Fit statistics are reported in Table A3 and discussed below.

First, Information Criteria were examined across the models. Typically, lower values of the Akaike Information Criterion (*AIC*) and the Bayesian Information Criterion (BIC) indicate a better fit. For a mixture model, BIC is considered the most reliable of the information criterion fit indices (Nylund et al., 2007). Considering the relatively small sample of this study, the Sample Size Adjusted BIC (SSA-BIC) is also reported. For all models that converged (1-, 2-, 3-, and 4-class solutions) the SSA-BIC decreased as the number of classes were increased. One approach to comparing Information Criteria is a visual examination of SSA-BIC plotted for each solution, looking for the point at which adding an addition class produces diminishing returns. While a slight "elbow point" indicates a possible point of diminishing return between the 1-class and 2-class solutions, this pattern is not clear enough to make a definitive decision (see Figure A2). A

similar pattern of decreasing indices as models were built was observed when comparing AIC and BIC.

Likelihood ratio tests (LRT) are another comparison tool that provide a test of significance to compare models. The Bootstrap Likelihood Ratio Test (BLRT) uses a bootstrap sampling method to estimate the test statistic that can be used to compare the *n* class model to the *n-1* class model. The BLRT is considered to be the most consistent of the LRTs in identifying correct models in Growth Mixture Modeling (Nylund et al., 2007). Comparing BLRT *p*-values demonstrated a similar pattern as the comparison of Information Criteria described above; each class added in the model building procedure yielded a statistically significant *p*-value associated with the BLRT. That is, the test statistic suggested the *n*-1 class solution should be rejected in favor of the *n* class solution. It should be noted, this pattern was not observed in other LRTs (i.e., Vuong-Lo-Mendell-Rubin likelihood ratio test and the Adjusted Lo-Mendell-Rubin likelihood ratio test). For the 2-, 3-, and 4- class solutions, none resulted in a statistically significant *p*-value, which would suggest a 1-class solution was the best fit. Importantly, Nylund and colleagues (2007) note that significance values for LRT other than the BLRT commonly move across the threshold of significance (e.g., $p < 0.05$) and thus are less reliable than the BLRT in mixture models. As such, the BLRT is weighed more heavily in this assessment of model fit.

Finally, model fit can be determined based on the accuracy of individuals' class assignment, or *entropy*. This statistic ranges from 0 to 1, with adequate fit considered to have entropy estimates above 0.8 and higher levels indicating stronger classification accuracy. Comparison of entropy levels across each model, show that all models meet the threshold of entropy greater than 0.8. The 2-class solution resulted in entropy of 0.914. The 3-class solution resulted in a level of 0.939, and the 4-class solution entropy is reported as 0.953. Taken together,

these entropy levels suggest all models have strong classification of individuals, with the 4-class solution having a slight advantage.

Overall, comparison of model fit statistics did not yield a clear best-fit solution across the 1-, 2-, 3-, and 4-class solutions. Examination of the SSA-BIC plot suggested adding a second class might be a point of diminishing return; however, there was not a distinct elbow point to indicate a strong preference for the 2-class over the 3-class solution. Comparison of the *p*-values associated with the BLRT suggested the 4-class solution as the best fit. Finally, with entropy levels for all models well above the threshold for adequate classification, the 4-class model demonstrated slightly higher accuracy in classifying individuals. Each solution will be described below in more detail and later considered in line with theories of production in upper elementary writing as the best remaining method to select the most appropriate solution.

1-Class Solution

The 1-class solution (see Figure A3) identified a single class (*nc* = 228) of writers who wrote an average of 59.15 words at 7 minutes in the writing assessment. The slope estimate of 5.77 ($p < 0.001$) words written per minute, indicated that students increased their production across time, and the significant negative quadratic estimate indicates this group of students decelerated or slowed in their rate of production across the assessment ($\alpha_3 = -0.31$, $p < 0.001$). The variance of the intercept ($\psi_{11} = 1251.02$, $p < 0.001$) suggests a high amount of between-student variation of the number of words written at 7 minutes.

2-Class Solution

The 2-class solution identified a class of 168 students (approximately 74% of the sample) and a class of 60 students (approximately 26% of the sample). Class 1 (*nc*= 168) wrote an average of 50.51 words at 7 minutes ($p < 0.001$) with a slope of 3.95 words per minute (*p*

<0.001). The quadratic slope (α_3= -0.33, p <0.001) indicates a deceleration in rate of production over time. Class 2 (nc = 60) had written more words at 7 minutes (α_1= 83.35, p <0.001) and produced these words at a faster rate on average than Class 1 (α_2= 10.88, p <0.001). The magnitude of deceleration is smaller for Class 2 than for Class 1 (α_3= -0.26, p <0.001), meaning Class 2's rate of production did not slow as rapidly as that of Class 1, as illustrated in Figure A4.

3-Class Solution

The 3-class solution identified a group of 159 students (approximately 70% of the sample), a class of 50 students (approximately 22% of the sample), and a class of 19 students (approximately 8% of the sample; see Figure A5). Class 1 (nc= 159) wrote an average of 49.84 words at 7 minutes (p <0.001) with a linear slope of 3.76 words written per minute (p <0.001). The quadratic slope (α_3= -0.33, p <0.001) indicates a deceleration in rate of production over time. Class 2 (nc = 50) had 21.53 more words written at 7 minutes (α_1= 71.37, p <0.001) and produced these words at rate nearly three times as fast on average than Class 1 (α_2= 9.17, p <0.001). Class 2 also displayed a statistically significant quadratic (α_3= -0.28, p <0.001), meaning Class 2's rate of production did slow across time, though not as quickly as that of Class 1. Finally, Class 3 (nc= 19) represented the group with the highest number of words written at 7 minutes (α_1= 102.229, p <0.001) and the steepest rate of production (α_2= 13.135, p <0.001). Compared to Class 1, Class 3 had written 52.39 more words at 7 minutes at a rate 3.5 times faster. Compared to Class 2, Class 3 wrote 30.86 more words at the 7-minute mark at a rate nearly 1.5 times faster. Notably, Class 3 did not yield a statistically significant quadratic estimate, suggesting their rate of production did not change across the assessment. In other words, students in Class 3 did not show a pattern of slowing or stopping their writing.

4-Class Solution

The 4-class solution identified 4 groups of students consisting of Class 1 (*nc* = 149 students, approximately 65% of the sample), Class 2 (*nc* = 27 students, approximately 12% of the sample), Class 3 (*nc* = 39 students, approximately 17% of the sample), and Class 4 (*nc* = 13 students, approximately 6% of the sample; see Figure A6). Class 1 was made of the largest number of students and demonstrated the fewest average words written at 7 minutes (α_1= 49.35, p <0.001) with a slope of 3.55 (p < 0.001). This class showed a statistically significant deceleration across time (α_3= -0.321, p <0.001). Members of Class 2 wrote more words on average at 7 minutes (α_1= 60.81, p <0.001) with an average slope estimate of 7.64 words written per minute (p < 0.001). Students in this class also decelerated in their rate of production (α_3= -0.343, p <0.001). Class 3 wrote an average of 80.37 words at the intercept (p < 0.001) with a steeper rate of production than Classes 1 or 2 (α_2= 10.18, p <0.001). This class also had a statistically significant deceleration (α_3= -0.261, p <0.001), though the rate of change was smaller than Classes 1 or 2. Finally, Class 4 wrote the highest average TWW at 7 minutes (α_1= 97.557, p <0.001). This group's average slope was the steepest (α_2=12.81, p <0.001), and Class 4 did not have statistically significant quadratic estimate, suggesting this class did not slow or stop their production across the 15 minutes.

Summary of Results for Research Question 1

Model selection should consider a combination of fit statistics and interpretability (Ram & Grimm, 2009). Fit statistics alone did not yield a clear best-fit model, as described above, so I will take an interpretability approach. Previous studies have described different types of writers based on time spent in written production (e.g., "early terminators", Graham, 1990; López et al., 2019), thus the 1-class solution was rejected in favor of multi-class solutions that describe

multiple groups. While the 2-, 3-, and 4-class solutions all point to several patterns of written production, the 2-class solution presents two groups that display quadratic shapes (i.e., deceleration) to production over time. While this is aligned with my hypothesized patterns of production, the 3- and 4-class solutions are more compelling as they identify an additional class that does not decelerate across time and point to greater variation in upper elementary school writing production patterns. This is similar to findings presented by Lopez et al. (2019) that show great variation in students' engagement in translation (i.e., idea generation and transcription) across a writing task, including students who write through the end of the task, suggesting a group that has a linear slope that does not taper or plateau. Finally, to adjudicate the 3-class and 4-class solutions, I consider the interpretability of each group. The 3-class solution presents 3 groups of writers that are distinct in their intercepts, rates (linear slopes), and shapes (quadratic slopes). Students with steeper slopes decelerate less and also have higher intercepts. This aligns with previous findings that students who write faster (rate) across time (shape), write more (intercept) (Alves & Limpo, 2015). This also allows for interpretation of low-, mid-, and high-performing groups of writers.

On the other hand, the 4-class solution contains two classes (Class 1 and Class 2) whose slopes cross, suggesting a class of writers who have written fewer words at the beginning of the task but write at a faster rate so they eventually overtake another group in production. While this is a plausible pattern of production, previous findings align more clearly with the 3-class solution in which intercept, slopes, and deceleration are more parallel with each other across groups. Finally, while a 4-class solution would provide additional nuance to an understanding of upper elementary writing patterns, the 4-class solution provides little additional information about those students who struggle with maintaining production across a writing task. That is, the 4-

class solution appears to parse the classes who are the highest performing writers into smaller classes. The largest class (Class 1) is made up of 69% of students in the 3-class solution and 65% of students in the 4-class solution. Adding this additional class provides little additional nuance to the two-thirds of upper elementary aged writers who write the least at the slowest rate and end their writing early.

Thus, the 3-class solution will be described as the best-fit solution as a model of patterns of written production in upper elementary school writing based on the information it provides about multiple groups of writers, its alignment with existing literature.

The 3-class solution may be best characterized as three patterns of production. Class 1 are the "Early Terminators." They have the lowest intercept, least steep slope, and the most deceleration. Their production slows to a flat plateau at 10 minutes, indicating they have stopped writing. Class 2 are the "Decelerating Producers." Their production is characterized by a higher intercept at 7 minutes than the Early Terminators. Interesting, towards the beginning of the task, the Decelerating Producers had a similar number of words written as the Early Terminators; however, because they wrote at a faster rate, their production across time was much greater than Early Terminators. Additionally, though the Decelerating Producers have a statistically significant deceleration seen in the quadratic slope, their slowing is not as strong as the Early Terminators, and though their rate of production slows across time, it does not stop or plateau completely. Finally, class 3 are the "Steady Writers." These students have the highest intercept and write more than their peers in the Early Terminators or Decelerating Producers groups. Remarkably, this group does not have a statistically significant quadratic slope, indicating no slow down across time. The Steady Writers' production is modeled best by a steep linear slope that continues across the 15-minute task.

Research Question 2: Predictors of Class Membership (R3STEP Approach)

The R3STEP approach resulted in logistic regressions that estimate how a change in the predictor (i.e., planning) and covariate values (i.e., typing fluency, gender, and grade) increase or decrease the likelihood of membership in a particular class. These likelihoods can then be interpreted as a description of the profiles of each class based on planning, typing fluency, gender, and grade. The R3STEP approach was used separately for each of the multi-class solutions (2-, 3-, and 4-class solutions) and results are presented below and in Tables 4-6.

2-Class Solution

The results of predictors of class membership for the 2-class solution are presented in Table A4.

Planning as a Predictor of Class Membership. In the 2-Class solution, planning was a statistically significant predictor of class membership ($\beta_{planning}$= 0.501, p =0.006). The odds ratio of planning indicates that for a 1-unit increase in planning, a student's odds of being a member of class 2 increase by 65% ($e^{\beta}{}_{planning}$ -1).

Typing Fluency as a Predictor of Class Membership. Typing fluency was a small, yet statistically significant predictor of membership between Classes 1 and 2 (β_{typing}= 0.011, p =0.003). Students who typed one more character were 1% more likely to belong to Class 2 than Class 1.

Gender as a Predictor of Class Membership. Gender was not a statistically significant predictor of class membership in the 2-class solution.

Grade as a Predictor of Class Membership. Grade level predicted a student's class membership, when holding all other variables constant (β_{grade}= 0.758, p =0.039). Students in grade 5 were 113% more likely to belong to Class 2 than Class 1.

Summary of Predictors of Class Membership for 2-Class Solution. When holding other variables constant, planning, typing fluency, and grade level were statistically significant predictors of class membership. Students with higher levels of each of these variables were more likely to belong to Class 2 than Class 1.

3-Class Solution

The results of predictors of class membership for the 3-class solution are presented in Table A5.

Planning as a Predictor of Class Membership. In the 3-Class solution, planning was a statistically significant predictor of membership between Class 1 and Class 2, holding other covariates (typing fluency, gender, and grade) constant. When comparing Class 2 to reference Class 1, the beta-coefficient for planning is positive and statistically significant ($\beta_{planning}$= 0.687, p <0.001). This indicates that as a student's planning score increases, they are more likely to belong to Class 2 than Class 1. When comparing Class 1 and 2, the odds ratio of planning indicates that for a 1-unit increase in planning, a student's odds of being a member of Class 2 increase by 98.8% ($e^{\beta}_{planning}$ -1). Planning was not a statistically significant predictor of membership in the comparison between Classes 1 and 3 or between Classes 2 and 3.

