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As science teachers gain increasing access to resources through an ever-expanding resource system, the study of how science teachers decide which resources to use and how to use them becomes increasingly important and complex. When science teachers exercise agency to select and adapt resources in alignment with their context, teaching and learning can improve. However, little is known about the ways in which school and district infrastructure mediate these processes. This study uses the documentational approach to didactics (DAD) and the structure-agency dialectic to explore how instructional guidance infrastructure (IGIs) influenced science teachers in one district to select, adapt, and use a set of instructional resources developed by other teachers in the district with the goal of creating collections of resources aligned with the district's infrastructure.

This two-phase, explanatory sequential mixed methods study featured the collection and analysis of quantitative and qualitative data with the purpose of exploring how teachers used the collections' resources, if at all, and how IGIs shaped these decisions. In the first phase, metadata from teachers' access to the resource collections was used to create a set of initial conjectures about the nature of teachers' work with the resources and to create a sampling frame for further analysis. In the second phase of the study, teacher interviews and teaching artifacts were used to construct case narratives illustrating how teachers used these resources, if at all, and how IGIs influenced these decisions.

Results of this study indicated that teachers' past experience with resources in their content area played an influential role in how teachers searched for, interpreted, evaluated, adapted, and implemented resources. Several IGIs influenced each stage of this work by

enabling and / or constraining teachers' agency for using these resources, often in inconspicuous ways. These findings provided insight into the ways in which science teachers selected and adapted resources to create coherence with their infrastructure, informing the future design of resources and the IGIs that support teachers' work with resources.

RESOURCES THAT WORK HERE: THE ROLE OF INFRASTRUCTURE IN SHAPING SCIENCE TEACHERS' DOCUMENTATIONAL GENESIS

by

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DEDICATION

To all of the strong women in my life. You carried me when I could not carry myself.

APPROVAL PAGE

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I: INTRODUCTION

My First Experiences With Resources

When I accepted my first job as a high school Chemistry teacher, I began laying the foundation for the instructional practices and resources upon which I would build and revise throughout my teaching career. After completing a traditional undergraduate education program in secondary Biology, I accepted a job teaching Chemistry in a state in which I had never lived. This meant adjusting to a new set of state standards, an unfamiliar system of teacher accountability, and a system of standardized student assessment that was in the process of being heavily revised. Fortunately, the school had built a brand new science wing just a few years prior to my arrival. This meant that the classrooms were well stocked with chemicals, safety equipment, lab tables, fume hoods, and a projector. Despite this idyllic access to scientific equipment, I quickly found that I would need to independently seek support for understanding the pedagogical practices that leveraged these resources to effectively teach Chemistry. The high school at which I accepted my first job was the only traditional high school in the district, and I was the only Chemistry teacher at that high school. While the other teachers in my department readily volunteered to help me make sense of the school, district, and state processes, none of them had experience teaching Chemistry. As is typical of a first year-teacher, I spent many long nights relearning the high school Chemistry content, searching for teaching resources, researching pedagogical strategies for teaching with those resources, and creating unit and lesson plans virtually from scratch. As a result of this work during my first year of teaching, I created a set of lessons upon which I could build and iterate in subsequent years.

Several years later, I accepted a new position teaching at a nearby magnet school built around project-based learning. The summer before I began teaching, I received a three-day

training in the specific framework that I would be expected to use. Unlike my previous school, this school was located in an old elementary school converted into a high school; there was no laboratory equipment, no chemical storage, and almost no safety equipment. However, each student in the school had a laptop and stable internet access. In order to adapt to this new setting, I would need to change the resources I used and the ways in which I used them. Specialty scientific equipment would give way to digital resources and household materials. My previous assessment practices evolved to align with the expectations outlined in my training on project-based learning. My class periods shortened as I transitioned from block scheduling to a year-long schedule, creating the need to break up lessons into smaller chunks. In short, I adapted my teaching practices to leverage the available resources in order to meet both the school and the state accountability expectations.

Rationale for the Study

As a science teacher, I learned the importance of selecting and adapting resources that aligned with the context in which I worked. The resources I used and the ways in which I used them changed as I modified my practice to meet the needs of a new school by leveraging the resources available at that school while meeting the instructional expectations of the school, district, and state. However, this work of selecting and modifying resources depended on my abilities to both make sense of my context and align the resources I used with that context.

The purpose of this study is to contribute to the body of research on the relationship between school, district, and state infrastructure and science teachers' selection and use of resources. The emergence and proliferation of Web 2.0 technologies like social media, blogs, and websites specifically structured for teachers (e.g. Teachers Pay Teachers) has facilitated the development of a network of educators and curriculum developers who create, refine, discuss,

and share resources online. As a result of this work, teachers have increasing access to a vast array of resources for instruction, each of which can be used in a variety of ways. As this network of available resources continues to grow, research on how teachers select and use resources to align with their context becomes increasingly significant for shaping school, district, and state policies designed to shape and support teaching (Balgopal, 2020; Honig & Hatch, 2004; Joyce & Cartwright, 2020). Furthermore, such research can inform the design of programs intended to support teachers' selection and use of resources that align with school, district, and state infrastructure such as during pre-service teaching programs (Grossman & Thompson, 2008).

Research on the ways in which teachers select and use resources to align with their context holds particular potential for supporting science teachers. Science education is a resource-dependent practice, and teachers' access to resources can significantly influence the kinds of instruction in which they engage. Students' engagement with authentic, hands-on scientific inquiry practices necessitates physical and / or digital materials. Laboratory resources can serve as a powerful element for supporting student inquiry (Hofstein & Lunetta, 2004), and access to physical resources that are designed to support science teaching and learning can enhance students' gains in scientific content knowledge (Dickerson et al., 2006). However, teachers' access to such equipment can vary significantly; the 2018 National Survey of Science and Math Education (NSSME+) revealed that science classrooms comprised primarily of students who were designated as having low prior achievement had significantly less access to basic equipment like sinks, lab tables, microscopes, and gas for bunsen burners than their more highly prior-achieving counterparts (Banilower et al., 2018). Despite science education's reliance on resources, schools and districts often invest fewer hours and monetary resources to

science instruction than subjects like English and math (Trygstad et al., 2020), potentially increasing the value that science teachers may place on resources that are not provided by schools and districts. Yet without access to resources for teaching science (e.g. microscopes, lab tables, safety equipment), the scope of resources available to a science teacher can narrow considerably as they must either heavily modify or abandon any resources that are incongruent with the rest of their infrastructure. As such, science teachers' professional practice is intricately tied to their resource system, and the absence of one resource can have cascading effects that limit the use of other resources (NASEM, 2019).

Problem Space

Teachers as Critical Curators

Not every science teacher may have shared my experience illustrated in the opening vignette in the same way. Science teachers may find themselves with different accountability expectations, access to resources, departmental configurations, and levels of agency in making instructional decisions. However, this story highlights the situated nature of the resources that teachers use and the ways in which they use them. Not only did I shape my practice to fit the contextual needs by leveraging the resources to which I had access, but I also exercised my professional agency by making decisions about which resources to use and in what ways. This included both resources that were provided by the school and those that I found independently online or received from colleagues. Following in the footsteps of Cohen et al. (2003), my use of the term *resources* expansively includes all things with which a teacher engages in designing and implementing instruction including conventional resources (e.g. teachers' formal qualifications, books, facilities, lab equipment, time); teachers' personal resources (e.g. skill, knowledge, background experiences); and environmental and social resources (e.g. professional leadership,

instructional standards, academic norms). A teachers' *resource system*, then, refers to "the whole set of resources with which a teacher works" (Pepin et al., 2017, p. 261) including district-supplied curriculum resources, laboratory supplies, technology resources, and digital resources.

This dynamic in which teachers select resources to use and the ways in which to use them speaks to an essential role for teachers: that of the *critical curator* (Sawyer et al., 2020). In this view of teaching, teachers must not only locate resources, but evaluate the quality and usefulness of the resources they find and make decisions about whether the resource would be appropriate and beneficial for their practice. In other words, teachers *explore* a wide variety of resources, *exploit* those that they find useful, and *prune* those resources that do not help teachers meet their teaching objectives (Chen et al., 2021). According to the 2018 NSSME+, 65% of middle school and 78% of high school science teachers reported incorporating activities at least once per week from outside sources to supplement what the teachers deemed to be lacking in the provided curriculum, if a curriculum was provided at all (Banilower et al., 2018). Among the reasons provided for using supplemental curriculum materials, science teachers most commonly cited as "Major Factors": the need to provide students with additional practice; support for differentiation; and simply using activities that they preferred over the school- or district-supplied curriculum. Brown (2011) goes so far as to call the supplementation and adaptation of curriculum materials "an inevitable reality" (p. 19).

To make sense of science teachers' role as critical curators, I leverage the Documentational Approach to Didactics (DAD). As a theory of teacher resource use, DAD (Gueudet & Trouche, 2011) positions the resources that teachers use as being inextricable from the ways that they are used. Together, a resource and its scheme of utilization represent a *document* (Gueudet & Trouche, 2009). Teachers engage in back-and-forth relationships with

their documents by making ongoing decisions about which resources to use and how to use them in a process known as *documentational genesis* (Trigueros & Lozano, 2011). Teachers may choose to revise their documents for a variety of reasons including engagement with formal professional development, evolving district policies, the acquisition of a new lab tool, or hearing about a new lesson idea from a colleague. Over time, documents begin to take a *documentational trajectory* (Rocha, 2018), representing their ongoing evolution over the course of a teacher's career. In this way, DAD embodies the perspective of teachers as critical curators by placing teachers' engagement with resources as the central focus of analysis, shedding light on what resources teachers select to use and how they use them.

While teachers acting as critical curators can benefit teaching and learning, many potential pitfalls can limit the effectiveness of this work. For example, not all resources available to teachers are of high quality (Trgalová & Jahn, 2013), and even resources that are useful in one instructional context may not translate well into another context (Joyce & Cartwright, 2020). Resources themselves can be complex (Remillard, 2018), and the ways in which a resource is used may vary significantly from teacher to teacher (Drijvers et al., 2013), which can raise issues if the resource does not provide clarity about its intended use (Davis & Krajcik, 2005). When teachers select and adapt resources, they can undermine the intended design of those resources, resulting in worse instructional outcomes (Pintó, 2005). Thus, a tension exists between teachers' need to select and adapt instructional resources to their context and the need for structures to guide and transform practice (Corno & Randi, 1997). This tension is particularly pronounced in schools that serve high-poverty neighborhoods (Clotfelter, Ladd, Vigdor, & Wheeler, 2006; Lacour & Tissington, 2011). Teachers in these schools often experience a "support gap" in which teachers receive less support than those in wealthier

communities, part of which includes a complete curriculum that aligns with state standards, yet provides flexibility for teacher adaptation (Johnson et al., 2004). Such working conditions contribute to the high rates of teacher turnover relative to schools that provide more support for teachers' resource use (Johnson et. al, 2012).

While addressing these issues of equitable access to resources is critically important for alleviating systemic issues of equity, finding solutions can prove more complicated than simply providing schools and teachers with more resources. Indeed, having access to a broad resource system does not guarantee better teaching and learning outcomes (Adler, 2013). Teachers' professional growth depends on both the available resources and support for their adaptive use. As Adler (2000) argues, "Our conception of a resourced teacher then becomes a teacher acting with material and socio-cultural resources and not simply a teacher surrounded by material resources." (p. 221) The insufficiency of resources alone to improve teaching and learning has given rise to explorations of infrastructure that support or inhibit teachers' use of resources.

Infrastructure and Teacher Agency

The great promise of improved instructional outcomes as a result of critical curation and the potential pitfalls that teachers may encounter in this work underscores the significance of school, district, and state infrastructure designed to support teaching. Therefore, this study seeks to shed light on the ways in which infrastructure can enable and constrain teachers' documentational genesis. Hall and colleagues (2021) define infrastructure as "a system of common working practices or routines and material resources that a community of professional actors (e.g., teachers, district science coordinators) collaboratively use to accomplish their work" (pp. 2-3). Time, space, policies, standards, and accountability measures can all positively and

negatively influence the way in which teachers seek, select, adapt, and implement resources (Allen & Heredia, 2021). For example, state learning standards provide guidance on the scope, sequence, and content that students should learn in a given class, thereby reducing design load for teachers when deciding what to teach. However, these same standards can set boundaries around what is to be taught in a class, limiting what teachers can reasonably teach in a given course in a given length of time, thereby limiting the resources that teachers select and use (Fogo et al., 2019; Taylor, 2013); in the 2018 NSSME+, 55% of science teachers reported that science standards were a barrier to instruction (Banilower et al., 2018). Additionally, missing infrastructure may limit the use of a specific resource by teachers, such as when a school implements a new technology tool but does not provide pedagogically-focused professional development to support teachers in using that tool (Waight, Chiu, & Whitford, 2014). Thus, the proliferation of teachers acting as critical curators has prompted some scholars to call for new ways to conceptualize and study teachers' work with resources, particularly attending to the ways that elements of the school and district infrastructure shape this work (Allen & Heredia, 2021; Balgopal, 2020; Hall et al., 2021; Joyce & Cartwright, 2020; Penuel, 2019).

As I detail in Chapter 2, work using the DAD framework has revealed much about how teachers engage in documentational genesis. This work generally positions teachers as the central agents of their practice and often attends to the selection and use of resources from across a variety of sources (e.g. Gruson et al., 2018). However, the DAD lens fundamentally assumes that teachers possess agency to select the resources they wish to use and implement those resources how they see fit. As I previously illustrated, infrastructure can significantly shape the amount of agency that teachers possess. Making an assumption that teachers have agency can blind one to the factors that subtly restrict this agency. To make sense of how teachers' context

can enable and constrain their agency, I turn to a second framework: the structure-agency dialectic. Drawing from Giddens (1984), I conceptualize structures as "rules and resources recursively implicated in social reproduction" (p. xxxi). Agency, then, is defined as the ability to alter structures, whether intentionally or unintentionally. In other words, a teacher's capacity to act agentically when making instructional decisions about which resources to use and how to use them is both enabled and constrained by the infrastructure with which they work. Whereas DAD attends to *in what ways* teachers do the work of documentational genesis, the structure-agency dialectic can highlight how teachers *could* or *could not* do this work. In other words, the structure-agency dialectic can shed light on why teachers choose not to use certain resources or practices that may otherwise appear available to them. In the next section, I overview how I used these two frameworks to study how teachers in one school district used a set of teacher-developed resources designed to align with their infrastructure. I conclude this chapter by presenting a set of research questions to guide this study.

Study Context

This study follows secondary science teachers at Grantham County Schools (GCS) (a pseudonym) as they engaged with a set of curriculum resources developed by other teachers in the district. As part of a larger district-wide initiative to support teacher leadership funded by a grant from the Teacher and School Leader Incentive Program (TSL), the *Grantham County Schools Curriculum Collection* (GCSCC) contains a body of lesson plans and instructional resources developed by GCS teachers to be used by other teachers in the district. The development of the GCSCC was driven by the belief that teachers in the district already use resources that work in their local context; by sharing those resources in an online repository, other teachers in the district would more likely find these resources useful than more broadly-

distributed resources given that these resources have already been adapted for the state and district infrastructure (e.g. state curriculum, community resources, etc). In other words, the developers of the GCSCC sought to shift away from *what works generally* toward *what works here* (Joyce & Cartwright, 2020).