Typing Fluency as a Predictor of Class Membership. In the 3-Class solution, typing fluency predicted a small and significant difference in membership between Classes 1 and 3 (β_{typing} = 0.022, p<0.001). Typing fluency is also a statistically significant differentiator between Classes 2 and 3 (β_{typing} = -0.023, p=0.006). Students who typed 1 character more in the 90-second typing test had 2% greater odds of belonging to Class 3 than Class 1. Similarly, students who typed 1-character more had 2% greater odds of belonging to Class 3 than Class 2. Typing fluency did not have a statistically significant influence on membership between Classes 1 and 2.

Gender as a Predictor of Class Membership. Gender was a statistically significant predictor of membership in Class 2 versus Class 3 (β_{gender} = -1.774, p= 0.043). The negative coefficient indicates that in comparison to reference Class 3, students who were female (coded as 1) were less likely to belong to Class 2. Based on the odds ratio, students who are female are 83% less likely to belong to Class 2 than Class 3. Gender was not a statistically significant predictor of membership between Classes 1 and 2 or Classes 1 and 3.

Grade as a Predictor of Class Membership. Grade predicted a student's class membership when comparing Classes 1 and 2, but not Classes 1 and 3 or Classes 2 and 3. For students in Class 2, the logistic regression coefficient of 0.968 is positive and statistically significant (p=0.014), indicating that an increase in grade level is associated with an increase in the likelihood that a student will be grouped in Class 2, as opposed to reference class 1. The odds ratio of 2.633 indicates that students in grade 5 (i.e., a 1-unit increase in grade level) are 2.633 times more likely to belong to Class 2 than Class 1.

Summary of Predictors of Class Membership for 3-Class Solution. Overall, planning predicted a difference between Class 1 and 2, but not Classes 1 and 3 or Classes 2 and 3. Typing fluency predicted group membership between Classes 1 and 3 and Classes 2 and 3 but not Classes 1 and 2. Gender was a predictor of membership when comparing Classes 2 and 3, but not Classes 1 and 3 or Classes 1 and 2. A student's grade level (i.e., grade 4 or grade 5) predicted membership between Classes 1 and 2, but not between Classes 1 and 3 or Classes 2 and 3. Taken together, these results suggest that planning is most important in differentiating between writers who stop early and write the least (Class 1) with students who write for slightly longer (Class 2). Grade level also plays a role in distinguishing membership between Classes 1 and 2, with older students (grade 5) more likely to belong to the class whose members write more at a faster rate,

which may suggest a developmental change between grades 4 in 5 related to production pattern or planning. Finally, typing fluency and gender set apart Class 3 which writes the most at the fastest rate.

4-Class Solution (R3STEP Approach)

The results of predictors of class membership for the 4-class solution are presented in Table A6. Of note, the 4-class solution appears to contain a nondifferentiated class (Class 2) that challenges the interpretability of this solution. Planning, typing fluency, gender, and grade were not statistically significant predictors of membership in Class 1 versus Class 2. This suggests that the members of model-identified Class 2 in this solution do not share characteristics in these variables that are typically influential in upper elementary writing. As such, this suggests the 4-class solution may lack interpretability as a description of upper elementary writers. Alternatively, there may be predictive metrics to discriminate between the classes but were not measured in this study. For the sake of comprehensiveness, the results of the logistic regressions evaluating each predictor in the 4-class solution are presented below.

Planning as a Predictor of Class Membership. In the 4-Class solution, planning was a statistically significant predictor of membership between Classes 1 and 3 and Classes 2 and 3, holding other covariates (typing fluency, gender, and grade) constant. When comparing Class 3 to reference Class 1, the beta-coefficient for planning is positive and statistically significant ($\beta_{planning}$= 0.627, p =0.001). This indicates that as a student's planning score increases, they are more likely to belong to Class 3 than Class 1. When comparing Class 1 and 3, the odds ratio of planning indicates that for a 1-unit increase in planning, a student's odds of being a member of Class 3 increase by 87% ($e^{\beta}_{planning}$ -1). A comparison of Class 2 (reference class) and Class 3 shows the beta-coefficient for planning is positive and statistically significant ($\beta_{planning}$= 0.696, p

=0.015). This means that as a student's planning score increases, the odds of their membership in Class 3 (as opposed to Class 2) increase by approximately 100% (odds ratio= 2.006). That is, students in Class 3 are more likely to have higher planning scores. Planning was not a statistically significant predictor of membership in the comparison between Classes 1 and 2, Classes 1 and 4, Classes 2 and 4, or Classes 3 and 4.

Typing Fluency as a Predictor of Class Membership. In the 4-Class solution, typing fluency predicted membership in several of the class comparisons, particularly when comparing classes of writers who wrote less (e.g., Class 1) and writers who wrote more (e.g., Classes 3 and 4). When comparing Class 1 and Class 4, typing fluency predicted a small and significant difference in membership ($\beta_{typing} = 0.022$, $p<0.001$). Students who typed one more correct character were 2% more likely to belong to Class 4 than Class 1 (odds ratio=1.022). A comparison between Classes 2 and 4, shows a similar small, yet significant increase in the odds of belonging to Class 4 with higher typing fluency ($\beta_{typing} = 0.022$, $p=0.016$). Finally, when comparing Classes 3 and 4, students with higher typing fluency were slightly more likely (<2%) to belong to Class 4 than Class 3 ($\beta_{typing} = 0.016$, $p=0.036$). Typing fluency did not have a statistically significant influence on membership between Classes 1 and 2, Classes 1 and 3, or Classes 2 and 3.

Gender as a Predictor of Class Membership. Gender differentiates Classes 2 and 4 ($\beta_{gender} = 1.909$, $p=0.04$). and Classes 3 and 4 ($\beta_{gender} = 1.941$, $p=0.02$), holding all other covariates constant. The positive coefficients indicate that in comparison to the reference class, students who were female (coded as 1) were more likely to belong to Class 4, in their respective comparisons. Based on the odds ratios, students who are female are 575% more likely to belong to Class 4 than Class 2 and 596% more likely to belong to Class 4 than Class 3. Gender was not a

statistically significant predictor of membership between Classes 1 and 2, Classes 1 and 3, Classes 1 and 4, or Classes 2 and 3.

Grade as a Predictor of Class Membership. In the 4-class solution, grade differentiated Classes 1 and 3 only. For students in Class 1, the logistic regression coefficient of 0.932 is positive and statistically significant (p=0.027), indicating that an increase in grade level is associated with an increase in the likelihood that a student will be grouped in Class 3, as opposed to reference class 1. The odds ratio of 2.54 indicates that students in grade 5 (i.e., a 1-unit increase in grade level) are 153% more likely to belong to Class 3 than Class 1.

Summary of Predictors of Class Membership for 4-Class Solution. The profile of predictors of class membership for the 4-class solution generally align with that of the 3-class solution. That is, in general, students with higher planning and typing fluency are more likely to belong to Class 3 or 4 (students who wrote at the fastest rate and slowed less) than Classes 1 or 2. Gender differentiated Class 4 from Classes 2 and 3, but not from Class 1. Grade differentiated students only between Classes 1 and 3.

What stands out about the 4-class solution is the comparable profile of predictors between Class 1 and 2, suggesting these classes are more similar than different. In fact, as described above, none of the predictors of interest (i.e., planning, typing fluency, gender, or grade) were a statistically significant predictor of belonging to Class 2 versus Class 1. While these classes may be differentiated by factors not measured in this study, these predictors do differentiate Class 1 and Class 2 from the other classes in the solution (Classes 3 and 4) in a similar way. For example, when comparing planning as a predictor of membership between Classes 1 and 3, the estimates are of a similar magnitude to planning as a predictor of membership between Classes 2 and 3. The estimate of planning as a predictor of class

membership between Classes 1 and 3 is β= 0.627 (p =0.001), which is very close to that in the regression predicting membership between Classes 2 and 3 (β= 0.696, p =0.015). There are similar parallels between Classes 1 and 2 when comparing other predictors' relationships to class membership.

Overall, the 4-class solution presents an interpretation challenge based on the undifferentiation between Classes 1 and 2 by common elements that contribute to upper elementary writing (i.e., planning, typing fluency, gender, and grade level). As such, it is difficult to characterize the differences between Classes 1 and 2 in the 4-class solution.

Research Question 3: Types of Planning in Upper Elementary Writing

Research question 3 asks what type of planning elementary school writers in this sample completed based on a frequency analysis of planning scores (see Table A7). Students that did no written planning received a score of 0. Across the sample, about 20% of students (n= 44) did not plan before writing. Nearly half of students in the sample (46.6%, n= 103) engaged in drafting of text prior to writing (most often the beginning of their essay), received a score of 1, and demonstrated some idea generation but little organization (i.e., Knowledge Telling). Plans that were scored as 2 (18%, n= 4) had short phrases or illustrations, which indicated some organization through categorizing ideas. Plans that scored as 3 (approximately 15% of students, n= 33) included more complex organization through text-level structure markers (e.g., outline format). Plans that included organization (i.e., those that scored 2 or 3) represent a version of Knowledge Transforming. In sum, most students (about 80%) engaged in some type of planning prior to writing, with nearly half of the sample simply drafting their responses.

The cross tabulated distribution of planning scores by individual's class membership is presented in Table to provide further interpretation of the makeup of each class. Notably, the

Early Terminators (Class 1) have the highest percentage (25%) of students who did not engage in any planning. Half of students drafted their text (score of 1), with about 13% and 12% who engaged in organization-related planning (scores of 2 and 3, respectively). The Decelerating Producers (Class 2) had very few students who did not plan at all (8%), with about one-third of students engaging in drafted text (score of 1), 35% of students planning with short words or illustration (score of 2), and 23% of students planning with structural reminders. Finally, the Steady Writers (Class 3) had only 1 student (5%) not engage in planning prior to writing, half of students drafting their text, and 21% of students in each category of organized planning (scores of 2 and 3).

CHAPTER 5: DISCUSSION

The purpose of this study was to identify patterns of writing production among upper elementary school writers and to understand the role of planning in these patterns. Inspired by anecdotal observations and previous research studies that find certain students terminate their writing earlier than peers (e.g., Graham et al., 1990), this study sought to understand who stops writing early and why this might be. I hypothesized that planning functionally serves as goal setting, and that students who have a more structured goal write more during a complex task. This discussion summarizes the major findings across three research questions, notes the limitations of the studies, and describes implications for theory, research, and practice in this area. The research questions from the study were:

1. Are there distinct differences (classes) in students' writing production patterns during a 15-minute writing task?
2. Is class membership dependent on the characteristics of a student's planning?
3. Are upper elementary school writers' plans more aligned with knowledge telling or knowledge transforming?

Summary of Major Findings

There are differences in production patterns in upper elementary school writing (Research Question 1). My hypothesis was supported as the growth mixture model identified three differentiated classes of writers (Early Terminators, Decelerating Producers, and Steady Writers) based on the rate and shape of the number of words written across a 15-minute writing task. The Early Terminators produced writing at a rate that slowed significantly across the task to a plateau, indicating they had stopped writing before the end of the task (i.e., terminated early). The Decelerating Producers also had a significant deceleration in production rate across time,

though it was not as strong as the Early Terminators. While this group slowed their production across the task, they did not display a strong plateau in their production curve, suggesting that as a whole, this group continued to write, albeit at a continuously slowing rate, across the task. Finally, the third model-identified group of writers (Steady Writers) did not decelerate in their production across the task. This group wrote at the fastest rate across the task and likely could have used additional time in the task to express all of their ideas.

The second research question explored how planning and other important covariates in upper elementary writing (i.e., typing fluency, gender, and grade) predicted class membership. Logistic regressions indicated the odds of being classified into one class over another by each characteristic. My hypothesis that planning would predict membership was partially supported by predicting group membership between just the two lower performing groups. For the three-class model, planning was a significant predictor of class membership when comparing the Early Terminators to the Decelerating Producers. Students with higher planning scores were nearly 99% more likely to be classified as a Decelerating Producer than an Early Terminator.

Adding additional nuance beyond my hypotheses, other covariates included in the models predicted membership in comparison between other groups. Typing fluency set the Steady Writers apart from both other classes in the 3-class model with a small, yet significant increase in the odds of membership (about 2% increase for each additional character typed in the typing fluency test). Gender defined the Decelerating Producers from the Steady Writers, with girls more likely to be Steady Writers. Finally, grade level differentiated the Early Terminators from the Decelerating Producers. Students in grade 5 (when compared to grade 4) were more likely to be Decelerating Producers than Early Terminators.

When looking at the types of plans created by upper elementary writers (Research Question 3), my hypothesis was partially supported. First, more students engaged in written planning than I hypothesized; however, students may have been more likely to engage in planning because they were explicitly instructed to do so (Gillespie & Graham, 2014). On the other hand, my hypothesis that the most common type of written plan would align with Knowledge Telling was supported. The frequency analysis showed that nearly half of students simply began drafting their essays on the planning sheet (Knowledge Telling). One in five students did not plan at all prior to writing. About 19% of students used short phrases or words for planning, and about 15% of students used indicators of structure such as an outline or web. While the frequency analysis is simply observational, it is notable that 39 of the 44 students who did not engage in planning before writing were classified as Early Terminators. This class also had the largest number of students who began drafting essays as their form of planning (77 out of 103).

Three Patterns of Production in Upper Elementary Writing

This study not only confirms variability in rates of production among upper elementary school writing, but it also sheds light on the patterns associated with slowing production and terminating writing early. While educators and researchers have long noted that some students terminate their writing early (e.g., Ferrari et al., 1998; Graham, 1990; Thomas et al., 1987), prior studies have only provided rough estimates of production rates and termination (e.g., Ignacio et al., 2019). This study contributes to the field by identifying three distinct groups based on production patterns, capturing the nuanced rate and shape of production that lead to termination for some writers and persistent production across the task for others.