The GCSCC represents an embodied effort to align resources provided to GCS teachers with their infrastructure. By studying how teachers engage with, evaluate, and use the resources in the GCSCC, we can learn more about how infrastructure shapes the ways in which teachers select and use resources. To make sense of this interaction, I use the Documentational Approach to Didactics (DAD) (Gueudet & Trouche, 2011) and the structure-agency dialectic (Giddens, 1984) as dual lenses through which to view teachers' engagement with the GCSCC. In the next section, I overview how I use these two theoretical frameworks to highlight both science teachers' work with resources and the ways in which infrastructure enables and constrains that work.

Research Questions

Because the GCSCC provides teachers with new resources developed by in-district colleagues working in presumably similar contexts, one might infer that the resources would translate readily into teachers' existing teaching practices. However, this assumption must first be tested by asking *whether* and *to what extent* teachers accessed and used resources from the collections. The need to elicit these trends leads to the first research question:

1. What patterns exist in science teachers' access to the GCSCC, if any?

While this research question suggested the existence of different kinds of infrastructure that shaped teachers' use of the GCSCC such as within individual schools and subject areas, this question alone could not provide insight into teachers' actual implementation of the resources

that they browsed. In the parlance of DAD, their documentational genesis represents the new resources and schemes of utilization that teachers select, including adaptations that may diverge from the way in which the resource was originally designed. This means that an analysis of the impact of the GCSCC on teachers' practice cannot focus solely on the resources that teachers select to use, but must also include an analysis of how they use those resources. Thus, a second research question regarding the nature of teachers' use of the GCSCC was needed:

2. In what ways did science teachers use the resources and / or framework from the GCSCC, if at all?

In addition to these research questions, this study attends to the ways in which school and district infrastructure shaped teachers' interaction with and decisions to use or not use GCSCC resources. As a part of the district infrastructure, the design and implementation of the GCSCC itself provides critical information about the design and intended use of its resources. The third research question addresses the role of infrastructure in shaping teachers' documentational genesis with the GCSCC:

3. In what ways did IGIs enable or constrain teachers' agency when using the GCSCC resources?

To answer these research questions, I employed a two-phase explanatory sequential mixed methods study (Cresswell & Clark, 2017). In the first phase, I used metadata from the Canvas courses that housed the GCSCC collections to analyze teachers' access and browsing patterns, answering the first research question in the process. The second and third research questions served as the focus of Phase 2 of the study, which sought to elaborate on the findings in Phase 1 through teacher interviews and artifact analysis. As I will illustrate, these analyses

revealed a number of ways that infrastructure both enabled and constrained GCS science teachers' agency for using the GCSCC.

CHAPTER II: REVIEW OF THE LITERATURE

In Chapter 1, I outlined the importance of deepening our understanding of how science teachers select and use resources with a focus on how school, district, and state infrastructure shapes those decisions. In Chapter 2, I present a synthesis of the existing literature on science teachers' interactions with resources and infrastructure as well as the theoretical frameworks that guide this study. I begin this chapter with a review of the relevant literature surrounding resources for science teaching and their use, using the Documentational Approach to Didactics (DAD) as a theory that describes science teachers' resource use. I then use the structure-agency dialectic as a lens to explore the significance of infrastructure in shaping this work. I conclude this chapter with an overview of how I use these frameworks to address the research questions in this study.

Resources and Their Use

As I described in Chapter 1, the use of the term "resources" can expansively include all things with which a teacher engages in designing and implementing instruction (Cohen et al. 2003). Resources for teaching come from a variety of sources including resources provided by a school or district, acquired from independent research, developed from practice, or discovered in contexts not directly related to formal education like TV or the grocery store (Russ et al., 2016). Given the vast array of sources for and kinds of resources, thinking of teachers' resource systems as the total set of resources with which a teacher works (Pepin et al., 2017) positions resource systems as impossibly vast and complex. As such, comprehensively studying every facet of a resource system may be impossible. This issue is further compounded when considering the latent resources to which teachers have access but do not engage with or use (Navy et al., 2020). These complexities that frustrate comprehensive studies of teachers'

resource systems can be alleviated by placing the teachers' engagement with their resource systems as the central focus -- a line of inquiry embodied by the documentational approach to didactics (DAD).

The Documentational Approach to Didactics (DAD)

As a theory of teacher learning, DAD conceptualizes teachers' practice as inextricable from the resources with which they interact. In other words, teachers' knowledge takes the form of "knowing with tools" (Radford, 2011), much like knowing how to perform complex division problems takes different forms depending on whether one uses a calculator or performs long division using pencil and paper. As Adler (2000) argues, the word "resource" can serve as both a noun and a verb, referring to the inextricable interplay between the resource and teachers' engagement with the resource. This means that the resources teachers use and the ways in which they use them are inseparably significant to the shape teachers' practices take, and that both the *what* and the *how* are of equal significance when studying teachers' resource use. This combination of a resource and the way in which it is used -- often referred to as its *scheme of utilization* -- represents what is known as a *document* (Gueudet & Trouche, 2011). These schemes of utilization represent both the visible usages of the resources and the invisible cognitive structures that guide teachers' use of the resources during instruction (Gueudet & Trouche, 2009). Consistent with Cohen et al. (2003), the term "resource" is used intentionally in descriptions of this work due to its expansive inclusion of anything used in the enterprise of teaching including material resources, relationships, actions, skills, knowledge, ideas, and beliefs (Gueudet & Trouche, 2011).

Gueudet & Trouche (2011) define *documentation* as occurring when "teachers collect resources, select, transform, share, implement and revise them" (p. ix). *Documentational*

genesis, then, represents the ongoing work of documentation by iteratively implementing and revising documents (Trigueros & Lozano, 2011). Through *documentational experiences* -- past events that shape documentational genesis -- the documents begin to develop a *documentational trajectory*, which Rocha (2018) defines as "the set of events through which a teacher constructs her documentational experience as an interplay between individual and collective documentational work" (p. 239). Documentational genesis does not typically occur in isolation, and teachers often work collaboratively on documents through *community documentational genesis* (Gueudet & Trouche, 2011). Cumulatively, the sum of a teacher's documentational geneses represent their *professional genesis* (Gueudet & Trouche, 2011). Documentational genesis typically occurs incrementally; as described by Davis, Janssen, and Van Driel (2016):

> In adapting designs teachers will not strive for an unrealistic optimum but rather for step-by-step improvements congruent with their goal systems. Teachers will only consider proposed (parts of) curriculum materials as an improvement if these will serve their goals better than their current way of teaching. (p. 152)

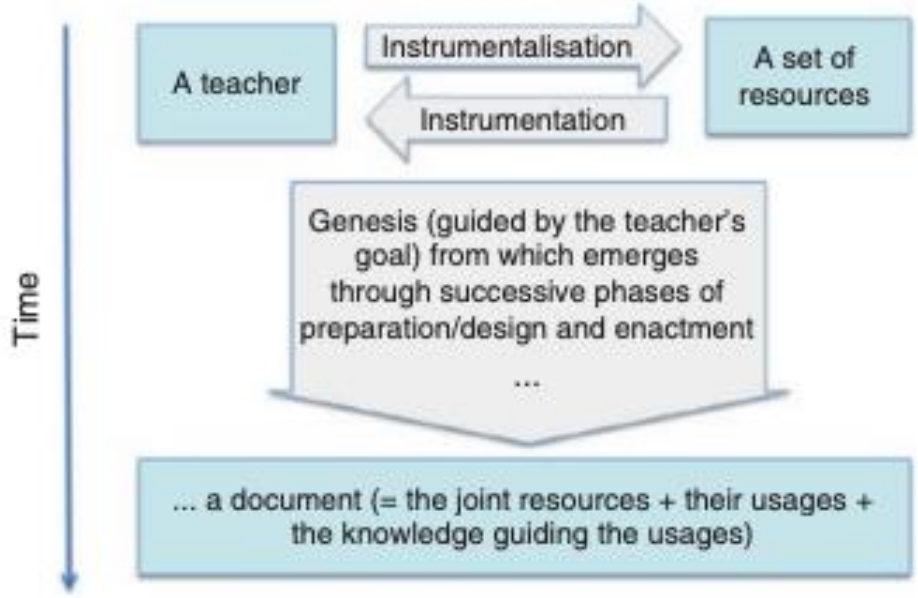
The ways in which teachers undertake documentational genesis evolve over the course of a teacher's career as the teacher learns from past experiences and engages with new resources (Rocha, 2018). For example, a novice Biology teacher will typically look for different things in an instructional text about RNA transcription than a veteran teacher (Remillard, 2011) and implement that resource differently during instruction (Visnovska et. al, 2011). Similarly, teachers with little technology experience who engage with a digital resource for the first time initially focus on using the resource itself, only pivoting toward a focus on the resource as a tool for teaching after gaining experience with the resource (Drijvers et. al, 2013). Documentational genesis, therefore, is idiosyncratic, taking different forms depending on factors like the stage of a

teacher's career, the teacher's personal experiences, the context in which the teacher works, and the material and social resources to which the teacher has access (Gueudet, 2019; Trigueros & Lozano, 2011). The view of teacher learning presented by DAD places the ongoing evolution of teachers' practice at the center of focus, regardless as to whether the documentational genesis derives from resources specialized for teaching or from everyday knowledge and experiences (Russ et al., 2016).

Documentational genesis involves the interplay between the teacher and the resource. As the teacher interacts with a resource, the resource begins to take new shapes and forms through *Instrumentalization*. However, teachers' interactions with resources also shapes the teacher in various ways such as new knowledge, skills, experiences, and changing dispositions in a process known as *Instrumentation* (Remillard, 2005; Trouche, 2004). In this way, teachers become mediators of resources, shaping and adapting the resources for use in their context while themselves being shaped over time (Barton, 2011). The diagram in Figure 1 illustrates the relationships between teacher, resource, and document (reproduced from Pepin et al., 2017).

To illustrate how the various components of DAD fit together, let us return to the story of my practice which opened Chapter 1. As I transitioned from teaching Chemistry at a school that was replete with scientific equipment to a school that privileged laptop access and project-based learning over scientific equipment, I evaluated whether the lesson materials I used in my previous school would translate to my new school in order to meet my instructional objectives. Over the previous four years of my career, I had created a set of *documents* – the instructional resources I used and the schemes that guided their use -- and refined them over time through *documentational genesis*. In my new context, I needed to make judgments about whether each document was appropriate for a new set of instructional expectations and

Figure 1. A Model of Documentational Genesis (Pepin et al., 2017)



resources for instruction. If I determined that a document would not meet my learning goals in this new context, I would need to change the resource(s) I used, the schemes of utilization that guided their use, or both.

One such episode of documentational genesis involved a lesson on titration. One of the state standards indicated that students would need to use titration as a laboratory technique to find the concentration of an unknown acid or base. In my first school, I conducted a demonstration of sodium reacting with water without measuring either the mass of sodium or the volume of the water. I performed this demonstration early in the semester as a foundation for exploring ionization and metallic character. I would store the sodium hydroxide that was created and have students use biurets, hydrochloric acid, and phenolphthalein to argue as to its exact concentration as part of my lesson on titration later in the semester. In my new school, I had no access to elemental sodium and had no way to store it safely; thus, I needed to seek new resources for teaching titration. I searched online for some ideas about how to teach titration

without specialized laboratory equipment and came across a virtual laboratory that allowed students to simulate the kind of titration I had performed in my earlier school. To adhere to the tenets of project-based learning, I tied the simulator to an exploration of global issues of water quality anchored in the United Nations Sustainable Development Goals (https://sdgs.un.org/goals) (*scheme of utilization*). In the process of creating and implementing the lesson, I came to realize that this hypothetical situation was too detached from the local context for students to relate with (*instrumentation*). Searching again online for lesson ideas the following semester, I found a blog in which a Chemistry teacher had posted a lesson in which students used dilute vinegar and pipettes to perform a titration. Finding this resource helped me realize that the lesson might be more engaging if students used a local body of water as a resource, even if I did not use advanced equipment (*instrumentation*). The following semester, I refined the lesson, maintaining an overarching focus on the Sustainable Development Goals but applying the concepts to a nearby creek. Instead of students using the virtual simulator, I used the simulator to demonstrate titration procedures (an adjustment to the *scheme of utilization* for this resource). Students designed and conducted experiments by diluting vinegar to a desired molarity, then using the vinegar to titrate samples from the creek (*instrumentalization*). Students found this lesson much more engaging than the simulator-only lesson, leading me to redesign other lessons to leverage local resources (*instrumentation*).

As this story shows, documentational genesis is an iterative process that happens over the course of a teacher's career. As I gained experience in my new context, I continued to refine my documents to take advantage of new resources and alter my schemes of utilization for existing resources. Through these *documentational experiences*, I gained insight into the ways that I might change this and other lessons through ongoing *documentational genesis*, thereby shaping

my overall *professional genesis*. For this particular lesson on titration, my *document* had undergone another step in its *documentational trajectory*. Engaging in documentation not only led me to refine the lessons I taught, but I also learned about the success of instructional strategies in my context. In other words, I gained knowledge through my experiences working with resources that would further guide the development of my documents. In this way, documentation is a back-and-forth process between teacher and resource that results in changes in both the resource and the teacher. This story also illustrates that this work involves many steps and processes, which I highlight in the next section.

A Logic Model of Resource Use

Studies of teachers' resource use have surfaced a number of activities in which teachers engage while navigating their resource systems. These activities include a *Prompt*, a *Search* for resources, *Interpreting* the resource, *Evaluating* the resource's usefulness, considering modes of *Adaptation* for the resource, *Preparing* the resource for instruction, *Implementing* the resource in the classroom, *Reflecting* on the experience of using the resource, and sometimes *Sharing* the resource with others. While these activities are not explicitly part of the DAD model, other lines of scholastic inquiry have revealed the significance of each of these activities in teachers' documentation work. I begin this section by summarizing those activities which are most relevant to this research, then organize these activities into a logic model that maps the coordination of teachers' engagement with resources. I conclude this section by connecting these activities with DAD by revisiting the story of refining a lesson on titration.

Prompt

Teachers' engagement with new resources begins with a *prompt*. This prompt can come in many forms, but generally requires teachers to identify an area of their teaching practice that

they would like to improve or respond to a change in the system in which they operate (Allen & Heredia, 2021). For example, a teacher may not have liked the outcome of their previous attempt at teaching the concept of mitosis, so they seek a new resource to achieve better learning outcomes for students. Alternatively, a teacher may be introduced to a new resource without seeking one through a conversation with a colleague, newsletter, or professional development session. Still other prompts may be imposed on teachers like a new requirement to incorporate a word wall into their daily teaching. Wherever the prompt comes from, teachers' incorporation of new resources begins either with an encounter with a new resource or an identified need to change their practice.

Search

While a prompt may result in teachers receiving resources from an outside source, a prompt may also lead teachers to *search* for supplemental resources. Many secondary science teachers use resources directly provided by a school, district, or state such as material resources (e.g. electronic devices, lab supplies), curriculum resources (e.g. standards, pacing guides, instructional resources), and personnel (e.g. instructional coaches, administrators), yet the results of the NSSME+ (Banilower et al., 2018) indicate that the majority of secondary Science teachers use supplemental resources in their teaching. A teacher may opt to search for additional resources when they identify a specific aspect of their practice that they wish to improve (Jones & Dexter, 2014) such as a need for deeper content knowledge, instructional tools, pedagogical support, or resources for student assessment. Teachers may search for resources in a wide array of places including those affiliated with the school context (e.g. other teachers in the school, instructional coaches, school resources, media specialists) as well as sources not affiliated with the school context (e.g. online networks). For example, many teachers use education-specific

websites like Teachers Pay Teachers (Sawyer et. al, 2020; Shelton & Archambault, 2019), PhET Simulations (Wieman, Adams, & Perkins, 2008) and Khan Academy (www.khanacademy.com). Teachers have also created spaces for sharing resources on social networks like Twitter (Lord & Lomicka, 2014; Shelton & Archambault, 2018) and Facebook (Rutherford, 2010). In such spaces, teachers not only share resources designed for direct use in instruction, but these sites also serve as platforms for sharing ideas and experiences. Teachers may also search for science resources through news sites, blogs, and video sharing platforms like YouTube.

Interpret

Regardless as to whether teachers search for a resource or receive it directly as a prompt, they must *interpret* the intent and potential utility of each resource they encounter. Each resource bears a certain degree of interpretative flexibility (MacKenzie & Wajcman, 1999), meaning that two teachers can and typically do interpret and use the same resource in different ways (Chávez-López, 2003). How a teacher decides that a resource should be used may deviate from the resource creator's intent (Fogo et al., 2019). This has led to conversations of fidelity in teachers' use of curriculum resources. In some cases, teachers' interpretation of the use of a resource can undermine the fundamental elements of the resource that the designer included as keystones to success (Pintó, 2005). Educative curriculum materials, or those materials that provide pedagogical support through descriptions of design principles and keys for implementation (Davis & Krajcik, 2005; Brunner & Abd-El-Khalick, 2019) may provide a solution to issues of ineffective resource use resulting from issues with interpretation. Such educative resources can reduce the cognitive demand on teachers' design work, freeing up both time and mental energy for teachers to work on other aspects of lessons (Davis et al.,

2016). However, others have argued that interpretive flexibility is critical for teachers' success and that the failure of a resource stems from a failure to support teachers in adapting and implementing that resource (Taylor, 2013).

Evaluate

As teachers interpret the features and possible uses for a resource, they engage in ongoing *Evaluation* of the resources' potential benefits and drawbacks. Teachers primarily select resources that they believe will be most likely to achieve the desired instructional results (Waight et al., 2014). Such selections are mediated by teachers' value beliefs about the outcomes of the use of a resource (Ottenbreit-Leftwich et al., 2010). Six types of considerations drive this process : teacher-driven, student-driven, content-driven, constraints-driven, resource-driven, and culture-driven (Siedel & Stylianides, 2018). Even if a teacher determines that a resource may be appropriate for their context, they may be deterred from using the resource by the perceived costs associated with using the resource such as financial costs or perceived time required to learn how to use or prepare the tool for instruction (Wozney et al., 2006). The balance between perceived outcomes and cost, then, creates a dynamic in which teachers continually evaluate the use of instructional resources and tools. If the teacher deems a resource to be inappropriate for their needs, they may search for new resources, refine resources already in their repertoire, or decide to create resources of their own (Libbrecht, 2011). This evaluation of the usefulness of a resource is ongoing, taking place throughout the processes of planning for and using the resource.

Prepare & Adapt

Once a teacher identifies a resource that they would like to try, the teacher must *prepare* the resource for instructional use - a process that often involves *adapting* the resource in some

way. Two teachers using the same instructional resources will rarely use them in the same way, a phenomenon that Brown (2011) likens to jazz performers who play the same song in different ways. Here, I define adaptation as teachers' work of modifying resources in order to meet their perceived contextual needs. Teachers undertake the adaptation process in response to perceived contextual needs such as perceived learning needs of their students or to address content demands that teachers deemed lacking in the lesson (Fogo et al., 2019), often resulting in improved instructional outcomes (Squire et al., 2003). Davis et al. (2016) posit that,

> …an individual teacher's curricular decision making is in essence a difference reduction process in which the teacher will try to reduce the differences between their current state (their available personal resources and curriculum materials) and the desired state of instruction, through making adaptations to the current state. (p. 147)

Cirillo et al. (2009) describe this difference reduction process as stemming from "curriculum vision", which they describe as teachers' big-picture vision for their classroom which they achieve by adapting resources. Such adaptation looks different depending on the nature of the resources and the needs of the context. As Squire and colleagues (2003) note, "contextualizing the curriculum is ultimately a local phenomenon that arises as a result of a number of factors, including students' needs, students' goals, teachers' goals, local constraints, and the teacher's pedagogical values." (p. 483)

Adaptations can occur in different ways and to varying degrees. Remillard (2005) describes the various ways in which teachers interact with resources as following the resource to fidelity, drawing on the resource as source material, interpreting the resource into context, or participating with the resource in a dynamic back-and-forth relationship. Fogo et al., (2019) describe four modes of adaptation: addition, as seen when a teacher supplements the resource in

some way; subtraction, which occurs when a teacher removes a component of the resource; reformatting, in which a teacher does not alter the information but changes elements like arrangement, color, and font to align with existing resources; and revision, in which teachers modify the resource by changing one or more of its components.

However, teachers do not always adapt resources prior to implementation, opting instead to use the resource to fidelity (Davis et al., 2016). Brown (2011) refers to fidelity as *offloading*, which he defines as teachers' use of a resource without adaptation, often resulting in instruction that is not tailored to the contextual needs of the class. Some scholars have argued that the adaptation of curriculum resources can actually decrease the effectiveness of these resources (e.g. Pintó, 2005). Proponents of this position argue that deviation from the intent of the curriculum can undermine the underlying principles that make the curriculum "effective". Other scholars note the tension between the need for the underlying structures of curriculum to be maintained while still being flexible enough to meet the needs of diverse contexts (Corno & Randi, 1997). This line of thinking balances the need for professional development to influence and shape practice while still affording teachers the leverage to adapt resources based on the needs of their context. Some scholars propose educative curriculum materials that instruct teachers on the intended use of a resource as a solution to this problem (Davis & Krajcik, 2005; Brunner & Abd-El-Khalick, 2019).

Still other scholars argue that curriculum must be designed to maximize and support teachers' adaptation of the resources. In one study of how four teachers adapted a tech-rich, project-based science curriculum, Squire and colleagues (2003) found that:

> [...] for the most part the preordained project challenges did not have local relevance to students and were not likely to anchor learning in productive ways. Rather, the most

> effective instantiations involved teachers taking the tools, resources, and challenges we provided them, and rearranging them in novel ways that met local needs. (p. 483)

This conclusion is echoed by Penuel et al. (2011), who found that among professional developments that either focused on fidelity to curricular resources, focused on both the use of the resources and the underlying pedagogical principles of those resources, or the underlying principles alone, the structures that provided both curriculum resources and training in the structures underlying the curriculum yielded the largest learning gains among students. Brunner and Abd-El-Khalick (2019) found similar results in a study in which they concluded that providing elementary science teachers with both resources and guidance on their use resulted in stronger learning outcomes for students.

Ball and Cohen (1996) noted three reasons why many curriculum initiatives fail: a failure to account for individual teacher characteristics, an inability for teachers to adapt the resources to their context, and an underlying assumption among reform-oriented teachers that the best teachers do not use textbooks. They propose that curriculum can be improved by placing a lower focus on fidelity and by establishing equal partnerships between teachers and professional development facilitators as opposed to the top-down professional development delivery that pervades among schools. Taylor (2013) expanded on these proposals, calling for the field to push away from developing the "teacher-proof curriculum" toward the idea of a "curriculum-proof teacher" -- one who "does not ignore or sabotage the text; rather, he or she can and does use any given curriculum in highly-effective ways" (p. 297) -- that is, a teacher who can adapt any curriculum to her or his context. In the same article, Taylor describes a professional development structure that focused on helping teachers develop their ability to adapt curriculum

resources, which resulted in an increase in adaptation of the provided curriculum and a subsequent increase in students' test scores.

Implement

Once a teacher has prepared a resource for use in instruction, the teacher proceeds to *implement* the resource. Adaptation can occur prior to, during, and after instruction (Sherin & Drake, 2009). As such, teachers' enacted use of the resource during in-the-moment teaching may diverge from the intended use of the resource conceived during the planning process as teachers adapt instruction on the fly (Fogo et al., 2019; Ruthven, 2018). A teacher may even use a single resource in different ways in different classes (Eisenmann & Even, 2011), such as when a teacher rapidly adapts a lesson for a 2nd period class based on feedback from teaching the lesson in 1st period. As the teacher engages with the resource through practice, the teacher continues to make adaptations and to evaluate the appropriateness of the resource for ongoing use.

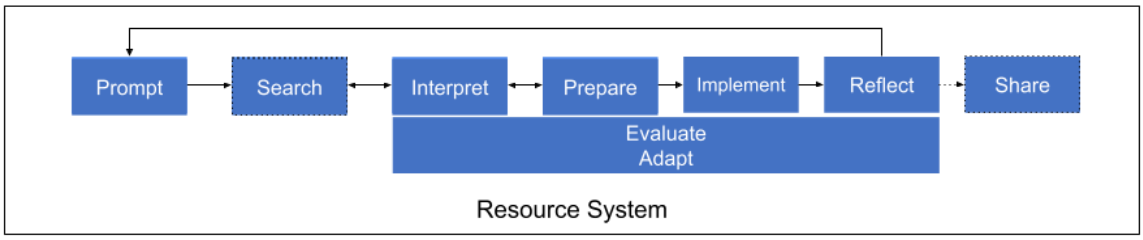
Reflect & Share

Following implementation, teachers often *reflect* on whether their use of the resource met their instructional needs. If the teacher believes that the resource did not meet their expectations, this can serve as a prompt to begin the search for resources again. Alternatively, teachers may seek assistance in using the resource from someone they deem as having greater expertise with the resource. If the teacher deems the resource to be potentially useful to others, they may *share* the resource with colleagues. This sharing may occur privately with colleagues both within and outside the department. Sharing may also occur publicly, often through online platforms. Such sharing continues the spread of the resource. The decision on whether or not to share a resource

with others positions teachers as experts who evaluate and curate resources that they believe to be effective for instructional use.

Linking these activities involved in engagement with resources together, I created the logic model represented in Figure 2. Here, the various activities are represented in sequence, although the actual process which teachers undergo is rarely linear and can terminate at any point in the process. The dotted lines around the Search and Share boxes represent that these activities do not always occur. For example, a teacher may be given a resource by a colleague without searching for one or may choose not to Share a resource after using it. The double arrows between Search, Interpret, and Prepare represent the often back-and-forth processes as teachers plan for instruction. As previously mentioned, the Evaluate and Adapt processes occur concurrently as teachers engage in other activities of the overall process of using resources in their instruction.

Figure 2. A Logic Model of Teachers' Engagement With Resources



To illustrate how these processes link together in practice, let us return to the previous illustration in which I refined a lesson on titration. When I began teaching in a new school, I realized that the difference in access to laboratory equipment would require me to change my lesson on titration (*prompt*). I began by *searching* online for resources when I encountered a website that provided a virtual lab for simulating the titration experiment. As I explored the simulator, I made *interpretations* about its design and intended use and considered whether it

would be appropriate for meeting my learning objectives (*evaluate*) as well as how I would need to *adapt* it to help my students learn about titration. Once I decided to use the simulator, I *prepared* it by incorporating it into my school's learning management system, creating a set of questions to guide my students through the process, and creating slides to help set the stage for the simulator. I then *implemented* the simulator as part of a lesson with my students, from which I learned that the simulator may not have been the best tool for helping my students master the learning objective (*reflect*). This *prompted* me to *search* for more resources online, where I found the blog post by the other teacher. As I read the post, I again *interpreted* what the teacher had done in their classroom and *evaluated* whether the idea would work in my context better than the simulator. I *adapted* the lesson from the blog post to align with the overall unit project related to the Sustainable Development Goals. To use the virtual simulator as a demonstration tool, I had to again *prepare* the instructional materials I had previously made by *adapting* them to the new lesson scheme. This time, I further *prepared* the lesson by buying some vinegar and verifying that I already had all other materials. As I *implemented* the lesson with my students, I made some in-the-moment *adaptations* to help students make sense of the procedure and calculations. Upon *reflecting* on this second iteration of the lesson, I decided that this version had done a better job of stimulating students' scientific thinking, so I *shared* the lesson with a colleague in the building who taught Earth and Environmental Science.

While these resource engagement activities do not stem directly from the DAD literature, separating the work of documentation into discrete activities can help narrow the focus of research on teachers' documentational genesis. For example, if a teacher implements a lesson that fails to meet the desired learning objectives, the DAD lens dictates that the teacher should change the resource(s) they use and / or the scheme of utilization guiding the use of the

resource(s). While this represents a case of instrumentation as the teacher learns from the lesson's implementation, further defining the activities involved in documentation can help shed light on where specifically the documentation process could use help. Is the teacher unable to find or access appropriate resources? Is the teacher misinterpreting the intended use of the resource? Is the teacher adapting the resource in a way that mitigates its instructional potential? Is the in-the-moment implementation of the resource diverging from its designed use? In this way, the activities included in the logic model can provide a more granular lens on teachers' documentation. Furthermore, this logic model portrays a discrete yet interconnected set of activities involved in DAD -- an operationalization of documentation on which I draw in my data analysis as described in Chapter 3.

To be clear, this logic model is in no way meant to be exhaustive, and further research may reveal other activities in which teachers engage and new ways that those activities connect together. Rather, this model illustrates the complexity and nonlinearity of teachers' work with resources. Furthermore, these interactions are mediated by teachers' access to resources within their resource system and the infrastructure in which they work (Adler, 2012; Penuel, 2019). Despite the benefits of viewing teachers' work with resources through the DAD lens, this analysis points to an essential limitation of the framework: its assumption that teachers have agency to select resources and how to use them. I expand on these concepts in turn in the following sections.

Limitations of DAD

While the DAD framework can shed light on the ways in which science teachers learn through engagement with resources, DAD does not readily provide insight into the things teachers are *not* doing. In other words, the focus of DAD on teachers' work with resources can

miss elements of teachers' resource system with which they do not engage during a particular round of documentation. For example, DAD assumes that teachers are undergoing documentation regularly, which may or may not be true for a given teacher. Latent resources that are available to teachers yet remain unaccessed can still be considered parts of the teacher's resource system (Navy et al., 2020). DAD's focus on engagement with resources can miss the resources that teachers do not access or access and decide not to use. Similarly, the DAD framework does not readily shed light on power dynamics in schools and districts including who can access which resources, how, when, why, and how that work is supported or inhibited by other factors in schools and districts. These issues are particularly problematic in high-poverty schools which often do not have access to as many resources as their wealthier neighbors (Banilower et al., 2018).