The distribution of students among the three classes of writers aligns with expectations, with over two-thirds of students writing at a slower rate relative to peers and stopping writing before 15 minutes. There is a smaller group of students who write at slightly faster rate that slows over time. The smallest group of writers produces at the fastest rate throughout the task and does not slow. While these groups have not been previously identified, their distribution is supported by ample research indicating many late elementary students struggle with writing (White et al., 2015) and sustaining production in longer task lengths (Ignacio et al., 2019). This is likely especially pronounced in the informational genre, where students tend to have less practice and the language structure is more complex, placing more strain on cognitive resources (Beauvais et al., 2011; Dockrell et al., 2018).

Early Terminators- The Largest Group of Upper Elementary Writers

The largest group of writers wrote the slowest and the least amount during the writing task. These findings of a large group of Early Terminators aligns with previous research on writing production in upper elementary school. For example, the most recent National Assessment of Educational Progress (NAEP) for fourth grade writing demonstrates that the written production of this sample is similar to other upper elementary school writers. The lowest group of writers in this study wrote an average of 58.7 words at submission, aligning well with NAEP's lowest performing group who wrote an average of 60 words on that computer-based assessment (White et al., 2015). The results of this study extend our understanding by showing that the identified group of lowest performing writers (i.e., Early Terminators) not only produces the least amount of writing at the end of the task but writes at the slowest rate and decelerates the fastest, leading to early termination. Though not captured in the NAEP assessment, the results of

this study suggest that many students in this group are likely not writing for the duration of the writing task.

Decelerating Producers- A Group Who Uses Structured Planning

The Decelerating Producers are a group of students who are older and use structured planning to continue writing across the task. While the Decelerating Producers' planning structures still show that 1-in-3 students engage in drafting text, this group also shows a higher proportion of students engaging in more sophisticated structuring that transforms and organizes ideas (Bereiter & Scardamalia, 1987) than students in the Early Terminators group. This supports previous research showing that planning structure is related to text length and quality (Limpo & Alves, 2013b) and the amount of time students spend writing (Ferrari et al., 1998).

The significance of grade level as a differentiator between this group and the Early Terminators provides further evidence for the power of education. Though this study took place in a business-as-usual instructional context, with no particular emphasis on enhancing writing instruction, this finding suggests that with extra instruction (delivered in this case, through an additional year of school), students can grow in their planning skills and writing stamina. Furthermore, planning is a teachable skill with some of the highest effect sizes in writing instruction (Gillespie & Graham, 2014; Koster et al., 2015), and structured planning is one way to support upper elementary writing (Limpo & Alves, 2013b; Shen, 2022). Although my finding about planning is correlational, it is supported by experimental research showing that upper elementary writers who receive instruction in structured planning are more likely to create plans that use a Knowledge Transforming structure (Llaurado & Dockrell, 2019). Future research in this area should examine planning beyond structure to understand how the number and quality of ideas in planning differentiate Early Terminators from Decelerating Producers and the quality of

their texts. Indeed, there is evidence that despite students engaging in planning during elementary school, these skills are not developed to a point of affecting text quality until grades 7-9 (Limpo & Alves, 2013a).

Steady Writers- Girls Who are Fluent Typers

While the Decelerating Producers appear to use structured planning as a strategy to increase their rate of writing, the third class of Steady Writers, appear not to need explicit planning to sustain their writing throughout the task. This group's production is characterized by writing the most words per minute and maintaining that production across the writing task. The significant relationship between production pattern and typing fluency in the Steady Writers group reflects the literature finding that transcription plays a direct role in upper elementary writing quality (Gong et al., 2022; Graham, 2010; Limpo & Alves, 2013a).

Gender played a striking role in defining the Steady Writers group, with girls nearly five times as likely to be grouped in the highest performing group than the Decelerating Producers group. This aligns with the identified gender gap in writing production, accuracy, and overall performance (e.g., Fearrington et al., 2014; McMaster et al., 2017; Reilly et al., 2019) . Reilly and colleagues (2019) conducted a meta-analysis of National Assessment of Educational Progress data between 1988 and 2011 and found that girls consistently outperformed boys in writing from grades 4 to 12. They also noted that this gap was more pronounced on the extreme ends of performance, mirroring the results of the present study that girls are much more likely to belong to the highest performing group. Notably, this pattern was not replicated in the lowest performing group (Early Terminators), which suggests that within the largest group of writers, girls and boys are just as likely to struggle with maintaining production across time. The "girl advantage" in writing performance has been attributed to a number of factors, including

accelerated communication and language development (Fearrington et al., 2014), orthographic coding (Berninger et al., 2008), and motivation and perceptions of writing (Graham et al., 2017).

Implications for Theory and Research

Based on the results of this study, researchers should consider two main implications. First, this study was the first to examine different profiles of students' writing at a key developmental period (i.e., late elementary grades) and provides nuance to the field's understanding of how writing develops. Second, this study highlights a direct connection to an emerging theory of writing development (i.e., DIEW).

This study provides further justification for the use of analyses that consider different distributions and patterns among groups of writers (e.g., mixture models). To my knowledge mixture modeling has not been used before this study to identify groups based on the longitudinal patterns during production, though several recent studies have identified the importance of multiple distribution analyses in other production-related writing studies (see Torrance & Conijn, 2024). Identifying different groups seems especially important in a complex domain (e.g., writing) in which students within a grade level likely vary widely in their development.

The use of the mixture model to identify different groups of writers helps to clarify how writing production can be measured in the upper elementary grades. Often writing rate is calculated with rough estimates such as dividing Total Words Written by the allotted writing time, potentially obscuring information about a large group of the lowest performing writers who do not write for the entire task (e.g., Ignacio et al., Datchuk et al., 2022). These results suggest there is nuance to production, and it does not occur at a linear rate for most upper elementary writers. This study suggests that a 15-minute writing task may be too long for a pure measure of

production for most students (i.e., Early Terminators) who stop writing around the 10-minute mark and do not produce additional words, while the small group of Steady Writers continue writing. This results in a final production-based measure that may exacerbate the gap between the Early Terminators and the Steady Writers. While writing is a complex task that incorporates both transcription and self-regulatory processes, and some measures of performance should account for all components, the results of this study highlight that so-called "production" measures such as Total Words Written likely measure a multitude of skills that go beyond producing text on a page.

These results can be understood through the Direct and Indirect Effects of Writing (DIEW) model. DIEW provides a framework that acknowledges the nuanced complexities of writing as a process that involves more than simply transcribing words on a page, but also includes executive functions, component language skills, background knowledge, and social emotional and regulatory processes. While students varied in the amount of text they produced, as captured in the growth mixture model, each student's group membership was predicted by other characteristics identified in other layers of the DIEW model (e.g., planning/goal setting as a form of social emotional and self-regulation and typing fluency as a component skill). For researchers, this provides further evidence that capturing the behaviors that take place during the process, rather than simply looking at a final product, is especially important to understand younger and struggling writers. While this study benefited from efficiently capturing words written at certain timepoints across an existing computer-based assessment used in classrooms, other technologies, such as those used in the burst length studies (see Torrance & Conijn, 2024) may offer more exacting precision, in order to capture additional nuance of writing behavior

during a task. Future research questions could help address this by examining the integration of various components of the DIEW model and writing process.

Implications for Practice

The results of this study have implications for both instruction and assessment of upper elementary writing.

Implications for Instruction

Planning may be a tool for writers who struggle to sustain production throughout a task (e.g., "Early Terminators"). The analysis identified that, apart from grade level, higher quality planning was the sole differentiator between those who stopped writing the soonest (Early Terminators) and the group who wrote at a slightly faster rate and wrote for longer (Decelerating Producers). Planning and goal setting theories suggest that this occurs through enhanced self-regulation, idea generation, and knowledge transformation (Bereiter & Scardamalia, 1987; Kellogg, 1990), and these can be directly taught through evidence based instructional strategies in the classroom.

One especially strong example of a theory-aligned and evidence-based strategy for planning is taught within the Self-Regulated Strategy Development (SRSD) framework through the POWER strategy that describes writing as a five-step process (Laud & Patel, 2023). The first two letters of the POWER mnemonic guide writers to (1) Plan and (2) Organize their writing. Students are taught to set a goal and identify a task by pulling apart the prompt and asking, "Do What," addressing the self-regulatory function of goal setting. Next, students pick ideas to address that prompt, engaging in idea generation. Finally, students are taught to organize those ideas (knowledge transformation) through graphic organizers.

Implications for Assessment and Task Administration

With its emphasis on writing production throughout a writing task, this study also highlights several considerations for writing task administration, namely, task length and prompting to students to continue writing. First, the significant role a student's grade played in predicting class membership suggests this is a time in which some students are transitioning into needing a longer writing time period. As a group, the Early Terminators plateaued after 10 minutes, while the Decelerating Producers continued writing, albeit at a slower rate. This suggests that for fifth grade students, writing assessment task length should extend beyond 10 minutes; though this warrants further investigation as some research suggests little difference in production between shorter and longer tasks for middle school students (Ignacio et al., 2019). Additionally, the Steady Writers were not defined by grade level, illustrating that in the upper elementary years, regardless of grade, there will likely be a small group of students who will require more than 15 minutes to express all their ideas and would benefit from an even longer task.

One of the first studies of early termination of writing was to understand how to include feedback to prompt writers to "say more" after they have stopped writing (Graham, 1990). Planning cues have also been investigated as an additional piece of feedback to prompt writers to shift from knowledge telling to knowledge transforming (Bereiter & Scardamalia, 1987). Gillespie and Graham (2014) called this "procedural facilitation" in a meta-analysis that identified six studies of prompting. Though they found a non-significant effect size of 0.24 of prompting to continuing writing, the present study quantifies the common observation that the majority of students stop writing before the end of a writing task and suggests that further work is needed in this area.

Limitations and Future Directions

Though the results do show that planning was a predictor of patterns of production between the two lower performing classes of writers, this study is limited in the scope of its explanation. Though the theoretical framework presented goal setting as a mechanism by which planning facilitates persistence in writing, the way in which this happens cannot be tested by the present study. The planning metric was designed to be aligned with theories of writing, planning, and goal setting (i.e., Bereiter & Scardamalia, 1987; Flower & Hayes, 1981; Schunk & Swartz, 1993; Zimmerman, 2008); however, there may be additional nuance in these plans. Planning may be occurring cognitively and cannot be captured via permanent product. Using a think aloud protocol may better capture this. Additionally, by simply measuring the structure of planning, I was unable to make substantive conclusions about the relationship between idea generation and production. Studies could build on the finding that planning predicts the rate and shape of students' written production by considering how the ideas or content generated are related to production.

In addition to an alternative measure of planning, future studies should directly measure other characteristics in the DIEW model that are likely related to students' production and engagement throughout a task, namely, motivation, working memory, and attentional control. DIEW identifies a relationship between motivation and affect toward writing are related to goal setting in writing. This has been supported by empirical research that finds a relationship between fourth grade students' motivation and use of strategic writing behaviors, such as planning (Bai & Guo, 2021) and motivation and writing quality (Graham et al., 2017). DIEW also identifies domain-general cognitions (e.g., working memory and attentional control) that play a role in developing writing and are related to text length (Drijbooms et al., 2015) and

quality (Cordeiro et al., 2020). These should be examined in future research related to patterns of production as they are likely factors in when students start and stop writing.

Finally, another limitation to the present study is the lack of understanding the instructional context of the classrooms. Based on the plans that students created, it was clear that instruction was not strong enough to convince students to write out a specific text structure or explicitly set a goal, despite the prompt to plan before writing. This compromises the external validity of these results to other populations in which students receive different amounts of instruction in planning and goal setting in writing.

Conclusion

Educators have long noted the challenges students face in sustaining production throughout longer writing tasks, and this study supports the variation in upper elementary writing productivity. Further, this study shows that without strong writing instruction, a majority of upper elementary school writers stop writing early. Critically, this study highlights an opportunity for instruction in grades 4 and 5. The differences between Class 1 (where students stopped producing writing soonest) and Class 2 (where students wrote for longer and produced more), suggest that increasing students' persistence in the task could include explicitly teaching planning and goal setting for idea generation and organization. These findings provide yet more support for the ample body of literature identifying developmental variation in upper elementary writing and pointing to strong, systematic writing instruction to keep students going.

REFERENCES

Agha, A. A., Truckenmiller, A. J., Fine, J. G., & Perreault, M. (2022). A preliminary investigation into the role of planning in early writing development. *Assessment for Effective Intervention*, 15345084211073601. https://doi.org/10.1177/15345084211073601

Alexander, P. A. (2003). The development of expertise: The journey from acclimation to proficiency. *Educational Researcher*, *32*(8), 10–14. https://doi.org/10.3102/0013189X032008010

Alves, R. A., & Limpo, T. (2015). Progress in written language bursts, pauses, transcription, and written composition across schooling. *Scientific Studies of Reading*, *19*(5), 374–391. https://doi.org/10.1080/10888438.2015.1059838

Baaijen, V. M., & Galbraith, D. (2018). Discovery through writing: Relationships with writing processes and text quality. *Cognition and Instruction*, *36*(3), 199–223. https://doi.org/10.1080/07370008.2018.1456431

Bai, B., & Guo, W. (2021). Motivation and self-regulated strategy use: Relationships to primary school students' English writing in Hong Kong. *Language Teaching Research*, *25*(3), 378–399. https://doi.org/10.1177/1362168819859921

Bakunas, B. (1996). Promoting idea production by novice writers through the use of discourse-related prompts. *Applied Psycholinguistics*, *17*(4), 385–400. https://doi.org/10.1017/S014271640000816X

Beauvais, C., Olive, T., & Passerault, J.-M. (2011). Why are some texts good and others not? Relationship between text quality and management of the writing processes. *Journal of Educational Psychology*, *103*(2), 415–428. https://doi.org/10.1037/a0022545

Bereiter, C., & Scardamalia, M. (1987). *The psychology of written composition*. Lawrence Erlbaum Associates.