Teachers require some degree of agency in order to change a document including the ability to decide what resources to use and how to use them. Without attending to these factors that play an essential role in shaping the ways in which teachers undergo DAD, we would miss vital opportunities to understand the factors that shape documentation. This need for insight into the factors that shape DAD leads to the complementary theoretical framework used in this study: the structure-agency dialectic.

The Structure-Agency Dialectic

My analysis of the structure-agency dialectic draws primarily from the work of Giddens (1984) who put forth the theory of structuration. He defined structures as "rules and resources recursively implicated in social reproduction" (p. xxxi). Agency, then, is defined as the ability to alter structures, whether intentionally or unintentionally. Giddens positions social structures as being internal to individual agents rather than as external elements. For example, structuration

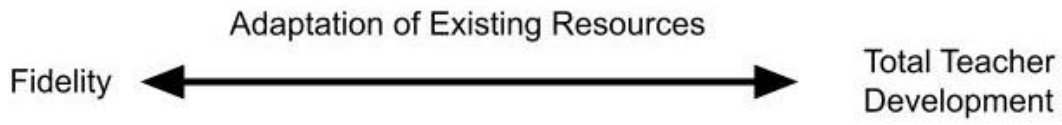
positions power as a property of the individual rather than as an objective reality. In this sense, power is neither inherently good nor bad as described by Marx or Foucault, but simply represents the capacity for individuals to achieve intended consequences. Giddens also describes resources as structures, both as material allocative resources and the capacity to transform structures in the form of authoritative resources.

Giddens describes structures as both enabling and constraining different forms of agency. Structures vary in degrees of stability, with collectives of extremely stable structures forming institutions. Giddens' descriptions of structures often focus on daily routine, as daily routines represent the most normative participation with structures over time and space. In doing so, individuals consistently enact social reproduction by intentionally or unintentionally maintaining the structures with which they interact. Structures and agency are therefore interdependent and not necessarily separate entities, but rather two sides of the same coin. In this view, humans are not wholly agentic in that all action participates with structures, yet structures are not wholly deterministic as individuals transform structures through agentic action. Archer (2010) expands on this work through her theory of morphogenesis which posits that the exercising of agency to alter a structure subsequently influences future agentic capacity. In many ways, this cyclical relationship mirrors the processes of instrumentation and instrumentalization in the DAD framework. The action of the agent on the structure (instrumentalization) in turn influences the agent (instrumentation).

To illustrate how the structure-agency dialectic can apply to teachers' use of resources, consider the three categories of resource use identified by Davis et al. (2016): fidelity, in which a teacher makes no adaptations to the resource; total teacher development, in which the teacher develops the resource entirely on their own; and adaptation of existing resources, in which the

teacher modifies an existing resource. One could consider these three categories as falling on a spectrum, as represented in Figure 3. On one extreme, the teacher exercises no agency over the resource, implementing the resource to fidelity. On the other extreme, teachers exercise total agency by completing creating the resource on their own. The space between those extremes represents adaptation, in which a teacher exercises some degree of agency by reshaping a structure for use in their context. As the literature on adaptation suggests, this middle area generally represents the most efficient and effective use of resources, yet the degree to which teachers adapt a resource may depend on how well the resource already aligns with their envisioned scheme of utilization for the resource. In the process, teachers are themselves shaped by the act of adapting the resources through instrumentation, learning from their work with the resource.

Figure 3. A Spectrum of Teachers' Exercised Agency With Resources



Just as resources act as structures that can enable and constrain teachers' agentic capacity, other structures in schools and districts can enable and constrain teachers' agency to select and use resources. For example, a school or district may have varying degrees of access to scientific equipment and may require the use of certain curriculum materials or instructional practices. In my personal story about how my documentational genesis evolved to adapt to a new context, my access to lab resources and safety equipment in my previous school significantly shaped the resources I used and how I used them, enabling my agency to use instructional resources that required access to this equipment. When I adjusted to my new school, I no longer had access to

the equipment around which I had structured my previous documents. Similarly, all teachers at the school were expected to implement a project-based learning framework; as a result, the resources I used and how I used them needed to align with the instructional vision embodied in this framework, thereby presenting a limitation to my agency to select and use resources. However, my enhanced access to technology in this context enabled my agency to use a variety of digital resources. In this way, structures at each school enabled my agency to use some resources, but constrained the use of others.

The structure-agency dialectic can prove particularly powerful for highlighting issues of inequitable access to resources. For example, Rodriguez (2015) highlighted the participatory nature of structure and agency in a study of Gary - a novice teacher who attempted to reconcile the transformative pedagogical practices he learned through his preservice teacher program with the structural constraints of his teaching context in an under-resourced school. In this study, Gary navigated a constant tension between the desire to implement pedagogies that he believed to be most effective for his students and the structures that limited his agency in teaching in this way. Rodriguez identified several institutional challenges that Gary faced including a lack of resources, tensions with administrators, and low expectations for students held and communicated by other teachers in the school. As he worked to exercise his agency in this context by raising his expectations for students in his class, his actions garnered opposition from administrators but resulted in larger student enrollment in his elective course. When his work created new opportunities for agentic action by overcoming some structural barriers, new barriers arose, such as administrators heaping additional duties on him due to his emerging status as a good teacher. Stated another way, Gary's limited agency shaped the structures in which he operated, presenting him with new structures that further shaped his agentic capacity. Despite

Gary's struggles with a seemingly endless stream of structures that limited his agency, Rodriguez carefully framed his work as a "narrative of engagement" rather than a "narrative of despair". In this way, the structures that both inhibited and supported Gary's work came to light, resulting in a more complex understanding of the ways in which the structural landscape of Gary's school shaped his professional practice.

Rodriguez's portrayal of Gary's work illustrates the dynamic nature of structure and agency as Gary sought to implement high-quality instruction. As a type of structure, some of the resources that Gary wanted to use in his teaching were not available to him due to lack of access to these resources. Other resources were available in the sense that he could access them, but may not have been able to implement them due to other structures like restrictive policy and a lack of time due the acquisition of additional duties. In this way, his infrastructure -- the total sum of the structures with which he worked -- bounded his agency when designing his instruction. However, Rodriguez cautions against using Gary's case as a justification for considering only the ways in which structures constrained Gary's agency. Instead, he argues that scholars should frame the relationship between infrastructure and teachers' agency dynamically as teachers' exercising of agency reshapes the structures with which they work. Resources, therefore, cannot be the sole focus of interventions that aim to improve practice and support teachers; rather, we must consider how those resources interact with other structures within the broader infrastructure.

Infrastructure

The insufficiency of resources alone to improve teaching and learning has given rise to explorations of infrastructure that support or inhibit teachers' access to and use of resources. Hall et al. (2021) define infrastructure as "a system of common working practices or

routines and material resources that a community of professional actors (e.g., teachers, district science coordinators) collaboratively use to accomplish their work" (pp. 2-3). Penuel (2019) describes the significance of infrastructure for shaping resource access in this way:

> [Teachers] draw on resources made available through an infrastructure that others have designed (e.g., a system for selecting and distributing materials), and they acquire and make use of recipes (e.g., curriculum materials, lesson plans) that are essential to guiding their work with students. (p. 3)

Penuel goes on to clarify that infrastructure includes a wide variety of components including standards, curriculum materials, assessments, routines, bell schedules, building-level policies, district-level policies, instructional support staff, and personnel evaluation systems.

Until this point, I have treated all resources equally. Here, I will begin to distinguish between those resources provided by the school or district as part of the infrastructure and personal resources. Sometimes referred to as "supplemental" resources, I define personal resources as those resources that a teacher brings to their practice from outside of the school and district infrastructure (Davis et al., 2016). For example, a teacher may seek resources from websites like PhET simulations (https://phet.colorado.edu/), the National Science Teaching Association (https://www.nsta.org/), Teachers Pay Teachers, or YouTube. Each of these websites provides something different that a teacher may deem preferable to the materials provided by the school or district as part of the infrastructure. As I outlined in my description of the logic model in Figure 2, teachers may opt to use personal resources in lieu of those provided as part of the infrastructure for a variety of reasons, ultimately considering whether the use of a resource will lead to desired instructional outcomes (Banilower et al., 2018; Waight et al., 2014).

Despite the promise that the effective selection and use of personal resources holds for improving instructional outcomes, such resources are often treated as second-class by schools and districts. The documentation work that can result in the incorporation of new resources into instruction requires time. Yet outside of planning periods that also involve a host of other tasks, teachers often receive little direct support from schools and districts for the selection and use of personal resources. By contrast, schools and districts often provide support for the use of resources that are part of the infrastructure including professional development time and help from technology departments. This contrast in the valuation between personal resources and those that are part of school and district infrastructures is further exemplified by recent political movements that restrict teachers' agency for documentational genesis by limiting teachers' use of personal resources (e.g. Patterson, 2023; Stanford & Najarro, 2023).

The inclusion of resources as part of a school or district's infrastructure suggests that infrastructure can contain different kinds of structures. For example, bell schedules, teacher accountability models, and the human resources department are all part of a school's infrastructure and can influence teaching, yet are not necessarily resources on which a teacher draws. This study seeks to reveal how teachers' infrastructure influences their documentational genesis, yet an analysis of all of a teacher's infrastructure would likely be so broad as to be irreducibly complex. As such, further refinement of the kinds of infrastructure can add clarity by focusing analysis on certain kinds of infrastructure that may most directly shape documentational genesis. To provide this focus, I will now turn to Instructional Guidance Infrastructure as a specific set of structures that influence teachers' documentation.

Instructional Guidance Infrastructure

The concept of *infrastructure* can present problems for research due to the vast pool of structures that influence teachers' work. Hopkins and Spillane (2015) present a solution to this problem by providing a conceptualization of a particular kind of infrastructure: Instructional Guidance Infrastructure (IGIs), which they define as "those structures and resources that are mobilized by local school systems (i.e., school districts in the US) to enable (and at times constrain) school leaders' and teachers' efforts to provide, maintain, and improve instruction" (p. 422). Drawing from prior scholarship on infrastructure, they identified five kinds of IGIs, as represented in Table 1. They argue that to understand how infrastructure shapes teaching and practice, scholars must look beyond individual infrastructure components to how those components work in tandem and how teachers interact with those components as guided by teachers' beliefs and experiences.

Considering documentational genesis in the context of IGIs, teachers interact with Instructional Materials to make determinations about which materials to use in their instruction and how to use them. While research on DAD often declaratively takes an expansive view of resources that mirrors that expressed by Cohen et al. (2003), much of the DAD literature ultimately operationalizes *resources* as Hopkins and Spillane (2015) describe *instructional materials*. For this reason, I will here use the terms *resources* and *instructional materials* interchangeably. Using these terms in this way highlights the fact that a variety of IGIs shape documentational genesis, not just the materials with which teachers work. As teachers search for, interpret, and evaluate resources, they must make decisions about the alignment of those resources with other IGIs. If a resource does not align with the IGI, then the teacher may decide to adapt the resource to better align with the IGI or pass on using the resource entirely

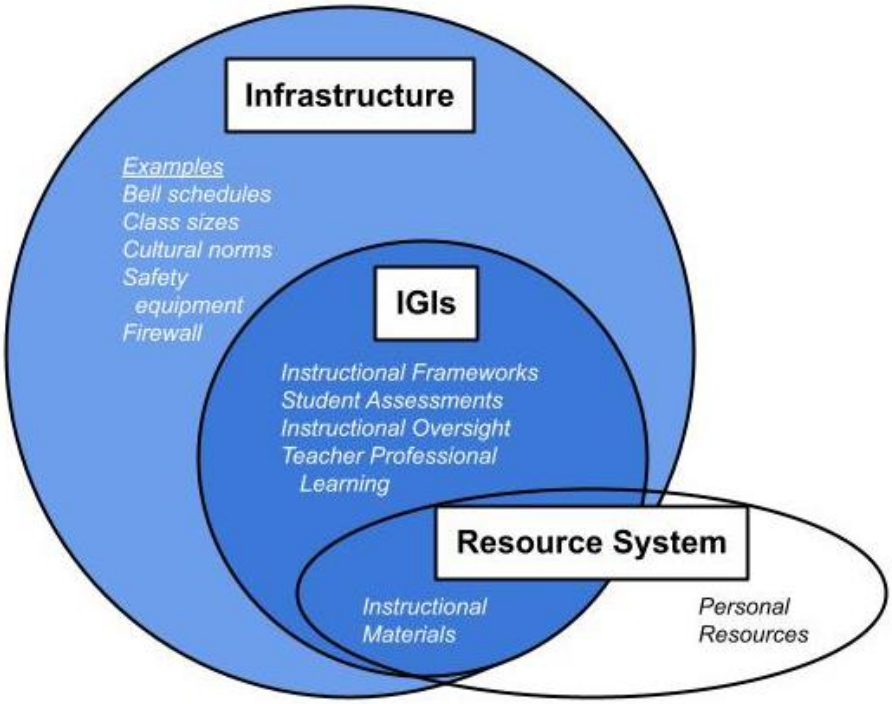
Table 1. Categories of IGIs (Hopkins & Spillane, 2015)

IGI	Definition	Examples
Instructional Framework	Provide information about the content, pacing, sequencing, and instructional practices to be used by teachers.	state standards, pacing guides, instructional frameworks like the 5E model
Instructional Materials	The resources used by teachers in classroom instruction	videos, articles, simulators, lab resources
Student Assessments	Measures of student performance, both formative and summative	state standardized tests, common district assessments
Instructional Oversight	Systems for monitoring teachers' classroom instruction and performance, often carried out by school and district administrators	teacher accountability models, administrative walkthroughs, student testing results
Teacher Professional Learning	Formal systems that provide support and guidance for teachers' ongoing professional growth	formal teacher professional development, professional learning communities, instructional coaches

(Sherin & Drake, 2009). Figure 4 illustrates the relationship among infrastructure, IGIs, instructional materials, resource system, and personal resources. In this illustration, instructional materials represent one kind of IGI that are part of the overall infrastructure, whereas personal resources lie outside of the infrastructure. Together, instructional materials and personal resources comprise a teacher's resource system.

Again returning to the illustration from my practice in Chapter 1, I underwent documentational genesis to adapt my practice to a new school with new resources and expectations. While much of my analysis of this story to this point has focused on the instructional materials to which I had access (i.e. losing physical materials like chemicals and laboratory equipment but gaining student technology access), other IGIs also shaped the

Figure 4. A Visualization of Infrastructure, IGIs, and Resource Systems



decisions I made about which resources to use and how to use them. For example, my new school's expectation that all teachers use a specific project-based learning framework represents an *instructional framework*. I received some initial *teacher professional development* the summer prior to starting at the school, from which I learned that application of this instructional framework required each lesson to support an overarching, student-driven project. This model of teaching required instructional time related to setting up, discussing, working on, and presenting the project - time that, in my previous context, had been used for directly teaching Chemistry concepts. Despite having less class time over the course of a unit to discuss Chemistry content knowledge, I was still teaching in the same state with the same content standards (another *instructional framework*) with the same teacher evaluation system -- a form of *instructional oversight*. This tension was somewhat alleviated by the fact that Chemistry did not have a state-

mandated *student assessment* like a standardized test. The absence of this IGI helped relieve some of the pressure to cover all of the content in the state standards, instead favoring a model of instruction that incorporated fewer concepts taught in a way that more directly applied to students' lived experiences.

This story illustrates that not only did the IGIs themselves play a role in shaping my documentational genesis, but also the tension that existed among those IGIs. The state standards represented a framework that provided guidance as to the Chemistry concepts that students should learn during their time in my class, yet the project-based learning framework made this challenging. It may be possible that the introduction of another IGI could have alleviated this tension, such as ongoing professional development throughout the school year or the provision of instructional materials that were aligned to both the state standards and the project-based learning frameworks.

Studies to date have largely focused on either DAD or IGIs with little insight into how these systems interact (Clough et al., 2009; Hall et al., 2021; Joyce & Cartwright, 2020; Russ et al., 2016). This study contributes to our collective understanding of these complex interactions and how they can enable or constrain teachers' decision making about which resources to use and how to use them. In the next section, I outline how the Grantham County Schools Curriculum Collection (GCSCC) provides a valuable context to study the dynamics of teacher agency through the interaction between DAD and IGIs.

Applications to The Present Study

As a set of resources designed by GCS teachers for the use by other GCS teachers, the GCSCC represented an intentional effort to align resources with other IGIs. Given that GCS teachers work in the same state and district, many of the IGIs that teachers of the same content

area experience across the district are identical such as state standards, state assessments, and accountability measures. Thus, if a teacher develops a resource that is aligned with their IGIs, then the resource should be useful to other teachers working with similar IGIs. This contrasts with searching for resources online, many of which were developed by teachers from different states working with different standards, assessments, accountability systems, etc. This intentional alignment between the GCSCC and other IGIs makes the GCSCC an excellent candidate to explore the ways in which IGIs influenced science teachers' documentational genesis using these resources. In the next chapter, I describe how I used DAD and the structure-agency dialectic to explore the relationship among resources, documentational genesis, agency, and IGIs through science teachers' interactions with and use of the GCSCC.

CHAPTER III: METHODOLOGY

Introduction

In Chapter 1, I provided an overview of the study and the need for further research into the ways in which infrastructure shapes science teachers' resource selection and use. In Chapter 2, I summarized the literature that highlights how teachers work with resources and how infrastructure -- the total set of structures that shape teachers' work, including resources themselves -- can shape this work. I further described how the documentational approach to didactics (DAD) and the structure-agency dialectic can be used as lenses for exploring both how teachers work with resources and how this work is shaped by Instructional Guidance Infrastructure (IGIs). In this chapter, I outline how I applied these frameworks to explore teachers' work with the Grantham County Schools Curriculum Collection (GCSCC) -- a set of resources designed by GCS teachers for use by other teachers in the district. Specifically, this study explores which resources secondary science teachers used from the GCSCC, how they used these resources, how these resources intersected with teachers' existing documents, and how other IGIs enabled or constrained this work. The following research questions guided this investigation:

1. What patterns exist in science teachers' access to the GCSCC, if any?
2. In what ways did science teachers use the resources and / or framework from the GCSCC, if at all?
3. In what ways did IGIs enable or constrain teachers' agency when using the GCSCC resources?

To answer these research questions, I conducted an explanatory sequential mixed methods study (Cresswell & Clark, 2017). This design incorporated both qualitative and quantitative data collection from a variety of sources across two phases of the study. The use of mixed methods was appropriate for the context of this study because of the kinds of research questions I am asking. Similar to other mixed methods designs that focus on teachers' use of resources (e.g. Sidel & Stylianides, 2018), one component of this study is to ask questions about which resources science teachers are using, to what degree they are implementing GCSCC resources in their work, and how they are interacting with the GCSCC. Each of these questions can best be answered through quantitative methods, analyzing the frequency of use of GCSCC resources in their practice and the metadata from the GCSCC Canvas course. Conversely, questions about the teachers' schemes of utilization with the GCSCC resources and the ways in which their selection and use of the resources interplays with their overall infrastructure can best be surfaced through qualitative data like interviews and artifact analysis.

In the first phase of this study, I collected and analyzed quantitative data from the GCSCC metadata, tracking which resources teachers were accessing, who was accessing those resources, and how often. I used these quantitative results to answer the first research question and create the sampling frame for the second phase of the study. I identified four schools in two communities in which to conduct follow-up interviews with teachers about what resources they ultimately chose to use (if any), how they used those resources, and what factors led to them making these decisions. I additionally collected district artifacts related to the GCSCC; lesson plans and materials that teachers used from the GCSCC; and school artifacts about instructional expectations and resources. These two phases of data collection and analysis enabled me not only to develop an overall picture of how science teachers across the district engaged with the

GCSCC, but also to develop descriptive profiles for individual teachers that highlight how various IGIs influenced teachers' idiosyncratic decision-making about their use of the GCSCC.

I begin this chapter with an overview of the context of the study and my positionality as both an insider and outsider in this context. This contextual analysis provides valuable background information that informed my analysis and interpretation of the findings. I then provide an overview of the data collection processes and analytical techniques I employed during the two phases of this study. All names in this study including the district, county, schools, and teachers are pseudonyms.

Position Statement

I believe that it is important for me to practice reflexivity and recognize my positionality as a scholar in this context (England, 1994; St. Louis & Calabrese Barton, 2002). As a science teacher at GCS, I stand at a unique junction of insider and outsider status. I have taught high school science in the district since the start of the 2019-2020 school year, spending several years prior to this position as a full-time scholar-in-training. I teach at an early college program attended by high school students from around the county, so I interact with a variety of students from all of GCS's communities. As a magnet school associated with the district, the early college is often exempt from rules that apply to other high schools in the district; as such, our IGIs can vary from those at other GCS schools. For example, the early college follows a different academic calendar from other schools, making us ineligible to participate in many of the professional development opportunities provided by the district. While I receive all of the district-level communications, am subject to many of the district policies, and teach students from across the county, my experiences as a teacher at the early college do not necessarily reflect the experiences of science teachers at traditional middle and high schools in the district. Indeed,

when I share with other teachers in the district that I teach at the early college, I am often positioned as an outsider (Banks, 2012), where my work is seen as having different supports and challenges than those experienced by other science teachers in the district.

Therefore, I am an insider in this community as a GCS teacher, and yet I am an outsider in that other secondary science teachers typically see my context and experience as significantly different than theirs. This insider-outsider status places me at a unique position in the context of this study in that I can, on some level, empathize with the teachers who serve as the subjects of the study. I live in the Grantham County community, participate in many district initiatives, and use the same technology resources (e.g. student iPads, digital resources) as other teachers. However, my status as an atypical teacher in the district enables me to approach the participants in this study with a degree of intellectual humility that stems from admitting that I do not walk in the same shoes as they do (Anderson-Levitt, 2012).

This insider-outsider status helped me surface findings that may not have otherwise come to light. My insider status gave me access to information like district-wide emails about the GCSCC, yet my outsider status enabled me to communicate that I need further elaboration on statements that a full insider may not require. In other words, I did not automatically assume that I know what teachers are talking about, and I was able to ask clarifying questions about things that some teachers took for granted. This ultimately provided greater insight into the ways in which teachers perceived and interacted with IGIs and how those IGIs shaped their documentational genesis.

While my status as both an insider and an outsider in the district can shape my perceptions of teachers' engagement in the GCSCC, I recognize that I also have some degree of power and bias in this context. I am a White, 35-year old male who married into a family with

deep ties in the community. I have a love for trying new pedagogies and have worked to align my practice with current science education reforms. I also have a significant amount of experience with various technologies and am working toward completing my PhD. These sources of power and bias can both shape the way that I interact with participants in this study and serve as lenses through which I interpret the qualitative and quantitative data that I collect. To help ensure that my representations of what participants share with me match the views of my participants, I used member checks (Merriam & Tisdell, 2016) with the participants in this study, ensuring that what I wrote accurately reflects their perceptions and experiences.

In the next section, I provide an analysis of the context of the GCS community and district as well as the development and implementation of the GCSCC. Here too, my status as an insider provided me with some background knowledge about these topics, yet I did not want to rely only on my own understanding of the district and GCSCC, as my perceptions may not always align with those of others who also experience this context. Therefore, the following analysis also incorporates the voices of several district leaders including the lead teacher who oversaw the development of the science GCSCC collections, Mr. Collins. The recruitment script and interview protocol I used with Mr. Collins are provided in Appendix A and Appendix B, respectively. I also interviewed a district-level beginning teachers coach, Mrs. Shore, as well as a district leader who oversaw the acquisition and use of science resources, Mrs. Koch. The recruitment script and interview protocol I used with these leaders are provided in Appendix C and Appendix D, respectively. I further sought to enhance the validity of this contextual analysis through the collection and analysis of district artifacts including emails, state-level data, and district and school websites. What follows is the product of this analysis, which informed my interpretation of the findings in this study.

Context: GCS and the Development of the GCSCC

Grantham County Schools

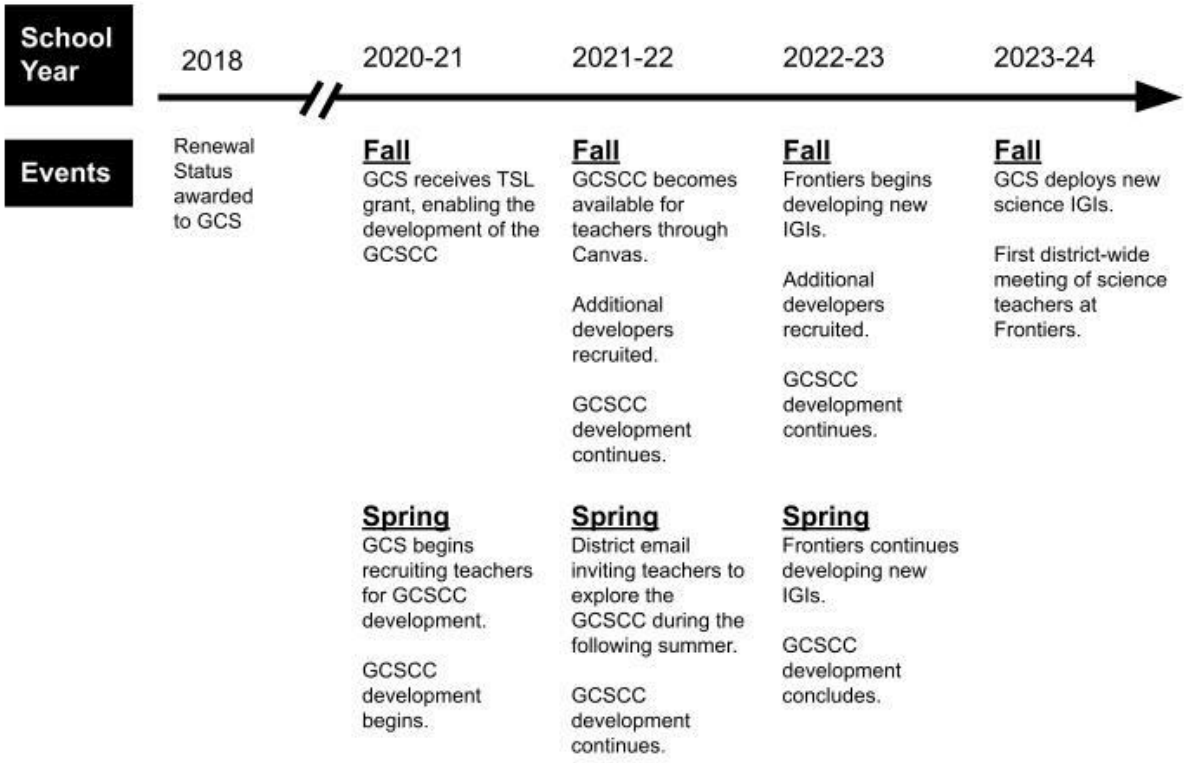
GCS is a relatively small school district in the Atlantic Coastal region of the United States. Serving nearly 19,000 students across 34 schools, the district serves a county nearly 75% of whose citizens are White with 25% of children living below the poverty line (National Center for Education Statistics, 2021). These statistics do not tell the whole story, however, as the landscape of the county varies from semi-urban to rural, resulting in schools within the GCS district that serve a diverse range of communities. The county lies on the outskirts of a large metropolitan area -- a fact that has recently driven growth and rapid evolution in the community as people move from the city to Grantham County seeking lower cost of living as they commute to the city for work. Yet only 20.6% of residents over the age of 25 have earned a Bachelor's degree or higher - a rate that is over 13 percentage points below the state average (United States Census Bureau, 2023).

As part of a pilot program with the state, the GCS district received special designation as a renewal district in 2018, providing the district with special exceptions to certain state mandates as an experiment to see how relaxing some restrictions might give the district more flexibility to make decisions to improve teaching and learning. Provisions of the renewal system that allow for local flexibility include decisions over curriculum, budgeting, scheduling, and the hiring of teachers who do not possess teaching licenses. This flexibility makes GCS a fertile ground for innovation and experimentation, resulting in many district initiatives like annual professional development days in which select teachers share innovations with the rest of the district and a district-wide teacher leader team that helps drive some of the decisions at the district level.

This renewal designation played an influential role in creating the culture and infrastructure of the district by fostering innovation through relaxed restrictions. While designing the changes that drove the renewal system, the then-superintendent focused on providing teachers with maximum agency, adopting a mentality of *getting out of the way and letting teachers teach*. Each school created a teacher-led design team in which teachers analyze data and drive decision making in their school. The district implemented a three-point priority system focused on helping students develop academic skills, interpersonal skills, and unique life goals. Many of the school and district decisions that followed aligned with this framework. In the context of this study, many of the school and district IGIs were designed to provide teachers with agency and autonomy by promoting teacher agency and leadership including flexibility over the resources that teachers chose to use. In alignment with this mission, the district launched an initiative to create a set of resources developed by GCS teachers for use by other GCS teachers, resulting in the creation of the GCSCC.

In the next section, I provide an overview of the development and implementation timeline of the GCSCC. I then provide an overview of how GCS collaborated with Frontiers -- an informal science institution in the community -- to develop and launch a new set of science-specific IGIs for GCS science teachers that were launched in the Fall of 2023, shortly after the conclusion of GCSCC development. As I will illustrate, understanding the development processes and launches of both the GCSCC and the new science IGIs proved invaluable for interpreting the findings of this study. A summary of the GCSCC and IGI development timeline is provided in Figure 5.