Berninger, V. W. (1999). Coordinating transcription and text generation in working memory during composing: Automatic and constructive processes. *Learning Disability Quarterly*, *22*(2), 99–112. https://doi.org/10.2307/1511269

Berninger, V. W., Nielsen, K. H., Abbott, R. D., Wijsman, E., & Raskind, W. (2008). Gender differences in severity of writing and reading disabilities. *Journal of School Psychology*, *46*(2), 151–172. https://doi.org/10.1016/j.jsp.2007.02.007

Berninger, V. W., & Swanson, H. L. (1994). Modifying Hayes and Flower's model of skilled writing to explain beginning and developing writing. *Children's Writing: Toward a Process Theory of the Development of Skilled Writing*, *2*, 57–81.

Berninger, V. W., & Whitaker, D. (1993). Theory-based branching diagnosis of writing disabilities. *School Psychology Review*, *22*(4), 623. https://doi.org/10.1080/02796015.1993.12085678

Bouffard-Bouchard, T., Parent, S., & Larivee, S. (1991). Influence of self-efficacy on self-regulation and performance among junior and senior high-school age students. *International Journal of Behavioral Development*, *14*(2), 153–164. https://doi.org/10.1177/016502549101400203

Bowen, N. E. J. A., Thomas, N., & Vandermeulen, N. (2022). Exploring feedback and regulation in online writing classes with keystroke logging. *Computers and Composition*, *63*, 102692. https://doi.org/10.1016/j.compcom.2022.102692

Brindle, M., Graham, S., Harris, K. R., & Hebert, M. (2016). Third and fourth grade teacher's classroom practices in writing: A national survey. *Reading and Writing*, *29*(5), 929–954. https://doi.org/10.1007/s11145-015-9604-x

Brown, A. L., Day, J. D., & Jones, R. S. (1983). The development of plans for summarizing texts. *Child Development*, *54*(4), 968–979. https://doi.org/10.2307/1129901

Butler, C. M., & De La Paz, S. (2021). A synthesis on the impact of self-regulated instruction on motivation outcomes for students with or at risk for learning disabilities. *Learning Disabilities Research & Practice*, ldrp.12264. https://doi.org/10.1111/ldrp.12264

Chai, C. (2006). Writing plan quality: Relevance to writing scores. *Assessing Writing*, *11*(3), 198–223. https://doi.org/10.1016/j.asw.2007.01.001

Chung, H. Q., Chen, V., & Olson, C. B. (2021). The impact of self-assessment, planning and goal setting, and reflection before and after revision on student self-efficacy and writing performance. *Reading and Writing*, *34*(7), 1885–1913. https://doi.org/10.1007/s11145-021-10186-x

Connelly, V., Dockrell, J. E., Walter, K., & Critten, S. (2012). Predicting the quality of composition and written language bursts from oral language, spelling, and handwriting skills in children with and without specific language impairment. *Written Communication*, *29*(3), 278–302. http://dx.doi.org/10.1177/0741088312451109

Cordeiro, C., Limpo, T., Olive, T., & Castro, S. L. (2020). Do executive functions contribute to writing quality in beginning writers? A longitudinal study with second graders. *Reading and Writing*, *33*(4), 813–833. https://doi.org/10.1007/s11145-019-09963-6

Datchuk, S. M., Rodgers, D. B., Wagner, K., Hier, B. O., & Moore, C. T. (2022). Effects of writing interventions on the level and trend of total words written: A meta-analysis. *Exceptional Children*, *88*(2), 145–162. https://doi.org/10.1177/00144029211027537

De La Paz, S., & Graham, S. (1997). Strategy instruction in planning: Effects on the writing performance and behavior of students with learning difficulties. *Exceptional Children*, *63*(2), 167–181. https://doi.org/10.1177/001440299706300202

De La Paz, S., Swanson, P. N., & Graham, S. (1998). The contribution of executive control to the revising by students with writing and learning difficulties. *Journal of Educational Psychology*, *90*(3), 448. https://doi.org/10.1037/0022-0663.90.3.448

Dettori, J. R., Norvell, D. C., & Chapman, J. R. (2018). The sin of missing data: Is all forgiven by way of imputation? *Global Spine Journal*, *8*(8), 892. https://doi.org/10.1177/2192568218811922

Dockrell, J., Connelly, V., Walter, K., & Critten, S. (2018). The role of curriculum based measures in assessing writing products. In B. Miller, P. McCardle, & V. Connelly (Eds.), *Writing Development in Struggling Learners* (Vol. 35, pp. 182–197). Brill. https://doi.org/10.1163/9789004346369_011

Dockrell, J. E., Connelly, V., Walter, K., & Critten, S. (2015). Assessing children's writing products: The role of curriculum based measures. *British Educational Research Journal*, *41*(4), 575–595. https://doi.org/10.1002/berj.3162

Drake, K., Belsky, J., & Fearon, R. M. (2014). From early attachment to engagement with learning in school: The role of self-regulation and persistence. *Developmental Psychology*, *50*(5), 1350. https://doi.org/10.1037/a0032779

Drijbooms, E., Groen, M. A., & Verhoeven, L. (2015). The contribution of executive functions to narrative writing in fourth grade children. *Reading and Writing*, *28*(7), 989–1011. https://doi.org/10.1007/s11145-015-9558-z

Eccles, J. S. (2020). From expectancy-value theory to situated expectancy-value theory_ A developmental, social cognitive, and sociocultural perspective on motivation. *Contemporary Educational Psychology*. https://doi.org/10.1016/j.cedpsych.2020.101859

Farooq, R. (2022). Heywood cases: Possible causes and solutions. *International Journal of Data Analysis Techniques and Strategies*, *14*, 79–88. https://doi.org/10.1504/IJDATS.2022.10045654

Fearrington, J. Y., Parker, P. D., Kidder-Ashley, P., Gagnon, S. G., McCane-Bowling, S., & Sorrell, C. A. (2014). Gender differences in written expression curriculum-based measurement in third- through eighth-grade students. *Psychology in the Schools*, *51*(1), 85–96. https://doi.org/10.1002/pits.21733

Ferrari, M., Bouffard, T., & Rainville, L. (1998). What makes a good writer? Differences in good and poor writers' self-regulation of writing. *Instructional Science*, *26*, 473–488. https://doi.org/10.1023/A:1003202412203

Ferretti, R. P., Lewis, W. E., & Andrews-Weckerly, S. (2009). Do goals affect the structure of students' argumentative writing strategies? *Journal of Educational Psychology*, *101*(3), 577–589. https://doi.org/10.1037/a0014702

Ferretti, R. P., MacArthur, C. A., & Dowdy, N. S. (2000). The effects of an elaborated goal on the persuasive writing of students with learning disabilities and their normally achieving peers. *Journal of Educational Psychology*, *92*(4), 694–702. https://doi.org/10.1037/0022-0663.92.4.694

Flower, L., & Hayes, J. R. (1981). A cognitive process theory of writing. *College Composition and Communication*, *32*(4), 365. https://doi.org/10.2307/356600

Gillespie, A., & Graham, S. (2014). A meta-analysis of writing interventions for students with learning disabilities. *Exceptional Children*, *80*(4), 454–473. https://doi.org/10.1177/0014402914527238

Gong, T., Zhang, M., & Li, C. (2022). Association of keyboarding fluency and writing performance in online-delivered assessment. *Assessing Writing*, *51*, 100575. https://doi.org/10.1016/j.asw.2021.100575

Graham, S. (1990). The role of production factors in learning disabled students' compositions. *Journal of Educational Psychology*, *82*(4), 781. https://doi.org/10.1037/0022-0663.82.4.781

Graham, S. (2010, September). Want to improve children's writing? *The Education Digest*, *76*(1), 49–55.

Graham, S. (2021). Executive control and the Writer(s)- within-Community model. In T. Limpo & T. Olive (Eds.), *Executive functions and writing* (pp. 38–76). Oxford University Press. https://doi.org/10.1093/oso/9780198863564.003.0003

Graham, S., Daley, S. G., Aitken, A. A., Harris, K. R., & Robinson, K. H. (2018). Do writing motivational beliefs predict middle school students' writing performance? *Journal of Research in Reading*, *41*(4), 642–656. https://doi.org/10.1111/1467-9817.12245

Graham, S., & Harris, K. R. (1997). Self-regulation and writing: Where do we go from here? *Contemporary Educational Psychology*, *22*(1), 102–114. https://doi.org/10.1006/ceps.1997.0920

Graham, S., Harris, K. R., Adkins, M., & Camping, A. (2021). Do content revising goals change the revising behavior and story writing of fourth grade students at-risk for writing difficulties? *Reading and Writing*, *34*(7), 1915–1941. https://doi.org/10.1007/s11145-021-10142-9

Graham, S., Kiuhara, S. A., Harris, K. R., & Fishman, E. J. (2017). The relationship among strategic writing behavior, writing motivation, and writing performance with young,

developing writers. *The Elementary School Journal*, *118*(1), 82–104. https://doi.org/10.1086/693009

Graham, S., MacArthur, C., & Schwartz, S. (1995). Effects of goal setting and procedural facilitation on the revising behavior and writing performance of students with writing and learning problems. *Journal of Educational Psychology*, *87*, 230–240. https://doi.org/10.1037/0022-0663.87.2.230

Grimm, K. J., Ram, N., & Estabrook, R. (2017). *Growth modeling: Structural equation and multilevel modeling approaches*. Guilford Press.

Hayes, J. R., & Nash, J. G. (1996). On the nature of planning in writing. In C. Levy & S. Ransdell (Eds.), *The science of writing: Theories, methods, individual differences, and applications* (pp. 29–55). Erlbaum.

Ignacio, P. L., McCurdy, M., White, J., Auge, M. B., Skinner, C. H., & Schwartz-Micheaux, J. (2019). The effects of explicit timing on middle-school students' writing production across 5- and 15-min sessions. *Psychology in the Schools*, *56*(9), 1482–1492. https://doi.org/10.1002/pits.22286

Jewell, J., & Malecki, C. K. (2005). The utility of CBM written language indices: An investigation of production-dependent, production-independent, and accurate-production scores. *School Psychology Review; Bethesda*, *34*(1), 27–44. https://doi.org/DOI: 10.1080/02796015.2005.12086273

Kaplan, A., Lichtinger, E., & Gorodetsky, M. (2009). Achievement goal orientations and self-regulation in writing: An integrative perspective. *Journal of Educational Psychology*, *101*(1), 51–69. https://doi.org/10.1037/a0013200

Kellogg, R. T. (1987). Writing performance: Effects of cognitive strategies. *Written Communication*, *4*(3), 269–298. https://doi.org/10.1177/0741088387004003003

Kellogg, R. T. (1990). Effectiveness of prewriting strategies as a function of task demands. *American Journal of Psychology*, *103*(3), 327–342. https://doi.org/10.2307/1423213

Kent, S. C., & Wanzek, J. (2016). The relationship between component skills and writing quality and production across developmental levels: A meta-analysis of the last 25 years. *Review of Educational Research*, *86*(2), 570–601.

Kim, Y.-S., Al Otaiba, S., Wanzek, J., & Gatlin, B. (2015). Toward an understanding of dimensions, predictors, and the gender gap in written composition. *Journal of Educational Psychology*, *107*(1), 79–95. https://doi.org/10.1037/a0037210

Kim, Y.-S. G. (2022). Do written language bursts mediate the relations of language, cognitive, and transcription skills to writing quality? *Written Communication*, 07410883211068753. https://doi.org/10.1177/07410883211068753

Kim, Y.-S. G., & Graham, S. (2021). Expanding the Direct and Indirect Effects Model of Writing (DIEW): Reading–writing relations, and dynamic relations as a function of measurement/dimensions of written composition. *Journal of Educational Psychology*. http://dx.doi.org/10.1037/edu0000564

Kim, Y.-S. G., & Park, S.-H. (2019). Unpacking pathways using the direct and indirect effects model of writing (DIEW) and the contributions of higher order cognitive skills to writing. *Reading and Writing*, *32*(5), 1319–1343. https://doi.org/10.1007/s11145-018-9913-y

Koster, M., Tribushinina, E., Jong, P. F. de, & Bergh, H. van den. (2015). Teaching children to write: A meta-analysis of writing intervention research. *Journal of Writing Research*, *7*(2), Article 2. https://doi.org/10.17239/jowr-2015.07.02.2

LaPorte, R. E., & Nath, R. (1976). Role of performance goals in prose learning. *Journal of Educational Psychology*, *68*(3), 260–264. https://doi.org/10.1037/0022-0663.68.3.260

Laud, L., & Patel, P. (2023). *POWER-up your students' writing*. thinkSRSD.