Figure 5. Timeline of the Development and Implementation of the GCSCC



The Development and Launch of the GCSCC

While not specifically designed for science teachers, the GCSCC became one element of the infrastructure intended to support instruction throughout the district. The GCSCC was one part of a larger grant written by an assistant superintendent focused on promoting teacher leadership in the district. When the district received the grant in Fall of 2020, the grant's author left GCS for a position in another district. GCS restructured her former position rather than refilling it, so the work of fulfilling the grant fell onto district leaders who did not author it. After some shuffling of roles, three district leaders who oversaw curriculum throughout the district took on the resource development component. According to Mr. Collins,

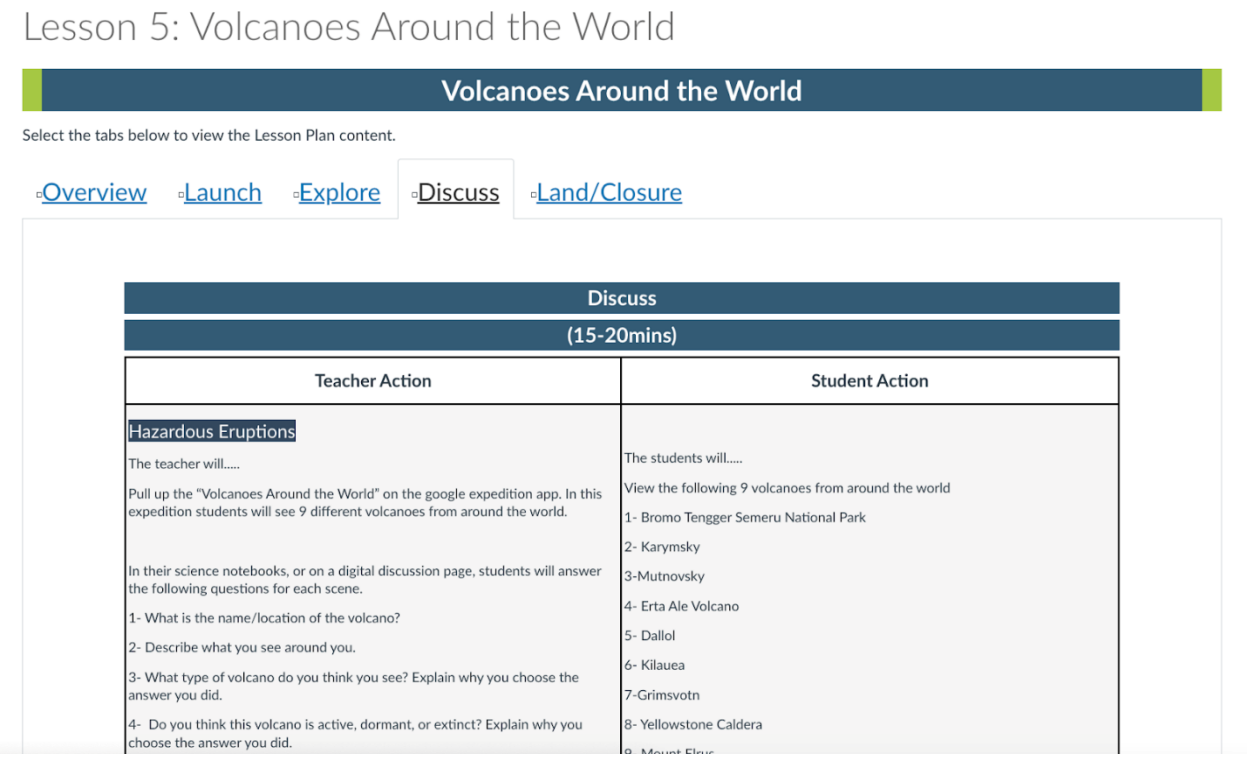
> Their idea was that they were going to create teacher-curated lessons for every grade K through 12 every course, and hopefully over the course of three years, complete every course and then put all of that into Canvas for teachers. So if you were a new teacher to our district, that we would have district-curated stuff K-12 for everything.

In February of 2021, the GCS leaders overseeing the grant sent a district-wide email inviting teachers to apply to develop lessons in all subject areas for what would become the GCSCC. Teachers would receive a stipend for each module they created with the stipulations that they complete all work outside of regular working hours and produce original content. These initial contracts lasted one semester, but subsequent contracts would last throughout the school year. Additionally, the district-wide email sought to recruit lead teachers to "ensure the quality of content and vertical alignment of modules created by lesson developers". District leaders also sent emails inviting teachers to apply to be lesson developers and lead teachers in September of 2021 and October of 2022.

Through the work of lesson developers and lead teachers, the GCSCC became embodied as a set of Canvas courses -- one for each grade level and core subject taught in the district. These courses contained a module for each standard taught in the course or grade level with complete lesson plans created by the teachers who served as developers. Lessons for all subject areas used the same lesson planning framework representing the district-envisioned flow of a lesson: Launch, Explore, Discuss, and Land. Each phase of the lesson was divided into two columns representing Teacher Actions and Student Actions. The lesson plan templates additionally contained the state standards addressed; the learning objectives; alignment with Digital Learning Competencies developed by ISTE (https://iste.org/standards/students); a list of vocabulary terms categorized into three tiers; anticipated obstacles, misconceptions, and gaps;

and additional considerations for English Learners, Exceptional Children, and Academically and Intellectually Gifted students. A screenshot showing part of the layout of one of these lessons is shown in Figure 6.

Figure 6. A Screenshot Showing the Organization of the GCSCC



As the lead teacher overseeing the development of the middle school and high school science resources, Mr. Collins asked his lesson developers to begin with their strongest unit and create one lesson using the designated lesson plan template. He would then review that lesson with the developers, identifying strengths and areas that needed improvement, then move on to the next lesson. "Pretty much after about the third lesson, you know, it was pretty intuitive at that point." However, Mr. Collins also noted that some developers struggled with the originality requirement of lesson development:

> A lot of times, I would catch teachers cutting and pasting from different curricula. Which is [...] you know, it's just an ethical issue. You're getting paid to write lessons. [...] And I'd be like, by the way, they paid those people good money to write that curriculum. We're paying you good money to write. And then, a lot of times, the teachers would drop out at that point because they had realized that every lesson they ever did was Googled.

Combined with the shortage of highly qualified science teachers across the district, this struggle to meet the originality requirements for lesson development led to a shortage in developers for the GCSCC science collections. As a result, only four of the anticipated seven middle and high school science collections were made available to teachers: 6th grade science, 8th grade science, Biology, and Earth and Environmental Science (EES). At the time of the conclusion of the grant funding this work, these four courses had attained varying levels of completion, and none of the four courses contained a complete set of resources covering every learning objective listed in the corresponding state standards documents. Each of the four implemented science collections also contains navigational challenges such as broken links and pages with placeholder text. As of the time of this writing, no formal district plans currently exist to modify or add to the GCSCC.

The GCSCC launched fairly quietly; a link to access the GCSCC Canvas courses appeared in the sidebar of the district Canvas page in August of 2021, containing only those initial resources developed the previous spring. No district-wide email was sent to announce this launch, and only 20 teachers enrolled in a GCSCC science Canvas course that Fall. To promote the GCSCC, district leaders sent an email in April of 2022 inviting all GCS teachers and support staff to explore its resources during an asynchronous summer exploration period. According to the email, this experience was open to “K-5 & 6-12 ELA, Math, Sci, and SS teachers and all who support them. (principal, AP, EC, AIG, EL, MTSS, Instructional Coaches, etc)”. The district

used grant funding to provide a stipend to participants who signed up for this exploration period. In June, teachers received a second email announcing a second window to participate in the summer resource exploration. No further district-wide emails followed these announcements, although the district continued to promote the GCSCC during district meetings and through instructional coaches. Development of the GCSCC concluded at the expiration of the TSL grant funding in July 2023.

Science Instruction at GCS

In parallel with the development and launch of the GCSCC, leaders at GCS began to restructure the system of support for GCS science teachers in response to perceived needs across the district. For example, fueled in part by the COVID-19 pandemic and its aftermath, many experienced teachers began leaving the district. Due to shortages of highly-qualified teaching applicants, many schools filled their science positions with unlicensed teachers or teachers with no science teaching experience. Coupled with a district program for supporting beginning teachers that one district leader described as "skeletal", the science departments at many GCS schools quickly filled with inexperienced, unlicensed teachers receiving minimal district support and oversight. While this set of circumstances can be problematic in any district, GCS experienced compounding issues due the renewal system's dependence on teacher leadership. With the number of highly-skilled and experienced science teachers shrinking, many of the district's initiatives like the teacher-led design teams and the development of the GCSCC encountered unforeseen barriers.

Other district-level organizational challenges became apparent during this time. For example, one district leader described issues with communication in this way:

> [Information] has to go through the principals. [...] They are the ones that disseminate the information. So it goes through the school team. It goes through C&I. It goes through all these different teams, and there's like a huge communication breakdown. And then, by the time you talk to the teachers, they're not getting the information.

Further compounding these issues, GCS faced frequent turnover in key district leadership positions; for example, GCS had three different superintendents from 2020-2022. As one district leader described, this became problematic as each change in leadership resulted in other organizational changes:

> Every time a new superintendent starts, they restructure the cabinet, restructure the positions. The organizational flow changes. I found it really difficult in this position to even know who to contact for anything. There is not a flow chart. There are no listservs. There's not a science teacher list. There's no list of all the science teachers anywhere.

While these issues applied to all subject areas, much of the district's energy during this time focused on math and English. Prior to the 2022-23 school year, no formal district position that focused solely on science instruction existed. Other barriers impeded science teaching including large class sizes, small science departments, minimal science courses included in graduation requirements, generally low expectations for science teachers, and a lack of systematic investment in science professional development.

In addition to the organizational challenges facing science instruction, understanding science teaching at GCS during this time also requires an understanding of the district's approach to acquiring instructional resources. Generally speaking, GCS heavily invested into technology infrastructure, providing every student in the district with an iPad. This focus on technology proved invaluable during the COVID-19 pandemic; all students already had a device when the

pandemic began, and GCS had the means to ensure that all students could connect to the internet at home by providing hotspots. However, the district's emphasis on developing technology infrastructure came at the cost of investment into discipline-specific support including both instructional materials and professional learning opportunities. When asked about how they might address some of the issues facing science instruction at GCS, one district leader said:

> I would shift away from 100% funding technology, and I would shift towards 100% investing in people teaching the content they're paid to teach. So pay teachers to go to high quality instructional training, pay teachers, pay them to get the subs in their classes to watch each other teach. [...] Cut that tech budget in half and take that money and invest it in our teachers.

Another leader echoed this sentiment: "I think until the county says this is an expectation as a teacher, your instructional plans need to include these criteria, we're always going to kind of struggle." As I illustrate in Chapter 4, this district-wide investment into technology became apparent in how teachers engaged with the GCSCC.

The consequences for the lack of science instructional support appear in the state testing data. According to publicly-available data posted on the state website, 23 of the 32 schools were labeled as "Low Performing" during the 2022-23 school year; in science specifically, 52% of GCS students were labeled "Not Proficient" based on state testing data compared to the statewide average of 32% "Not Proficient". While the efficacy of these tests for measuring students' mastery of science could be debated, these tests represent IGIs that hold substantial power for shaping decision making at the district, school, and classroom levels, as I'll show in Chapter 4. In the words of one district leader:

> You know GCS test scores are a dumpster fire. [..] It doesn't mean, no, the kids aren't dumb. No, teachers aren't bad. That's not the story it's telling. [...] It's telling the story that our instruction is not giving kids higher understanding. [...] I mean, I've heard all the excuses, but you can't tell me that [...] magically when you cross [the county line], those kids got 20% stupider.

Recognizing the need for additional support for science instruction, GCS began partnering with Frontiers (a pseudonym) starting in the 2022-23 school year. As an informal science institution, Frontiers serves the Grantham County community through activities like science summer camps for children, field trips for schools, and planetarium shows. Several of the employees at Frontiers were recruited to help the district, each focusing on a different role such as providing teachers with instructional support, developing new instructional support tools, and making recommendations for acquiring new resources specifically for science teachers. As part of this work, several members of the Frontiers team developed a set of IGIs focused on supporting science instruction such as an instructional framework based on the 5E model; common formative assessments for all science courses with a state test; a new district website with resources for guiding science instruction; monthly, science-specific professional development hosted by Frontiers for all science teachers in the district; and the acquisition of new science-specific instructional resources such as Kesler Science (https://keslerscience.com/), Gizmos simulators (https://gizmos.explorelearning.com/), and CIBL kits (https://ciblearning.org/our-science-kits/). Frontiers staff organized these resources into standards-aligned pacing guides which they distributed to teachers for feedback prior to implementation at the start of the 2023-24 school year.

While Mr. Collins both worked at Frontiers and oversaw the development of the science GCSCC collections, the development and launch of the new IGIs was managed by other Frontiers staff and was therefore conducted independently of the development of the GCSCC. As I will show in Chapter 4, the implementation of these resources represented a turning point not only for the support for science instruction at GCS, but also for the role that the GCSCC played in science teachers' documentational genesis. To quote one district leader:

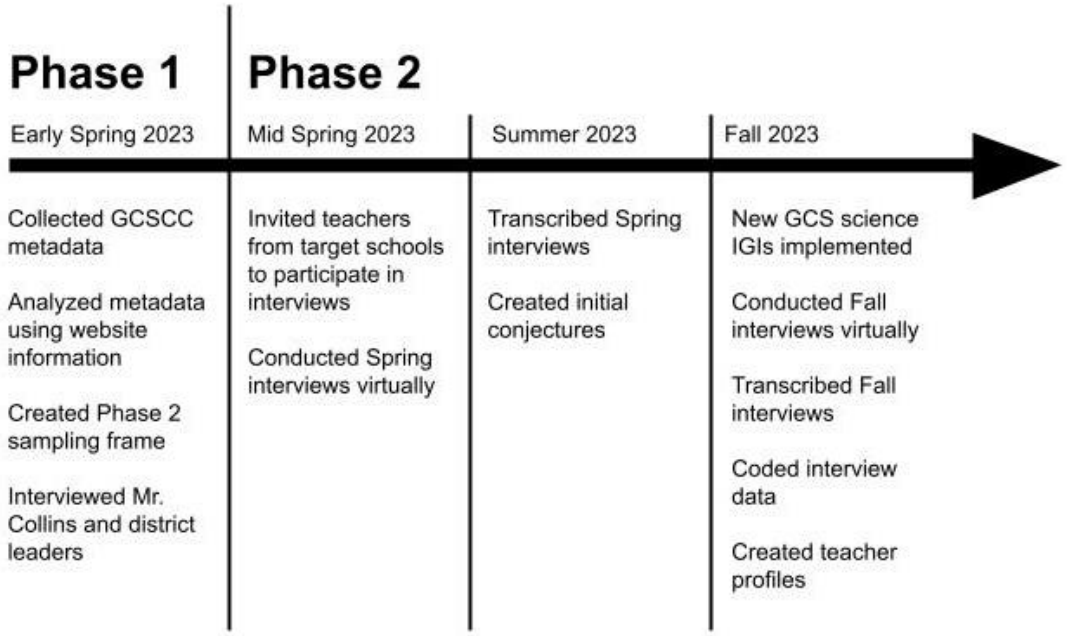
> The steps are being taken in science education. That's the cool part, that this is a dawn of a new age in science education. [...] There was never a district level science position. There was never any concerted effort to really focus on science instruction. It makes me in this last bit of my career be like, a little hopeful.

Data Collection and Analysis

As I will illustrate in Chapter 4, the analysis of the context, development, and launch of the GCSCC is vital to understanding the analysis and interpretation of the data from this study. This narrative also illustrates the significance of the two phases of this study. In Phase 1 of this study, I analyzed the metadata from the GCSCC access logs to explore access patterns among teachers. These findings both answered research question 1 and served as the foundation for the sampling frame I used in Phase 2 in which I interviewed teachers from four target schools in two communities to discover how they used the GCSCC resources, if at all, and how IGIs influenced those decisions. These interviews occurred at two timepoints: first, during the Spring 2023 semester and second, after the rollout of the new district science IGIs the following Fall. A diagram demonstrating the data collection and analysis is presented in Figure 7. In the remainder of this chapter, I provide a more in-depth summary of the data collection and analysis practices

employed in each phase of this study as well as a summary of strategies used to lend greater reliability and validity to the findings.

Figure 7. An Overview of the Data Collection and Analysis Phases of This Study



Phase 1 Data Collection

To answer the first research question and create my sampling frame for the second phase of this study, Phase 1 consisted of an analysis of the GCSCC Canvas metadata. The Canvas platform tracks metadata related to teachers' browsing of the courses including time spent in the course, most recent visit, number of logins, and the number of times each resource was accessed. The GCSCC collections were organized into a set of Canvas courses with one collection for each subject taught in K-12 schools in the district. For the purposes of this study, I focused my analysis on science collections aligned with courses taught in middle and high schools because there were no dedicated science collections at the K-5 level. Among the science subjects taught at these levels, only four GCSCC collections were available for teachers at the

time of the study: 6th grade science, 8th grade science, Biology, and Earth and Environmental Science.

In each of these four GCSCC courses, I used Canvas's New Analytics feature to gather data related to teachers' logins to the course beginning with the launch of the GCSCC in the Fall semester of 2021 and running through the time of the analysis in February of 2023. I compiled the data into an Excel spreadsheet organized into rows by teacher and columns by the week of login with each cell representing how many pages the teacher viewed in a given week. Page views measure the number of times a teacher loaded a web page in a given GCSCC collection that a teacher loaded in a given week. In alignment with the DAD logic model I presented in Chapter 2, I conceptualized these page views as a proxy for teachers' search activities. More page views suggests that the teacher clicked on more links and browsed more resources, and fewer page views suggests that teachers visited fewer pages in the collection and accessed fewer resources. In other words, the more pages a teacher viewed, the more they searched through the GCSCC resources. I therefore selected page views as a metric to represent engagement with the GCSCC. However, the other activities that occurred during this search like *interpret, evaluate,* and *adapt* could only be elicited through the individual teacher interviews during Phase 2 of the study. In addition to enabling me to answer the first research question, I used these data to form a set of initial conjectures about the kinds of IGIs that influenced teachers' search of the GCSCC, resulting in the creation of a sampling frame that I used to identify four target schools for further analysis in Phase 2.

Phase 1 Data Analysis

Using the metadata I collected from the GCSCC page views for each course, I conducted several different descriptive analyses based on the overall data and two different methods for

disaggregating the data. First, I conducted an analysis of trends in the overall access patterns, looking particularly at whether teachers' first logins corresponded with any patterns as well as whether teachers generally used the collections repeatedly over time or simply checked out the resources once or twice. Analyzing these data at the whole district level helped me construct a general picture of district patterns, which answered research question 1 and provided me with conjectures that I tested in Phase 2 of the study. After these initial aggregate analyses, I then disaggregated the data into the four collections, looking for trends in use of the different collections. Lastly, I used school website data to identify which school each teacher worked at, then grouped the overall login patterns irrespective of course into groupings based on the school at which each teacher worked. In the following paragraphs, I provide more detail and justification for these analytical strategies.

The initial analysis revealed a total of 113 enrollments across all four courses of the GCSCC. Accounting for the fact that some individuals enrolled in more than one GCSCC course, I found a total of 77 unique users. For each of these users, I searched school and district websites to determine the school at which each teacher worked and the subject that the teacher taught. As I documented the schools and roles of each participant in the GCSCC, I also noticed that many of the users accessing the GCSCC served non-teacher roles in schools including administrators, instructional coaches, and media specialists. While this finding could provide some valuable insight into the roles that administrators and instructional support staff play in promoting the GCSCC among teachers, such an analysis is beyond the scope of this study. This study focuses on the documentational genesis of teachers, so I separated the teacher access information from those of non-teachers; I used only those users whom I could identify as

teachers in the subsequent analysis. After making these adjustments, 68 enrollments across 55 unique users remained. These enrollments served as the foundation for my subsequent analysis.

Throughout my analysis of this GCSCC metadata, I chose to rely primarily on descriptive statistics rather than performing inferential statistical testing. I made this decision for two reasons. First, concerns about power arose due to the number of analyses that would result from two different disaggregations of the data (Howell, 2012). Phase 1 of this study focused on identifying the kinds of IGIs that may have influenced teachers' documentation using the GCSCC, thereby necessitating several different kinds of analysis. While a multivariate test may have revealed differences among subjects and schools as well as interactions between those, the sample size of teachers in this study was too small to provide enough power for such a test (Rencher, 2012). For example, at some schools, only one teacher accessed any collection. Conversely, a series of tests may have revealed differences among courses and schools, yet as the number of analyses rises, the likelihood of a Type 1 error increases (Howell, 2012). Furthermore, as I describe in Chapter 4, some of the four science collections had considerably more pages than others and would naturally have different numbers of page views simply because there are more pages to view. In other words, the relative completion of each course would serve as a confounding variable limiting the validity of the findings. Therefore, the use of inferential testing in this context would have presented a considerable likelihood of statistical error.

Second, this study focused entirely on the impact that the GCSCC had on teachers' documentational genesis in this place during this time period. Inferential testing is primarily used to determine whether a sample that is drawn from a larger population likely represents trends in the overall population (Howell, 2012). The use of such testing in this study might

indicate whether science teachers' search patterns with the GCSCC or a similar set of resources could transfer to other contexts. Such a generalization, however, is beyond the scope of the claims I make in this study. This set of resources was developed in a specific way by a specific group of individuals using a specific guiding framework for a specific group of users. At the time of this writing, no plan currently exists to open the GCSCC to users outside of the GCS district. As such, the GCSCC Canvas metadata provides the entire dataset of the population of interest in this study (teachers who searched the GCSCC science collections), and I make no claims as to the generalizability of the findings from the analysis of these data. Rather, this study focuses on eliciting the ways that IGIs influenced the documentational genesis of teachers working with these resources. Given the vast number of IGIs with which science teachers interact, it is unlikely that any other school or district would have exactly the same set of IGIs as those found in this study. Therefore, descriptive statistics provided sufficient insight to make conjectures about the ways that IGIs influenced teachers' documentational genesis that served as the foundation for sampling and data collection in Phase 2 of this study. Such analyses are consistent with those of similar studies (e.g. Shelton & Archimbault, 2019).

In the initial round of analysis, I used Excel to tabulate the total number of page views and the number of teachers accessing the GCSCC each week. I also tabulated the total number of page views and total number of teachers each semester including summer 2022. I compared these numbers to the overall average number of page views per week, allowing me to look for spikes or lulls in teachers' access of the GCSCC. I postulated that areas of sudden, exceptionally high activity may be in response to an event like a district email or professional development sessions whereas periods of lower engagement may have represented times in which teachers were not searching for resources like toward the end of a grading period. I particularly wanted to

see if the paid district incentive for teachers to explore the resources during Summer 2022 resulted in a surge of usage rates and first logins. A surge at this time would suggest that district action had a direct impact on the exploration and potential use of the GCSCC by teachers. I additionally compared the number of times each teacher accessed the collections; I postulated that if a teacher accessed the GCSCC only once or twice, then they likely implemented fewer resources than those who accessed the collections more frequently. As I will detail in Chapter 4, the results of this analysis informed my sampling frame for Phase 2 of the study.

After analyzing the overall data, I organized the spreadsheet in a way that separated the four GCSCC courses from each other. I repeated my analysis of page views over time, noting differences across courses. Differences in teachers' search of the courses may suggest the presence or absence of an IGI promoting or inhibiting the use of the GCSCC in these subject areas. For example, a Biology teacher may find more value in the GCSCC than an Earth and Environmental Science teacher due to Biology's state standardized testing requirement (Waight et al., 2014). However, during this analysis, I realized that each of the four courses had different numbers of pages, which may naturally create differences among their page views simply because some collections had more pages to view. Using the results of this analysis, I developed a set of conjectures that guided some of my questioning during the Phase 2 teacher interviews and artifact analysis.

Similar to my analysis of the four subject areas, I grouped the teacher page view data by school, again looking for differences in usage trends. If one school had more teachers accessing the GCSCC and with more page views than another school, then some difference in the IGIs between these schools may have facilitated these differences such as differences in building-level instructional expectations set by principals (Miller-Rushing & Hufnagel, 2022). In addition to

differences across individual schools, I attended to two relationships in particular. First, I wanted to know whether a difference existed between middle school and high school usage rates. A difference among high schools and middle schools may suggest that some difference about the organization of these schools may enable or constrain teachers' use of the GCSCC. For example, the middle school science curriculum in the state in which this study was conducted integrates several science disciplines in each grade level course, whereas the high school curriculum separates subjects into separate courses (e.g. Biology, EES, etc). Differences in curriculum organization may have led to differences in the organization of science departments, potentially resulting in differences in teachers' documentational genesis between middle schools and high schools. Second, I used information from the GCS district website to group the schools by community, linking each high school to its feeder middle school(s). If, for example, two schools in a community showed exceptionally high or low usage rates of the GCSCC, then some feature of the community may have resulted in this difference. As I described in my profile of GCS, the district serves a variety of communities ranging from semi-urban to rural farming communities. Due to the way that local taxes help determine school funding, I speculated that a difference in school and / or community resource access may exist across communities in the county. I summarize these findings in Chapter 4.

Using these findings from my analysis of the GCSCC, I identified four schools in two communities that would serve as the basis for my analysis in Phase 2 of this study. First, I selected Fremont Middle School (FMS) and Fremont High School (FHS) (both pseudonyms) because these two schools were in the same community and had an exceptionally high number of teachers regularly accessing the GCSCC over time. I postulated that due to the large number of regular users of the GCSCC at these schools, I would find one or more IGIs localized to these

schools that promoted the use of the GCSCC. As a contrast, I selected Bridgman Middle School (BMS) and Bridgman High School (BHS) due to the large number of teachers who accessed the GCSCC once or twice, but did not return. I chose these schools to represent low-engagement schools rather than schools that had few teachers accessing the GCSCC at all because the 1-2 logins for each teacher at these schools suggests that they at least have some familiarity with the GCSCC and chose not to revisit it regularly. I postulated that these schools may have one or more IGIs that conflict with the use of the GCSCC or may be missing one or more IGIs that may be present in FMS and FHS. In the next section, I describe how I recruited and interviewed teachers from these schools during Phase 2 of the study.

Phase 2 Data Collection

I began Phase 2 of the study by contacting teachers at each of the four target schools identified in Phase 1. I invited the teachers to participate in the study using the email addresses attached to their GCSCC Canvas accounts. I included all science teachers at each school who had accessed the GCSCC according to the reports generated by New Analytics regardless of the frequency with which they accessed the courses. Due to the focus of this study on teachers' use of the GCSCC for documentational genesis, I did not invite teachers who had not accessed the GCSCC according to the metadata logs. The recruitment scripts I used in this process are provided in Appendix E. Six teachers agreed to participate in a compensated interview via Zoom and, later, Microsoft Teams due to changes in institutional policy regarding video conferencing services. The six teachers are represented in Table 2. In the interest of disclosure, I will mention here that one teacher, Mr. Martinez, was my former student teacher during the Fall semester of 2021. My past relationship with Mr. Martinez as an authority figure may have influenced my interpretation of his interview. To address this threat to validity, I used frequent member

checking, and as I will discuss in a later section, Dr. Porter and I adjudicated our coding of his spring interview as part of our reliability check.

Table 2. Overview of The Six Phase 2 Teacher Participants

Teacher	School	Subject Taught
Mrs. Meyer	BMS	8th Grade
Mrs. Mason	BMS	8th Grade
Mr. Martinez	BHS	Biology
Mrs. Hughes	FMS	6th Grade[a]
Mrs. Cook	FHS	Chemistry[b]
Mrs. Branson	FHS	Biology

[a]Mrs. Hughes is a Math teacher who taught 6th grade science on semester to cover for a school vacancy.

[b]Mrs. Cook primarily teaches Chemistry, but had accessed the Earth and Environmental GCSCC course.

Each teacher participated in a one-hour semi-structured interview (Merriam & Tisdell, 2016) in which I asked about their instructional context, their experiences using the GCSCC, resources from the GCSCC they implemented in their instruction (if any), any adaptations that they made to those resources, reflections on their experiences implementing those resources, and the reasons for the decisions they made regarding their use of the GCSCC. The purpose of these interviews was to gain insight into teachers' experiences using the GCSCC for documentation and to uncover any IGIs that shaped this practice. I also used these interviews as an opportunity to test the conjectures I made during Phase 1 of the interviews, specifically looking for possible

differences in IGIs across schools and subject areas that could explain the variations in the Canvas metadata. The interview protocol for these interviews is provided in Appendix F.

Interviews were recorded in Zoom and Microsoft Teams and were transcribed using the auto-transcription software from these services. I later revisited these transcriptions to check for accuracy. Due to the demands of my own classroom teaching responsibilities, I could not directly observe their classroom instruction, presenting a limitation to this study. To address this limitation, I used artifacts like teachers' unit plans, lesson plans, and instructional materials to triangulate the narratives provided by teachers (Tracy & Hinrichs, 2017), although not all teachers shared these artifacts with me; specifically, Mrs. Cook and Mrs. Hughes provided robust depictions of their lessons but did not respond to email requests for lesson materials. In some cases, I was able to use the artifacts during the interviews to elicit teachers' decision making and rationales while adapting and implementing the resources. The use of lesson artifacts in this way is consistent with the DAD methodology of reflective investigation (Gueudet & Trouche, 2011; Pepin et. al, 2013) in which researchers use artifacts like lesson plans and instructional materials to serve as anchoring points for interviews. In this way, lesson plans and instructional materials served as mediating artifacts for discussion in this study and eliciting teachers' thinking and decision making processes. In addition to the teaching artifacts, I used artifacts on the school and district webpages to further triangulate the narratives provided by teachers, focusing specifically on IGIs that may be present. After constructing cases of GCSCC use as part of the data analysis, I checked the validity of these narratives through member checking, asking teachers to review summaries of the narratives I had created for accuracy (Merriam & Tisdell, 2016).

In the initial design of this study, I proposed the use of documentation tables (Gruson et. al, 2018) as a tool asking for teachers to track their use of GCSCC materials over the course of the fourth quarter of the school year. I planned to use these tables as part of a follow-up interview at the end of the school year as another mediating artifact to elicit the impact of the GCSCC on teachers' practice. However, as I discuss in Chapter 4, the first round of interviews revealed that teachers implemented far fewer GCSCC resources into their teaching than I had anticipated. Additionally, I learned of a number of planned district-level changes for IGIs to support science instruction coming for the Fall. Based on these findings, I decided to conduct a follow-up interview with these teachers at the end of the first quarter of the following school year instead of the planned documentation table interview at the end of the school year. During these Fall 2023 semi-structured interviews, I asked teachers about the changes in their IGIs and how their use of the GCSCC changed as a result of these changed IGIs, if at all. The interview protocol for these interviews is provided in Appendix G. Two of the teachers listed in Table 2 did not participate in these interviews: Mrs. Mason left the district the previous summer, and Mrs. Hughes had not taught a science class since the previous Fall. The remaining four teachers who participated in the initial interviews agreed to participate in this second interview. The protocol for these interviews is provided in Appendix G. In addition to these interviews, I revisited the GCSCC metadata for that Fall to add validity to the narratives portrayed by the teachers during the Fall interview. In the next section, I provide an overview of how I analyzed the data collected during Phase 2 of the study.