Limpo, T., & Alves, R. A. (2013a). Modeling writing development: Contribution of transcription and self-regulation to Portuguese students' text generation quality. *Journal of Educational Psychology*, *105*(2), 401–413. https://doi.org/10.1037/a0031391

Limpo, T., & Alves, R. A. (2013b). Teaching planning or sentence-combining strategies: Effective SRSD interventions at different levels of written composition. *Contemporary Educational Psychology*, *38*(4), 328–341. https://doi.org/10.1016/j.cedpsych.2013.07.004

Limpo, T., & Alves, R. A. (2017). Written language bursts mediate the relationship between transcription skills and writing performance. *Written Communication*, *34*(3), 306–332. https://doi.org/10.1177/0741088317714234

Limpo, T., Alves, R. A., & Fidalgo, R. (2014). Children's high-level writing skills: Development of planning and revising and their contribution to writing quality. *British Journal of Educational Psychology*, *84*(2), 177–193. https://doi.org/10.1111/bjep.12020

Llaurado, A., & Dockrell, J. E. (2019). Children's plans for writing: Characteristics and impact on writing performance. *Journal of Literacy Research*, *51*(3), 336–356. https://doi.org/10.1177/1086296X19859516

Locke, E. A., & Latham, G. P. (2002). Building a practically useful theory of goal setting and task motivation: A 35-year odyssey. *American Psychologist*, *57*(9), 705–717. https://doi.org/10.1037/0003-066X.57.9.705

López, P., Torrance, M., & Fidalgo, R. (2019). The online management of writing processes and their contribution to text quality in upper-primary students. *Psicothema*, *31.3*, 311–318. https://doi.org/10.7334/psicothema2018.326

MacArthur, C. A., & Graham, S. (1987). Learning disabled students' composing under three methods of text production: Handwriting, word processing, and dictation. *The Journal of Special Education*, *21*(3), 22–42. https://doi.org/10.1177/002246698702100304

McCutchen, D. (1996). A capacity theory of writing: Working memory in composition. *Educational Psychology Review*, *8*(3), 299. https://doi.org/10.1007/BF01464076

McMaster, K. L., Shin, J., Espin, C. A., Jung, P.-G., Wayman, M. M., & Deno, S. L. (2017). Monitoring elementary students' writing progress using curriculum-based measures: Grade and gender differences. *Reading and Writing: An Interdisciplinary Journal*, *30*(9), 2069–2091. https://doi.org/10.1007/s11145-017-9766-9

Midgette, E., Haria, P., & MacArthur, C. (2008). The effects of content and audience awareness goals for revision on the persuasive essays of fifth- and eighth-grade students. *Reading & Writing*, *21*(1/2), 131–151. https://doi.org/10.1007/s11145-007-9067-9

Nylund, K. L., Asparouhov, T., & Muthén, B. O. (2007). Deciding on the number of classes in latent class analysis and growth mixture modeling: A Monte Carlo simulation study. *Structural Equation Modeling: A Multidisciplinary Journal*, *14*(4), 535–569. https://doi.org/10.1080/10705510701575396

Olinghouse, N. G., & Graham, S. (2009). The relationship between the discourse knowledge and the writing performance of elementary-grade students. *Journal of Educational Psychology*, *101*(1), 37–50. https://doi.org/10.1037/a0013462

Olive, T., & Kellogg, R. T. (2002). Concurrent activation of high- and low-level production processes in written composition. *Memory & Cognition*, *30*(4), 594–600. https://doi.org/10.3758/BF03194960

Ong, J. (2013). Discovery of ideas in second language writing task environment. *System*, *41*(3), 529–542. https://doi.org/10.1016/j.system.2013.05.001

Page-Voth, V., & Graham, S. (1999). Effects of goal setting and strategy use on the writing performance and self-efficacy of students with writing and learning problems. *Journal of Educational Psychology*, *91*, 230–240. https://doi.org/10.1037/0022-0663.91.2.230

Perl, S. (1979). The composing processes of unskilled college writers. *Research in the Teaching of English*, *13*, 317–336.

Piazza, C. L., & Siebert, C. F. (2008). Development and validation of a writing dispositions scale for elementary and middle school students. *The Journal of Educational Research*, *101*(5), 275–286. https://doi.org/10.3200/JOER.101.5.275-286

Ram, N., & Grimm, K. J. (2009). Growth mixture modeling: A method for identifying differences in longitudinal change among unobserved groups. *International Journal of Behavioral Development*, *33*(6), 565–576. https://doi.org/10.1177/0165025409343765

Reilly, D., Neumann, D. L., & Andrews, G. (2019). Gender differences in reading and writing achievement: Evidence from the National Assessment of Educational Progress (NAEP). *American Psychologist*, *74*(4), 445–458. https://doi.org/10.1037/amp0000356

Romig, J. E., Therrien, W. J., & Lloyd, J. W. (2017). Meta-analysis of criterion validity for curriculum-based measurement in written language. *The Journal of Special Education*, *51*(2), 72–82. https://doi.org/10.1177/0022466916670637

Santangelo, T., Harris, K. R., & Graham, S. (2016). Self-regulation and writing. In C. MacArthur, S. Graham, & J. Fitzgerald (Eds.), *Handbook of writing research* (2nd ed., pp. 174–193). Guilford.

Schunk, D. H. (1985). Participation in goal setting: Effects on self-efficacy and skills of learning-disabled children. *The Journal of Special Education*, *19*(3), 307–317. https://doi.org/10.1177/002246698501900307

Schunk, D. H. (1990). Goal setting and self-efficacy during self-regulated learning. *Educational Psychologist*, *25*(1), 71–86. https://doi.org/10.1207/s15326985ep2501_6

Schunk, D. H., & Swartz, C. W. (1993). Goals and progress feedback: Effects on self-efficacy and writing achievement. *Contemporary Educational Psychology*, *18*(3), 337–354. https://doi.org/10.1006/ceps.1993.1024

Shen, M. (2022). Effective planning and revising strategies for meeting the needs of students with learning difficulties and literacy needs. In T. Abodeeb-Gentile & D. A. Conrad (Eds.), *Intersections of Diversity, Literacy, and Learner Difficulties: Conversations between Teacher, Students and Researchers* (pp. 57–80). Springer Nature. https://doi.org/10.1007/978-981-19-3532-9_4

Tabachnick, B., & Fidell, L. (2020). *Experimental designs using ANOVA*.

Thomas, C. C., Englert, C. S., & Gregg, S. (1987). An analysis of errors and strategies in the expository writing of learning disabled students. *Remedial and Special Education*, *8*(1), 21–30.

Torrance, M., & Conijn, R. (2024). Methods for studying the writing time-course. *Reading and Writing*, *37*(2), 239–251. https://doi.org/10.1007/s11145-023-10490-8

Torrance, M., Fidalgo, R., & Robledo, P. (2015). Do sixth-grade writers need process strategies? *British Journal of Educational Psychology*, *85*(1), 91–112. https://doi.org/10.1111/bjep.12065

Torrance, M., Thomas, G. V., & Robinson, E. J. (1994). The writing strategies of graduate research students in the social sciences. *Higher Education*, *27*(3), 379–392. https://doi.org/10.1007/BF03179901

Troia, G. A., Brehmer, J. S., Glause, K., Reichmuth, H. L., & Lawrence, F. (2020). Direct and indirect effects of literacy skills and writing fluency on writing quality across three genres. *Education Sciences*, *10*(11), Article 11. https://doi.org/10.3390/educsci10110297

Troia, G. A., Wang, H., & Lawrence, F. R. (2022). Latent profiles of writing-related skills, knowledge, and motivation for elementary students and their relations to writing performance across multiple genres. *Contemporary Educational Psychology*, *71*, 102100. https://doi.org/10.1016/j.cedpsych.2022.102100

Truckenmiller, A. J., Cho, E., & Troia, G. A. (2022). Expanding assessment to instructionally relevant writing components in middle school. *Journal of School Psychology*, *94*, 28–48. https://doi.org/10.1016/j.jsp.2022.07.002

Truckenmiller, A. J., McKindles, J. V., Petscher, Y., Eckert, T. L., & Tock, J. (2020). Expanding curriculum-based measurement in written expression for middle school. *The Journal of Special Education*, *54*(3), 133–145. https://doi.org/10.1177/0022466919887150

Vandermeulen, N., Leijten, M., & Van Waes, L. (2020). Reporting writing process feedback in the classroom using keystroke logging data to reflect on writing processes. *Journal of Writing Research*, *12*(1), 109–139. https://doi.org/10.17239/jowr-2020.12.01.05

Vandermeulen, N., Van Steendam, E., De Maeyer, S., & Rijlaarsdam, G. (2023). Writing process feedback based on keystroke logging and comparison with exemplars: Effects on the quality and process of synthesis texts. *Written Communication*, *40*(1), 90–144. https://doi.org/10.1177/07410883221127998

Whitaker, D., Berninger, V., Johnston, J., & Lee Swanson, H. (1994). Intraindividual differences in levels of language in intermediate grade writers: Implications for the translating process. *Learning and Individual Differences*, *6*(1), 107–130. https://doi.org/10.1016/1041-6080(94)90016-7

White, S., Kim, Y. Y., Chen, J., & Liu, F. (2015). *Performance of fourth-grade students in the 2012 NAEP computer-based writing pilot assessment: Scores, text length, and use of editing tools (NCES 2015-119)*. National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education.

Wilson, J., & Czik, A. (2016). Automated essay evaluation software in English Language Arts classrooms: Effects on teacher feedback, student motivation, and writing quality. *Computers & Education*, *100*, 94–109. https://doi.org/10.1016/j.compedu.2016.05.004

Wilson, J., Potter, A., Cordero, T. C., & Myers, M. C. (2022). Integrating goal-setting and automated feedback to improve writing outcomes: A pilot study. *Innovation in Language Learning and Teaching*, *0*(0), 1–17. https://doi.org/10.1080/17501229.2022.2077348

Zimmerman, B. J. (2008). Goal setting: A key proactive source of academic self-regulation. In D. H. Schunk (Ed.), *Motivation and Self-Regulated Learning Theory, Research, and Applications*. New York: Lawrence Erlbaum.

APPENDIX A: TABLES AND FIGURES

Table A1

Demographic Characteristics of Participants by Grade

Characteristic	Grade 4		Grade 5	
	n	%	*n*	%
Gender				
Female	68	30%	54	24%
Male	55	24%	51	22%
Race/Ethnicity				
White	91	40%	67	29%
Black	9	4%	15	7%
Asian American	8	4%	8	4%
American Indian	0	0%	2	1%
Hispanic	3	1%	3	1%
Other	12	5%	10	4%
Multilingual	6	3%	10	4%
Has IEP	7	3%	7	3%

Note. $n = 228$ (Grade 4 $n = 123$ and Grade 5 $n = 105$).

Table A2

Descriptive Statistics of Writing Production, Time, and Planning

Measure	Mean (SD)
TWW at 3 min	30.95 (17.88)
TWW at 5 min	46.92 (26.27)
TWW at 7 min	60.25 (37.46)
TWW at 10 min	72.47 (47.7)
TWW at 15 min	85.45 (59.2)
Total writing time (min)	9.39 (4.65)
Planning score	1.29 (0.95)
Typing fluency	101.07 (44.99)

Table A3

Fit Statistics for Growth Mixture Models

Solutions	# of free parameters	AIC	BIC	SSABIC	Entropy	VLMR	ALMR	BLRT	Class 1	Class 2	Class 3	Class 4
1 class	12	9366.611	9407.763	9369.731					228 (100%)			
2 classes	16	9259.569	9314.438	9263.729	0.914	0.0578	0.0632	<0.001	168 (74%)	60 (26%)		
3 classes	20	9187.003	9255.59	9192.204	0.939	0.1152	0.1207	<0.001	159 (70%)	50 (22%)	19 (8%)	
4 classes	24	9125.688	9207.992	9131.928	0.953	0.7453	0.7487	<0.001	149 (65%)	27 (12%)	39 (17%)	13 (6%)

Table A4

Logistic Regression Predicting Class Membership using R3STEP Procedure, 2-Class Solution

	β	se	*p*-value	Odds ratio (e^{β})
Intercept	-6.509	1.8	<0.001	0.001
Planning	0.501	0.182	0.006	1.650
Typing Fluency	0.011	0.004	0.003	1.011
Gender	0.313	0.374	0.402	1.368
Grade	0.758	0.368	0.039	2.134

Note. Comparisons are with reference to Class 1; se= standard error.

Table A5

Logistic Regression Predicting Class Membership using R3STEP Procedure, 3-Class Solution

	β	se	p-value	Odds ratio (e^{β})
		Comparing Class 1 and Class 2		
Intercept	-6.209	1.886	0.001	0.002
Planning	0.687	0.201	<0.001	1.988
Typing Fluency	-0.001	0.005	0.856	0.999
Gender	-0.431	0.409	0.292	0.650
Grade	0.968	0.392	0.014	2.633
		Comparing Class 1 and Class 3		
Intercept	-6.132	3.365	0.068	0.002
Planning	0.347	0.275	0.207	1.415
Typing Fluency	0.022	0.006	0.000	1.022
Gender	1.343	0.802	0.094	3.831
Grade	0.013	0.613	0.983	1.013
		Comparing Class 2 and Class 3		
Intercept	0.077	3.865	0.984	1.080
Planning	-0.341	0.309	0.270	0.711
Typing Fluency	0.023	0.008	0.006	1.023
Gender	1.774	0.877	0.043	5.894
Grade	-0.955	0.695	0.169	0.385

Note. Comparison of Class 1 and Class 2 is with reference to Class 1; Comparison of Class 1 and Class 3 is with reference to Class 1; Comparison of Class 2 and Class 3 is with reference to Class 2.

Table A6

Logistic Regression Predicting Class Membership using R3STEP Procedure, 4-Class Solution

	β	se	*p*-value	Odds ratio (e^{β})
		Comparing Class 1 and Class 2		
Intercept	-3.96	2.033	0.051	0.019
Planning	-0.069	0.265	0.795	0.933
Typing Fluency	0.001	0.007	0.920	1.001
Gender	-0.445	0.488	0.362	0.641
Grade	0.579	0.485	0.233	1.784
		Comparing Class 1 and Class 3		
Intercept	-6.894	2.198	-3.137	0.001
Planning	0.627	0.196	0.001	1.872
Typing Fluency	0.006	1.403	0.161	1.006
Gender	-0.477	0.424	0.260	0.621
Grade	0.932	0.423	0.027	2.540
		Comparing Class 1 and Class 4		
Intercept	-4.452	3.287	0.176	0.012
Planning	0.475	0.364	0.192	1.608
Typing Fluency	0.022	0.006	<0.001	1.022
Gender	1.464	0.787	0.063	4.323
Grade	-0.523	3.287	0.176	0.593
		Comparing Class 2 and Class 3		
Intercept	-2.934	2.891	0.310	0.053
Planning	0.696	0.285	0.015	2.006
Typing Fluency	0.006	0.008	0.459	1.006
Gender	-0.032	0.601	0.957	0.969
Grade	0.353	0.602	0.557	1.423
		Comparing Class 2 and Class 4		
Intercept	-0.492	3.731	0.895	0.611
Planning	0.544	0.433	0.209	1.722
Typing Fluency	0.022	0.009	0.016	1.022
Gender	1.909	0.905	0.035	6.746
Grade	-1.102	0.883	0.212	0.332
		Comparing Class 3 and Class 4		
Intercept	2.442	3.836	0.524	11.496
Planning	-0.152	0.397	0.702	0.859
Typing Fluency	0.016	0.008	0.036	1.016
Gender	1.941	0.862	0.024	6.966
Grade	-1.456	0.838	0.082	0.233

Table A6 (cont'd)

Note. Comparison of Class 1 and Class 2 is with reference to Class 1; Comparison of Class 1 and Class 3 is with reference to Class 1; Comparison of Class 1 and Class 4 is with reference to Class 1; Comparison of Class 2 and Class 3 is with reference to Class 2; Comparison of Class 2 and Class 4 is with reference to Class 2; Comparison of Class 3 and Class 4 is with reference to Class 3.

Table A7

Planning Scores by Class

Planning Score	Class 1		Class 2		Class 3		Total Across Classes	
	n	% of class	*n*	% of class	*n*	% of class	*n*	%
0	39	25.32	4	8.33	1	5.26	44	19.91
1	77	50	16	33.33	10	52.63	103	46.61
2	20	12.99	17	35.42	4	21.05	41	18.55
3	18	11.69	11	22.92	4	21.05	33	14.93
Total	154		48		19		221	

Note. Planning is scored according to the following: 0= no written plan; 1= drafted text; 2=short words, phrases, or illustrations; 3= structural reminders (e.g., outline).

Figure A1

Planning Scoring Rubric and Theoretical Alignment with Planning and Goal Setting

Planning Score and Example Criteria from Rubric	Alignment with Flower and Hayes (1981) Cognitive Model of Writing	Alignment with Bereiter and Scardamalia (1987)	Alignment with Goal Characteristics (Schunk & Swartz, 1993; Zimmerman, 2008)
3- Structural reminders, including bullet points, outline format, and graphic organizer	Organziation	Knowledge Transforming (Structure)	Increasing Specificity, Proximity, and Hierarchy 
2- Short words or illustrations	Organization	Knowledge Transforming (Categorization and Grouping)	
1- Drafted text	Idea Generation	Knowledge Telling	
0- No Written Plan	No Written Plan	No Written Plan	No Written Plan

Figure A2

Sample Size Adjusted BIC Compared to Number of Classes in Solution

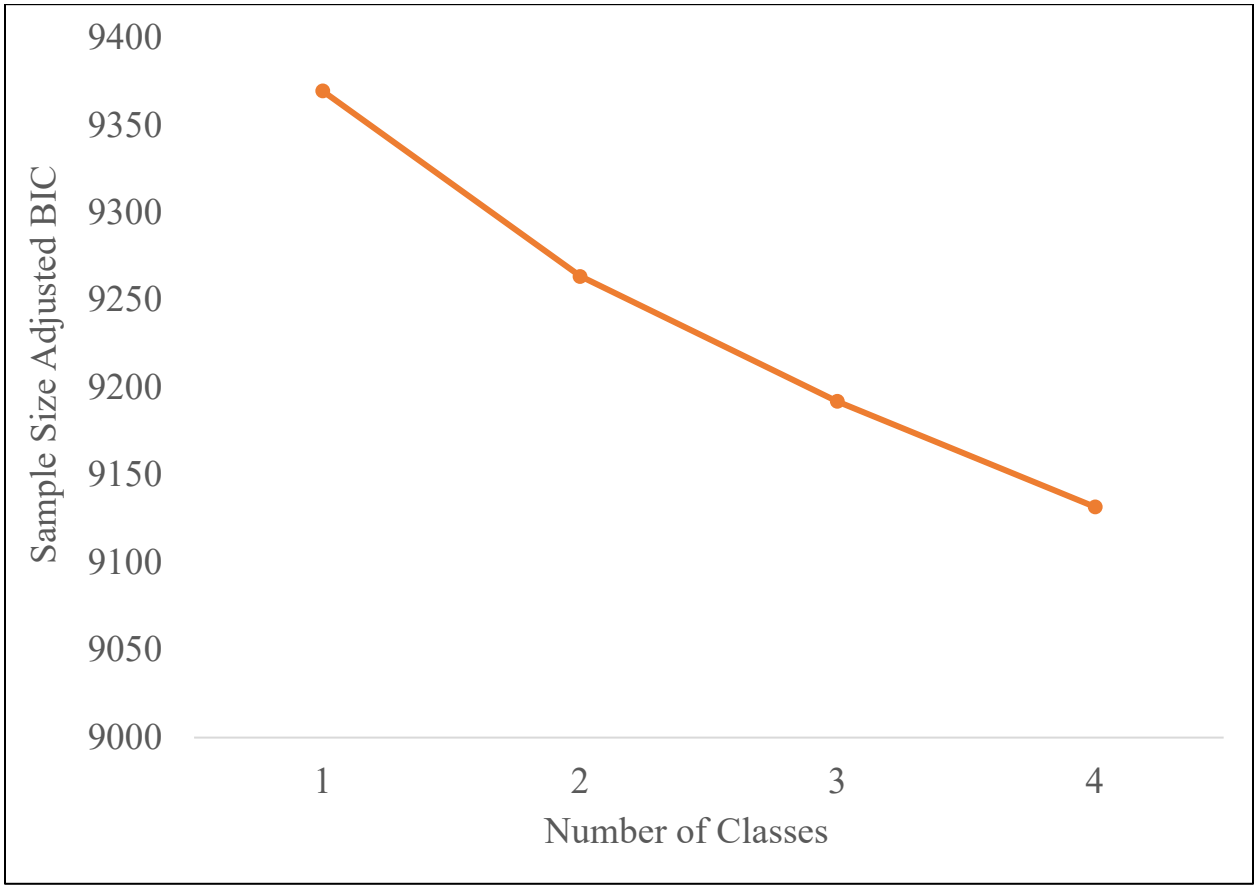


Figure A3

1-Class Solution

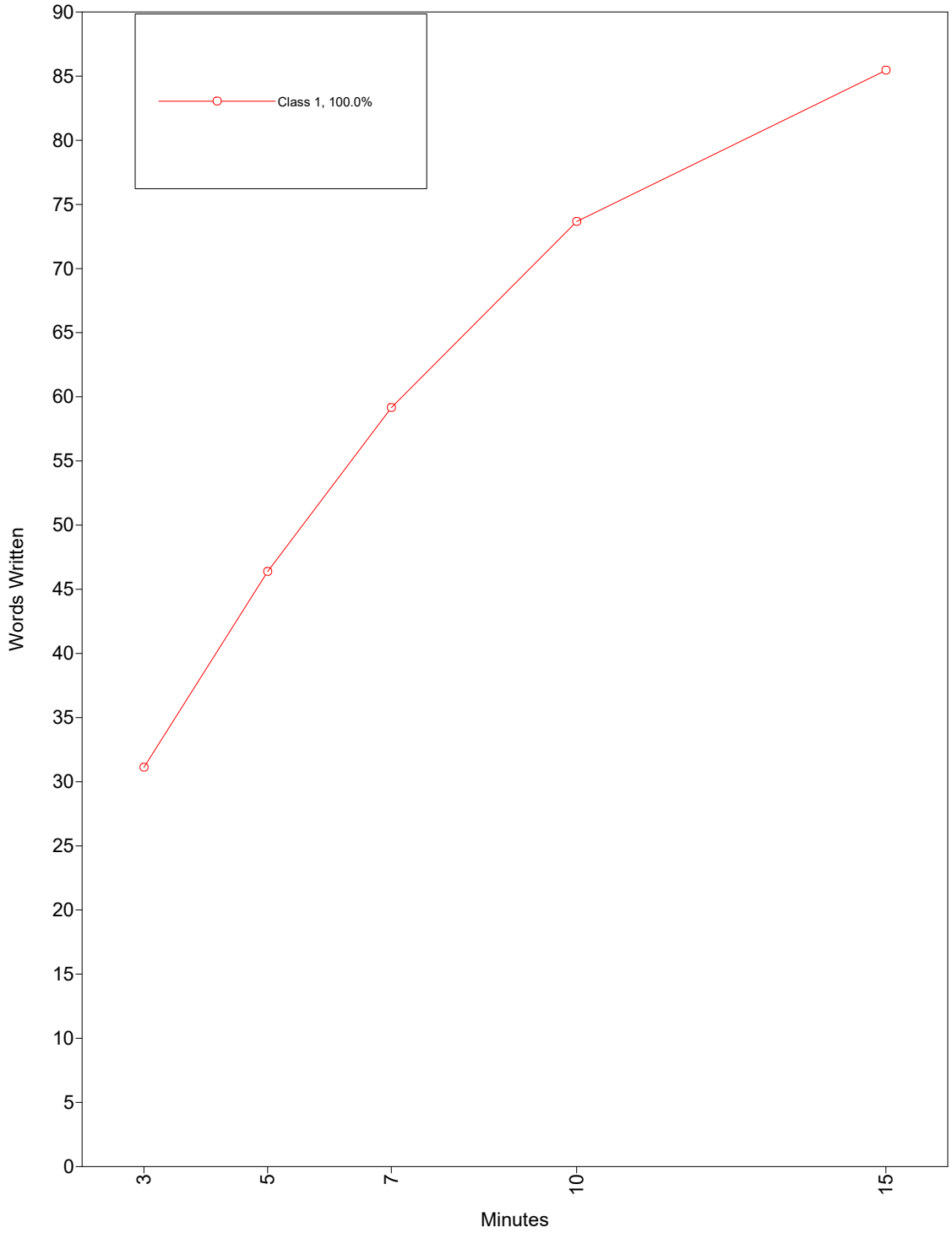


Figure A4

2-Class Solution

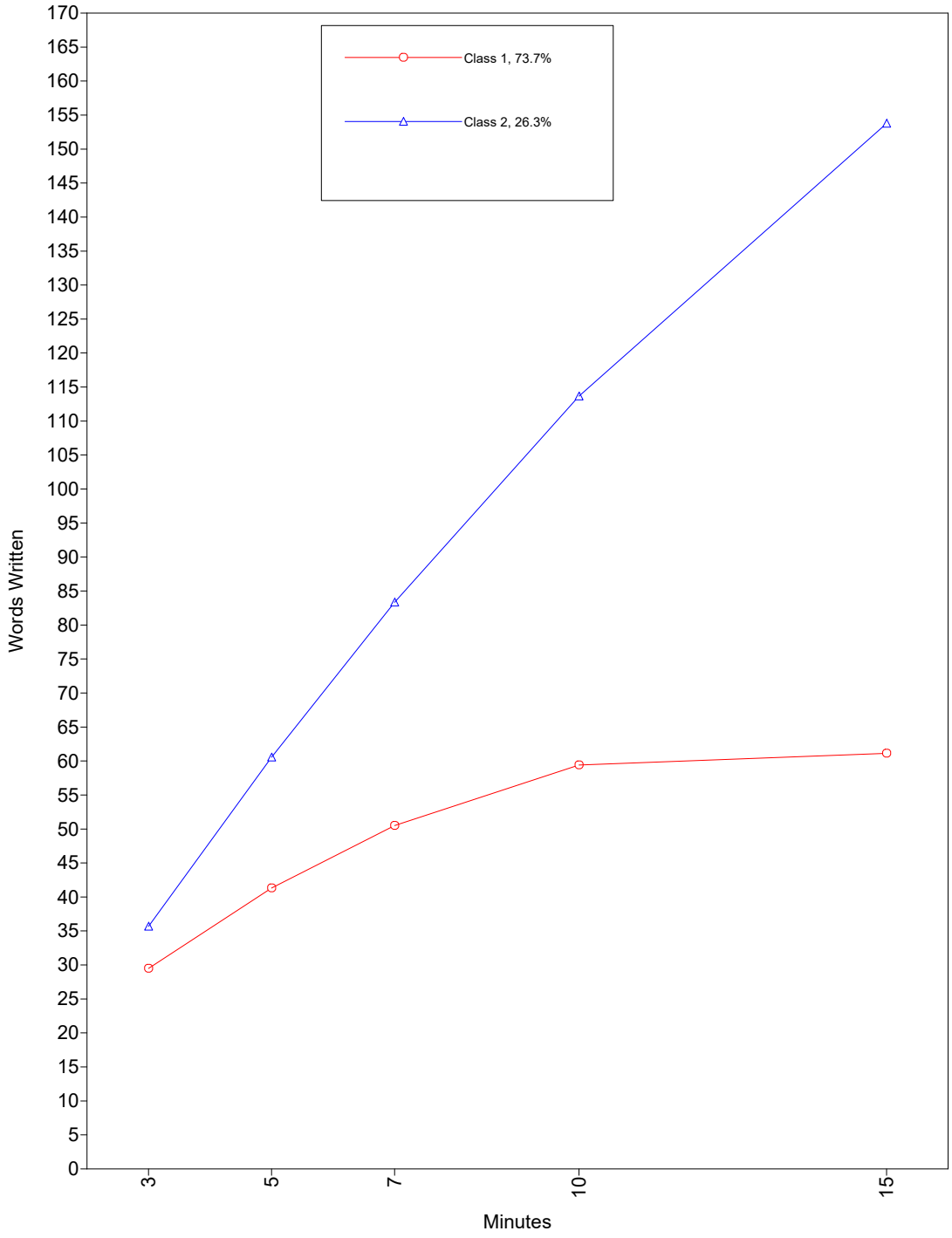


Figure A5

3-Class Solution

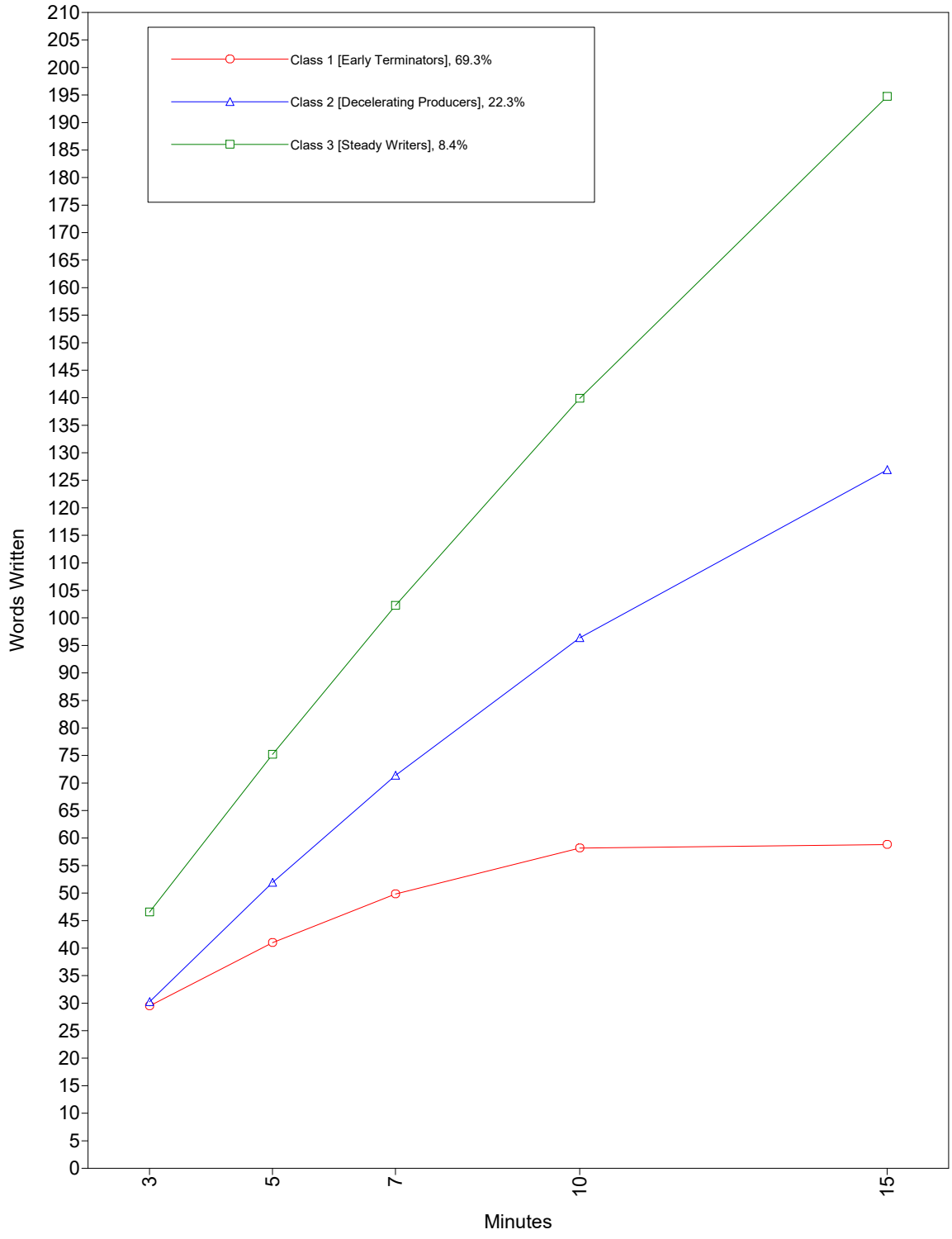
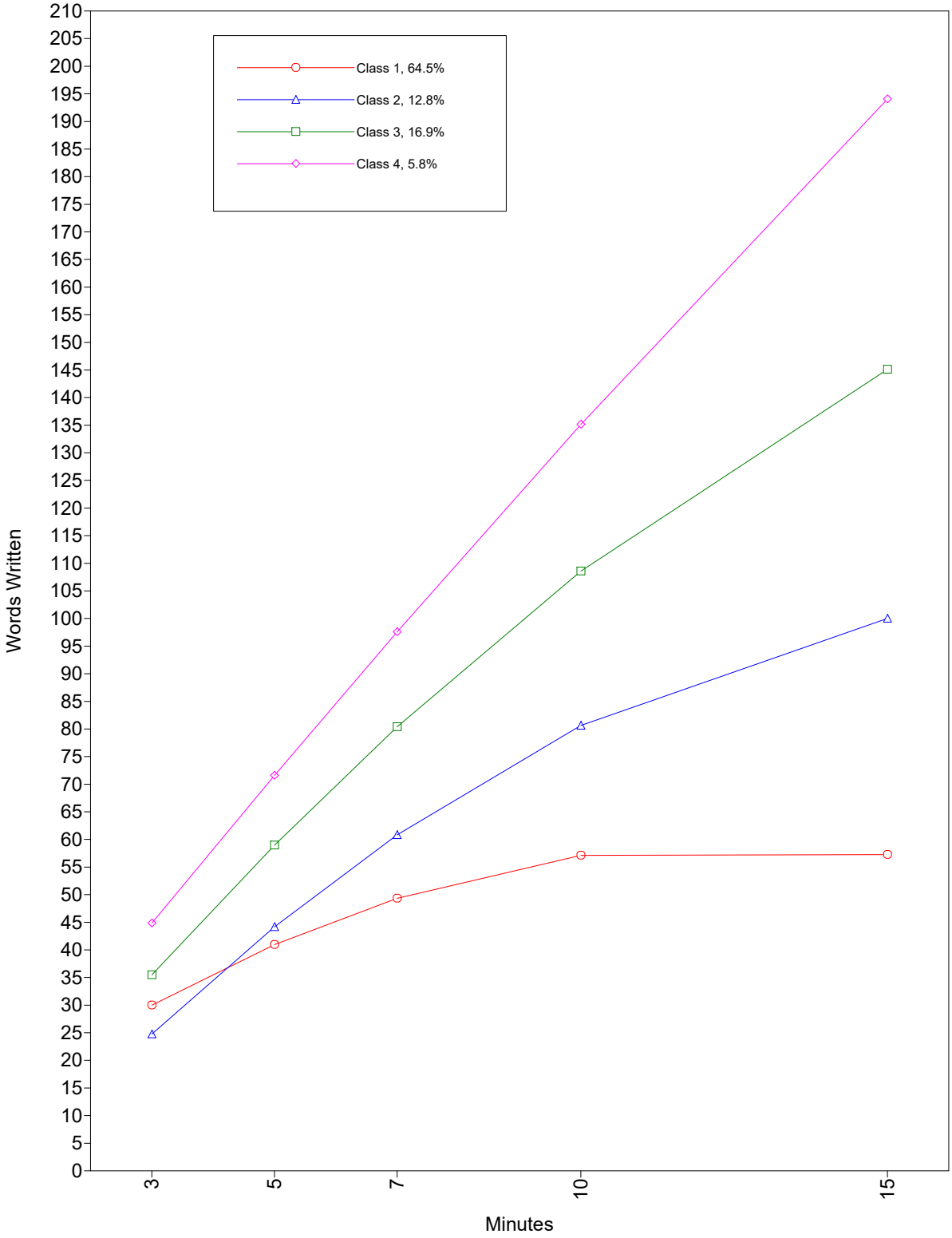


Figure A6

4-Class Solution



APPENDIX B: INFORMATIONAL PASSAGES AND PROMPTS

Here's a Food Wrapper You Can Eat

Source: Smithsonian Tween Tribune

Consider the cheese stick. It is not a pretty food. It also isn't very healthy. Cheese sticks are about as commonplace as snack food gets. In the packaged version, each cylinder of mozzarella or cheddar is individually wrapped. And, every day, thousands of those little pieces of plastic wrap are thrown in the trash. But maybe not for long.

Two researchers at the U.S. Department of Agriculture have made a film. It's made from a milk protein. The film can be eaten with the cheese. Which means that it may not be too long before we have a wrapper we can eat. It also could be healthy. Edible plastic exists. But it's largely made of starch. It isn't protein.

"It can be consumed with the food. So it gets rid of one layer of packaging, like with individually wrapped cheese sticks," says Peggy Tomasula. She is one of the lead researchers. "It also gives you the opportunity to add vitamins or minerals or ways to block light damage to the food. And, you can add flavors. If you wanted to add a strawberry flavor to something, you can embed that in the film."

There is a key factor in the innovative packaging. It is casein. Casein is a group of milk proteins. It has high nutritional value. Tomasula has been researching casein since 2000. She actually created a new version of the protein using carbon dioxide. She noticed that it wasn't very soluble in water. That made her believe it might be used to make a film coating that could extend the shelf life of dairy foods.

Tomasula kept exploring the potential of this research. Then another scientist, Laetitia Bonnaillie, joined the USDA team. Tomasula asked her to see if dry milk could be used to produce the film. That would also allow them to make use of surplus milk powder during times when dairy farms are producing too much milk. Bonnaillie also focused on refining the product. She wanted to make it less sensitive to moisture. She wanted to improve the process by which the film was made. She also wanted it to be more uniform and commercial.

At the annual meeting of the American Chemical Society, they announced the results of their efforts. It is edible, biodegradable packaging. The casein film could come in sheets. That is not unlike plastic wrap. Or it could be sprayed on as a coating. And, it's been found to be significantly more effective at blocking oxygen than ordinary plastic wrap. So it can protect food from spoiling for a much longer time. There would be some limitations at first.

"This would mostly be for dairy products or foods that would likely be used with dairy. Like cereal," says Tomasula. "We wouldn't put this on fruits and vegetables in a market. You couldn't do that because of milk allergies. There would have to be labeling to let people know it's milk protein."

Also, this wouldn't mean that all packaging would be eliminated for cheese and other dairy products. They would still need to be covered in some way, in a box or packet to keep the food from getting dirty or exposed to too much moisture. But dispensing with the individual wrapping around each food item could mean a lot less plastic would end up in landfills. By some estimates, it can take as long as 1,000 years for plastic to degrade. And, unfortunately, less than a third of the plastic Americans throw away actually gets recycled.

The idea, said Bonnaillie, is to create different versions of the casein film. One might be very soluble, making it better suited for a product you dissolve in water. Another could be

considerably less soluble. So it would be more resistant to moisture. It would work better as protective packaging.

"We are trying things with the extremes," she says. "We've just started exploring applications. There are many more things we can do."

Say so long to sugar?

For instance, instead of tearing open a paper container to make instant coffee or soup, you could just drop a casein packet of the ingredients into water. Everything would dissolve. Plus, extra protein would be added. But food companies might actually prefer a spray version of the product.

"That way they could store a mixture of the particular milk proteins in water. And then make the coatings and spray them on when they're processing the food," says Tomasula.

One possibility would be to spray the protein film on cereal. The cereal can be coated with sugar to keep it crunchy.

"It could be fat-free." It is a healthier way to replace a process that's now largely done with sugar, says Bonnaillie. Tomasula adds: "We're hoping that for something like meal replacement bars we can make the edible wrapping taste like chocolate. We could combine the ingredients together and provide a little more nutrition."

[Prompt script]
Write an informative paper that will help others learn about edible food packaging. Be sure to use information from the article you just read to give reasons why edible wrappers are an exciting development in food packaging. Remember, a well written informative paper (1) has a clear main idea and stays on topic, (2) includes a good introduction and conclusion, (3) uses information from the article stated in your own words plus your own ideas, and (4) follows the rules of writing.

13 Year Old World War II Veteran

Source: Smithsonian Tween Tribune

Calvin Graham was in the sixth grade in Crockett, Texas, when he hatched his plan. He would lie about his age. This was so he could join the Navy. He was one of seven children living at home with an abusive stepfather. He and an older brother moved into a cheap rooming house. Calvin supported himself by selling newspapers. He also delivered telegrams. Being around newspapers afforded the boy the chance to keep up on events overseas.

When he learned that some of his cousins had died in battles, he knew he wanted to fight. But he had no intention of waiting five more years. One day, he lined up with some buddies. All of them wanted to enlist.

He was about to be examined by a dentist. "I knew he'd know how young I was by my teeth," recalled Graham. He lined up behind a couple of guys he knew who were already 14 or 15. "When the dentist kept saying I was 12, I said I was 17. Finally, he said he didn't have time to mess with me. And he let me go."

By the time the South Dakota made it to the Pacific with Graham on board, the battleship had become part of a task force. The ship sailed alongside the legendary carrier USS Enterprise. By early October 1942, the two ships raced to the South Pacific. After the U.S. ships reached the Santa Cruz Islands on October 26, the Japanese launched an air attack. The South Dakota managed to protect the Enterprise.

Then, a bomb hit the South Dakota. The explosion injured 50 men.

The South Dakota was repaired at Pearl Harbor. And Seaman Graham quietly became a teenager. He turned 13 on November 6. This was just as Japanese naval forces began shelling an American airfield. It was on Guadalcanal Island. Steaming south with the Enterprise, the South Dakota and another battleship, the USS Washington, took four American destroyers on a night search for the enemy. On November 14, Japanese ships sank or heavily damaged the American destroyers. The encounter became known as the Naval Battle of Guadalcanal.

Graham was manning his gun when shrapnel tore through his jaw and mouth. Still, the 13-year-old helped pull other crew members to safety.

The shrapnel had knocked out his front teeth. He had flash burns. He received them from the hot guns.

Meanwhile, the South Dakota had disappeared in the smoke. The Japanese Navy was under the impression that it had sunk the South Dakota. The legend of Battleship X was born.

In mid-December, the ship returned to the Brooklyn Navy Yard. It required more repairs. Calvin Graham received a Bronze Star for distinguishing himself in combat. He also received the Purple Heart for his injuries. Then Graham's mother wrote to the Navy. She told them the gunner's true age.

So Graham was thrown in a brig. It was in Corpus Christi, Texas. The Navy eventually ordered Graham's release. But not before stripping him of his medals for lying about his age. His disability benefits also were revoked. He was released without an honorable discharge.

Back in Houston, though, reporters were eager to write his story but the attention quickly faded. At age 13, Graham returned to school. He quickly dropped out. He married at age 14. He became a father the following year and found work as a welder in a Houston shipyard. Neither his job nor his marriage lasted long. At 17 years old and divorced, and with no service record, Graham was about to be drafted when he enlisted in the Marine Corps. He soon broke his back in a fall. The only work he could find after that was selling magazine subscriptions.

President Jimmy Carter was elected in 1976. Graham hoped that Carter, "an old Navy man," might be sympathetic. All Graham had wanted was an honorable discharge. With it, he could get help with his medical and dental expenses.

In 1978, Carter announced that Graham's medals were restored, with the exception of the Purple Heart. Ten years later, President Ronald Reagan approved Graham's disability benefits.

It wasn't until 1994, two years after he died, that the military returned Graham's last medal. It was his Purple Heart. The medal was given to his family.

[Prompt script]
Write an informative paper that will help others learn about Calvin Graham and his story. Be sure to use information from the article you just read to explain why Calvin Graham had to wait so long to be recognized for his service. Remember, a well written informative paper (1) has a clear main idea and stays on topic, (2) includes a good introduction and conclusion, (3) uses information from the article stated in your own words plus your own ideas, and (4) follows the rules of writing.

Plastic Bottle Village

Source: DOGO News

According to experts, over 22,000 plastic bottles are discarded every second, and the numbers are only growing. Though the detrimental impact of plastic on the environment is well-known, consumption of drinks bottled in the most commonly used type of plastic continues to rise at alarming levels. Some of them do get recycled. Most bottles end up in the ocean. In the ocean, the bottles disintegrate into smaller pieces. The small pieces are often mistaken for food by innocent fish and birds.

Now, Robert Bezeau has come up with an idea that may not solve the world's plastic woes. But it may inspire others. He plans to use the plastic soda bottles to build an entire village in the jungles of Panama.

Originally from Canada, Bezeau has been living on an island in Panama for many years. He started a recycling project there in 2012. He started noticing plastic waste carelessly tossed on the island's beautiful beaches. In just 18 months, Bezeau and his volunteers collected over a million plastic bottles!

After the recycling project ended, Bezeau could not ignore the magnitude of the waste being generated. So in 2015, he came up with the idea of using the bottles to construct homes. Plastic Bottle Village was born. The project is located on the northernmost and main island in Panama. The project is still in its infancy. So far, only one two-story house has been built. But, Bezeau wants to build an entire community. Eventually, he hopes Plastic Bottle Village will have 19 to 20 plastic homes. In addition to home, the community will also include a vegetable garden, a small shop, and an eco-lodge.

If he can raise the funds, Bezeau also plans to build an education center. The education center will be a place where others can come and learn how to use the plastic waste more productively. He wants the village to be environmentally responsible to reflect its pristine jungle location.

Even though the idea to use plastic bottles to make homes is relatively new, it is surprisingly easy to do. The builders begin by constructing a steel frame that mimics the shape of all sides of the house. Then, they fill it with large plastic bottles. They usually use the kind of plastic bottles that contain soft drinks. Each home requires between 10,000 and 25,000 bottles. Smaller homes require fewer bottles and larger homes require more bottles. Once the bottles are in place, necessary services like electricity are installed. Next, the bottle-filled frame is plastered with layers of concrete. Finally, the windows, roof, and septic tank are installed.

Interestingly, the environmental benefits of using the plastic bottles for construction go beyond reducing the amount of waste in our oceans. As it turns out, the bottles are good insulators. They help keep the home at a comfortable temperature. This alleviates the need for expensive air conditioners. Good insulation is a significant advantage in tropical countries like Panama, where the weather is warm year round. Even better? The homes are also earthquake resistant. This feature is important given that Panama is susceptible to earthquakes.

While these buildings are a smart way to utilize the plastic waste, they are not the solution to our environmental woes. The only way to solve the issue is to reduce the amount of plastic that ends up in the ocean. The smartest thing to do is avoid buying plastic bottles altogether. However, placing plastic bottles in recycling bins will also go a long way in curbing the amount of plastic that ends up in our oceans each year. So be sure to do your part!

[Prompt script]
Write an informative paper that will help others learn about building houses out of plastic bottles. Be sure to use information from the article you just read to give reasons why using plastic bottles to build homes would be helpful. Remember, a well written informative paper (1) has a clear main idea and stays on topic, (2) includes a good introduction and conclusion, (3) uses information from the article stated in your own words plus your own ideas, and (4) follows the rules of writing.

Swat Up: Six Reasons to Love Flies

Source: BBC Radio Natural Histories

They buzz and bother us but have also taught us so much about who we are. Here are six reasons to respect, if not love, the fly.

1. First creatures in space.

In February, 1947, American scientists launched a group of fruit flies into space.

The flies were sent 42 miles from Earth to study the effects of radiation at high altitude. They were ejected in a container that parachuted to the ground. When they landed scientists found them to be in perfect health.

Fruit flies are still being sent into space to simulate the effects on astronauts. Fruit flies are chosen because humans and fruit flies are surprisingly similar.

2. Nature's detectives.

Flies help investigators establish the time of death of a body because the various stages of decomposition attract different insects at different times.

One of the first insects to settle into a freshly dead body is the blowfly. The blowfly has an acute sense of smell. Their sense of smell allows them to find decomposing matter quickly from miles away.

Female blowflies arrive within minutes to lay eggs. These eggs hatch into maggots within 24 hours. Across several days they go through six different stages before becoming fully-grown adult flies.

3. Flying aces.

Flies are the fastest insects on the planet.

Horse flies are the best flyers and can reach 90mph. They have a pair of balance organs near their wings called halteres. Halteres allow horse flies to fly upside down and rotate mid-air.

Some types of fly don't have any wings at all. Up against skills like the horse fly, we should perhaps feel sorry for the species of fly suffering an identity crisis because they can't fly.

4. No flies means no chocolate.

All the chocolate we eat comes from the seeds of a tree called the cacao. The cacao has flowers that are small and require tiny pollinators. This is where flies come in.

Chocolate midges are flies that are no bigger than the size of a pinhead. They seem to be the only creatures that can work their way into the flowers to pollinate them.

5. Natural born recyclers.

Whether its cow manure or dead bodies, flies recycle waste into the ground. Naturalist Peter Marren says this makes them the most valuable insect.

"Without houseflies and bluebottles and other types of fly, we would simply fill up with corpses and other filth. We would drown in filth," he says.

6. Nobel Prize winners.

Fruit flies helped scientists win four Nobel Prizes in Physiology or Medicine.

In 1933, Thomas Hunt Morgan won a Nobel Prize for his work on genetic inheritance. He researched mutations in fruit flies. This research led to the theory that genes were carried on chromosomes and passed down through generations.

Hermann J. Muller was awarded a Nobel Prize in 1946 for finding that X-rays can cause genetic mutations in fruit flies.

In 1995, Edward B. Lewis, Christiane Nüsslein-Volhard and Eric F. Wieschaus won a Nobel Prize for their studies into the genetic control of early embryonic development. They also used fruit flies in their research.

Most recently, Jules A. Hoffman and Bruce Beutler won a Nobel Prize in 2011 for studying immunity. The researchers used fruit flies because the results could later be applied to humans.

[Prompt script]
Write an informative paper that will help others learn about flies. Be sure to use information from the article you just read to give reasons why flies are important to people. Remember, a well written informative paper (1) has a clear main idea and stays on topic, (2) includes a good introduction and conclusion, (3) uses information from the article stated in your own words plus your own ideas, and (4) follows the rules of writing.

Can an Elevated Bus Solve China's Traffic Woes?

Source: DOGO News

To say that China has traffic issues is an understatement. A 2015 study revealed that the country is home to the most traffic congested cities in the world. Though Chinese authorities have tried to control the traffic flow, nothing appears to be working. They tried charging tolls for use of busy roads. They also tried adding 50 lanes to a highway. Now, some engineers are proposing an ingenious solution to improve the country's traffic woes — an elevated bus that glides over cars.

The concept for the "straddling" or elevated bus was first introduced six years ago. However, while the idea generated a lot of excitement, the bus never became a reality. This was due to safety concerns. Since then, Song Youzhou and his team have been working hard to perfect the design.

The new and improved Transit Elevated Bus was unveiled at an exhibition in China. The Transit Elevated Bus is a cross between a subway and a bus. Designed to run on rails, it covers two vehicle lanes. However because the bus is elevated over 6 feet above the road, it allows vehicle traffic to continue flowing beneath it. Retractable ramps enable commuters to board and disembark the bus at bus stops.

The Transit Elevated Bus can accommodate up to 1,400 passengers at a time. It can also reach a maximum speed of 37 miles per hour. With these features, the inventors believe that the Transit Elevated Bus is a better and cheaper alternative to subways. According to Youzhou, each elevated bus will cost about 4.5 million dollars. This cost is significantly less than building a new subway.

Also, thanks to its large passenger capacity, a single Transit Elevated Bus could replace 40 traditional buses. Besides reducing road congestion, eliminating the traditional buses would help alleviate another big problem the country is grappling with — pollution. That's because the Transit Elevated Bus is powered by solar energy and electricity, not fossil fuels. Furthermore, Youzhou estimates that replacing 40 buses could reduce the use of fuel by 800 tons. It could also reduce carbon emissions, by 2,500 tons every year!

Though some critics are still opposed to the idea, officials of one coastal city seem to be willing to give it a try. They commissioned the Transit Elevated Bus team to build a 12-mile track to test the innovative bus. If everything goes according to schedule, the bus will be ready for its first passengers very soon!

[Prompt script]

Write an informative paper that will help others learn about the potential benefits of transit elevated buses. Be sure to use information from the article you just read to give reasons why replacing regular buses with elevated buses would be beneficial. Remember, a well written informative paper (1) has a clear main idea and stays on topic, (2) includes a good introduction and conclusion, (3) uses information from the article stated in your own words plus your own ideas, and (4) follows the rules of writing.

APPENDIX C: PLANNING CODING SHEET

Coder: _____

Student ID	Genre (N, O, I)	Time (T1, T2, T3, T4)	Score 0 = no written plan present 1 = written plan includes drafted text or a portion thereof 2 = written plan includes idea words/phrases or illustration(s) as reminders for text to be written 3 = written plan includes structural reminders (e.g., characters and setting for stories, position and reasons for opinion essay) or graphic organizer or outline format plus drafted text or idea words/phrases or illustration(s)

(Troia et al., 2022)

APPENDIX D: PRELIMINARY SAMPLE RESULTS

As part of the preliminary investigation, data exploration with a subset of the data was conducted. Preliminary analyses were run with a subsample of data (*n*= 81) representing both fourth (*n*=35) and fifth (*n*=46) grades from one cohort of students collected in January/February 2019. Participants were mostly white (58%), English-only speakers (85%), and without disabilities (91%). Descriptive statistics to explain the results of the writing responses are presented in Table B1.

Table D1

Descriptive Statistics of Writing Production, Time, and Planning

Measure	**Mean (SD)**
TWW at 3 min	32.52 (18.77)
TWW at 5 min	49.31 (27.10)
TWW at 7 min	63.83 (41.72)
TWW at 10 min	74.07 (48.07)
TWW at 15 min	83.05 (57.85)
Total Writing Time (min)	8.51 (4.28)
Planning Score	1.23 (1.05)

Spaghetti plots of the Total Words Written (TWW) produced over the writing task at 3, 5, 7, 10, and 15 minutes were created. Spaghetti plots were paneled based on students' planning scores in order to provide information on how patterns in production across time might vary based on the character of planning. Visual inspection of the spaghetti plots (see Figure B1) indicates variability in patterns of production across students. A flat plateau shape indicates that

there was no increase in production past the leveling of the curve. This suggests a student stopped writing at that point and did not persist in writing. Visual inspection of the spaghetti plots suggests more of a plateau effect across 15 minutes of writing among students scoring 0 or 1 on their written plans. On the other hand, there appears to be greater variability in the patterns of production between students scoring 2 or 3 on their written plans. That is, fewer students have plateau patterns of growth that would indicate termination while more students have positive slopes across 15 minutes of writing time. Based on this inspection, I hypothesize the presence of multiple classes as defined by the pattern of production across 15 minutes of writing time. The stratification of the data by quality of planning score and associated visual differences in shape of production also support a hypothesis that planning may be a significant predictor of class membership. Finally, examination of these patterns of production suggests the presence of nonlinear patterns of production across 15 minutes, providing further justification for the use of GMM which can accommodate nonlinear estimates.

Figure D1

Spaghetti Plots of Total Words Written Across Writing Time