Phase 2 Data Analysis

I began analyzing the Phase 2 data by using the audio recordings to check the automatically-generated interview transcripts for accuracy, creating an initial set of research

memos based on the trends I began noticing. Using the DAD and IGI frameworks, I created a codebook to analyze the videos that would help address research questions 2 and 3. To address research question 2, I used codes derived from the logic model of documentational genesis that I presented in Chapter 2. Specifically, I looked for any mention of the teachers' engagement with the GCSCC including *prompt, search, interpretation, evaluation, adaptation, preparation, implementation,* and *reflection*. To address research question 3, I looked for any mention of the IGIs described by the teachers using the five categories identified by Hopkins and Spillane (2015) as a guide: *instructional framework, instructional materials, student assessments, instructional oversight,* and *teacher professional learning.* These two sets of codes allowed me to identify specific ways in which teachers used the GCSCC as well as the IGIs that influenced their decision making. Initially, I had also included a code for *external resources*, attempting to differentiate between those resources that were part of the school and district infrastructure (*instructional materials*) and those personal resources (*external resources*) that teachers use as illustrated in Figure 4 of Chapter 2. However, during adjudication while checking the reliability of the codes with Dr. Porter, we determined that the differences between *instructional materials* and *external resources* codes were too difficult for someone without insider knowledge of the district to determine, so we collapsed those two codes into *instructional materials*, which encompassed all resources teachers used including those from the GCSCC.

To complete this coding and reliability check process, I imported all of the interview transcripts into separate Excel sheets with each row representing a line of the transcript. I then created a separate column for each code, marking each line of the transcript with a 1 in the respective columns for each code that was present in that line of text. Interrater reliability was achieved when Dr. Porter and I independently coded the same interview, then tallied

discrepancies where one of us used a code for a line of teacher text when the other didn't. This analysis resulted in a 98.63% agreement across codes. We adjudicated the differences between our codes for this interview and determined that an additional code was required: *school culture / community*, referring to the role that other people played in the teachers' context. While interactions with peers do not fit neatly into one of the five IGI categories, this coded data revealed the significance that these interactions played when shaping the teachers' documentational genesis. While this code ultimately provided a more holistic view of these teachers' documentational genesis processes during subsequent analysis, the findings from these codes often overlapped with other codes including *prompt* and *share*. Further analysis of the results from this code could provide deeper insight into the documentational genesis of these teachers, yet such analysis is beyond the scope of this paper, which focuses on how IGIs influenced this work. After adjudication, I coded the rest of the spring and fall interviews independently.

Using these codes, I created a case profile (Yin, 2018) for each teacher. Using the coded interviews, I constructed profiles presenting each teachers' background and instructional context; engagement with an use of the GCSCC at the time of the spring 2023 interview; the IGIs they identified as influencing these decisions; and, for those teachers who participated in the Fall 2023 interview, the changes in both their IGIs and their use of the GCSCC that fall. Additionally, I used teacher artifacts including lesson plans and materials as a form of triangulation to ensure that the profiles I created were consistent with the artifacts. I then compared across these case narratives, searching for areas of convergence and divergence in the ways in which they used the GCSCC during documentational genesis and the IGIs that influenced that work.

Initially, I organized these cases around the communities I identified during Phase 1 of this study, testing the conjecture that some difference in IGIs across these schools contributed to the differences in GCSCC access that I found in the metadata. However, comparing across cases, I realized that there was more variation within communities than across communities, and those variations consistently demonstrated differences in how beginning teachers' documentational genesis with the GCSCC differed from those of their more experienced counterparts. This evidence signaled that the difference in IGIs was not community based, but rather based on differences in IGIs between beginning and experienced teachers. Therefore, to answer research question 2, I organized information about the teachers' use of the GCSCC into two categories: beginning teachers in the first three years of their career or in their first three years teaching their subject area and experienced teachers who have taught their subject for more than three years. The decision to use three years as the marker of an experienced teacher aligns with state licensure status; in the state in which this study was conducted, teachers' licensure changes from a provisional to a professional license after three years of teaching experience.

Additionally, my use of the term *beginning teacher* goes beyond the typical definition of teachers who are beginning their careers to also include those teachers who have teaching experience, but are new to the content area they currently teach. In other words, my use of the term *beginning teachers* reflects teachers who are beginning their documentational trajectory in a subject area, whether that means at the start of their careers or at the start of teaching a new subject. This inclusion is consistent with the literature on documentational trajectory (Rocha, 2018) which posits that, as teachers gain experience with using resources through documentation, they learn through instrumentation, resulting in the evolution of their documentational processes (Remillard, 2005; Trouche, 2004). My use of the term in this way

also stemmed from my findings from Mrs. Branson's documentational genesis; although she had taught science for five years, her Spring 2023 interview occurred in her second year of teaching high school Biology, and her documentational genesis aligned more with that of the beginning teachers than the experienced teachers. While my use of the term *beginning teacher* in this way may add confusion for the reader who may be accustomed to the traditional use of the term to denote only career status, I found no better alternative terms in the literature that did not frame teachers in a deficit-based way (e.g. *inexperienced teachers*) while maintaining a focus on documentational trajectory rather than career status (e.g. *novice teachers*). Keeping with the use of terms that highlight teachers' documentational trajectory, I use the term *experienced teachers* to refer to teachers who have more documentational experience in their current content areas.

To address research question 3, I organized the teachers' narratives around the five categories of IGIs to identify both IGIs that shaped the work of multiple teachers and those that influenced only one or two teachers both by enabling and constraining their agency to use the GCSCC in their documentational genesis. These findings are documented in Chapter 4.

Considerations for Validity and Reliability in Phases 1 and 2

As I have outlined throughout this chapter, I took several measures to ensure the validity of my findings in both phases of this study. In this section, I summarize these steps using the three kinds of validity identified by Yin (2018): construct validity, internal validity, and external validity. To provide construct validity to my data collection and analysis practices, I anchored each decision I made in the design of this study in both theoretical and methodological literature, using examples to justify each decision and frequently checking my methods with Dr. Porter. The codebook I used to analyze the teacher interviews stemmed directly from the frameworks that served as the foundation of this study. I also collected multiple forms of

evidence to answer each research question including quantitative data, artifact analysis, and interviews both with teachers and with district leaders. While I could not observe classroom instruction due to limitations in my schedule as a teacher, I used teaching artifacts to ensure my characterizations of the GCSCC and district infrastructure were consistent with those of the participants in this study. Collecting multiple forms of data in this way enabled me to ensure that my findings were consistent with the literature on the constructs I studied.

Throughout my analysis of the data I collected, I developed the internal validity of this study to demonstrate the cause-and-effect relationship between IGIs and teachers' documentation. Throughout my analysis, I considered several different conjectures about the nature of teachers' work with IGIs and the GCSCC, which are represented in Chapter 4. Conducting this study in two phases allowed me to test the competing explanations from Phase 1 by asking teachers about tentative conjectures during the Phase 2 interviews. Most of the claims I make in Chapter 4 about teachers' use of the GCSCC and the IGIs that shaped those decisions were discussed in both the spring and fall interviews; the consistency of teachers' claims during the fall interviews with those they discussed in the spring interviews adds to the validity of the findings. I also employed frequent member checks with both teachers and district leaders to ensure that any causal claims I made in my analysis of both the quantitative and qualitative data were consistent with the perceptions of the teachers I interviewed. Additionally, as teachers identified influential district leaders during interviews, I was able to conduct some interviews with some of these leaders to verify that teachers' perceptions of IGIs were consistent with those of these leaders, further increasing the validity of the study's claims.

As an illustration of how I analyzed various forms of data to ensure the validity of the findings, I used the GCSCC metadata to test teachers' claims about district communication and

the teachers' use of the GCSCC during the Fall 2023 semester. Teachers reported hearing about the GCSCC at a district-wide meeting of science teachers at Frontiers, yet all of the teachers I interviewed reported using the GCSCC very little that fall, if at all. The GCSCC metadata for that Fall showed that, after an initial spike of new users accessing the GCSCC shortly after that meeting, the number of page views quickly trailed off, and few teachers accessed any collections that semester. In this case, the metadata supported the narratives of the teachers, adding to the validity of the study. I conducted similar triangulations using the metadata, teacher artifacts, district artifacts, and verifications from district leaders.

While I did not attempt to generalize the findings from Phase 1 to other contexts due to the unique nature of GCS, the external validity of my findings about the ways in which IGIs influenced teachers' documentation with the GCSCC was supported by the consistency with which I found certain trends in the data. Each of the teachers I interviewed surfaced similar considerations, suggesting that the findings from these interviews were consistent with one another and consistent with other contexts, even if those other contexts do not have the same IGIs as GCS. Finally, in my Chapter 5 discussion, I anchor my claims in findings from the literature on my frameworks, thereby providing consistency between my findings and those of other studies.

In addition to taking steps to bolster the validity of the findings from this study, I also took steps to ensure the reliability of the analysis. Dr. Porter and I established the interrater reliability of the codebook and adjudicated any discrepancies before I coded the rest of the data. Member checks ensured that my interpretation of teachers' experiences were aligned with their perceptions. Consistent with Yin (2018), I kept extensive research memos about each action I took and maintained a chain of evidence showing the logic that resulted in my final

analysis and claims. In this way, I ensured that my interpretations of the findings from this study were consistent with others, thereby establishing the reliability of this study.

CHAPTER IV: FINDINGS

Introduction

The purpose of this study was to identify the ways in which instructional guidance infrastructure (IGIs) shaped the documentational genesis of science teachers working with the Grantham County Schools Curriculum Collection (GCSCC). The Canvas metadata revealed a number of patterns related to teachers' use of the GCSCC such as a large response to the district summer initiative; a majority of teachers investigating the collections for a short period of time and never returning; comparatively larger use of the collections in middle schools and tested subjects; and differences among communities in number of teachers accessing the collections and duration of engagement. These findings suggested that, while the varying levels of completion could account for some of the variation in teachers' use of the GCSCC, some IGIs likely existed that contributed to differences in teachers' access patterns. Further exploration of these trends in Phase 2 of the study revealed substantial differences in the ways that beginning and experienced teachers interpreted, adapted, and implemented resources from the collections. While several school, district, and state IGIs contributed to these differences, the only constraints on teachers' agency for using the GCSCC implicitly resulted from their perceptions of the IGIs rather than explicit mandates.

In this chapter, I present an analysis of the findings from this study. This chapter is organized into three parts, each aligned to one of the three research questions:

1. What patterns exist in science teachers' access to the GCSCC, if any?
2. In what ways did science teachers use the resources and / or framework from the GCSCC, if at all?

3. In what ways did IGIs enable or constrain teachers' agency when using the GCSCC resources?

I begin with the findings from Phase 1 of the study in which I answered research question 1 by analyzing Canvas metadata to elicit patterns in teachers' access to the GCSCC. From this analysis, I found alignment between district communication and teachers' first login to the GCSCC. I also found patterns in teachers' access to the GCSCC based on both the subject area and the schools and communities in which teachers worked, suggesting that differences in IGIs at both of these levels may have contributed to differences in how teachers searched for resources through the GCSCC.

I used these Phase 1 findings to generate my sampling frame for Phase 2 of the study in which I interviewed teachers from four schools to elicit their interpretations, adaptations, and implementations of the GCSCC resources. From these interviews, I answered research question 2 by eliciting patterns in how teachers interpret and implement the GCSCC resources. This analysis revealed that beginning teachers in the first three years of their career and / or content area(s) viewed and used the resources differently from more experienced teachers. I provide an analysis of these findings in the second section of this chapter.

I conclude this chapter with an analysis of the ways in which IGIs enabled and constrained teachers' agency for using the GCSCC resources in both explicit and implicit ways. I organized this section into five parts based on each of the five IGI categories identified by Hopkins and Spillane (2015), illustrating how IGIs in each of the five categories can promote and inhibit teachers' use of the GCSCC, thereby answering research question 3.

Phase 1: Findings From the GCSCC Metadata

Analysis of the GCSCC metadata revealed variations in teachers' initial access to the GCSCC over time, likely due to the actions of district leaders described in the GCSCC development and implementation timeline outlined in Chapter 3. Variations also existed in teachers' page views with the GCSCC based on content area and the school at which teachers taught, suggesting that differences in IGIs at these levels may have enabled or constrained teachers' use of the GCSCC. As I described in Chapter 3, I operationalized teacher documentational genesis as page views due to the way that Canvas reports data in its New Analytics feature. A page view represents each time a user loaded a page within the GCSCC Canvas course. The more pages a teacher has viewed, the more resources in the GCSCC the teacher explored, thereby allowing page views to serve as a proxy for the search function of documentational genesis.

I organized this section around the trends that surfaced in the Canvas metadata based on patterns across first logins for teachers; individual collections; differences between courses with and without a state test; differences between middle schools and high schools; and differences in communities as defined by the pairings of middle schools and high schools that share students. Relevant data is presented throughout these summaries, and a full data table containing a breakdown of GCSCC use over time using these metrics can be found in Appendix H. The findings from this quantitative analysis informed the sampling and analysis of Phase 2 of the study which elaborated on these initial findings through an analysis of which resources teachers implemented into their instruction, how they implemented those resources, and the IGIs that shaped those decisions.

First Logins and The Summer Incentive

When the district first made the GCSCC available for teachers, few science teachers enrolled in the Canvas courses. The incentive for teachers to explore the resources during the Summer of 2022 served as a prompt that resulted in a surge of teacher activity. However, many of the teachers who accessed the GCSCC only logged into the collections once or twice, suggesting that the GCSCC had limited sustained impact on their documentational genesis, if any. Table 3 contains data from teacher enrollments and page views broken down by semester during the target window of this study. Active Enrollments represents the total number of teachers accessing each collection for that time period; if a teacher accessed two different collections during one of the time periods, each collection enrollment counted toward the total, so one teacher could count for two or more enrollments if they enrolled in two or more courses. New Enrollments, then, represent only those enrollments that were new to that semester.

Table 3. Representations of Engagement and First Access with the GCSCC Over Time

	Page Views	Active Enrollments	New Enrollments
Fall 2021	3,909	18	18
Spring 2022	2,816	14	4
Summer 2022	3,211	41	28
Fall 2022	9,133	43	18
Totals	19,069	-	68

Note: Total active enrollments during each semester did not represent a useful metric of analysis, as total users is captured in the final column..

Throughout the 2021-22 school year, teachers created a total of 22 new enrollments, with the majority of those accounts created in the Fall. After the district sent an email in April 2022 inviting teachers to participate in a summer exploration of the GCSCC, a surge of 28 new teachers accessed the GCSCC. This illustrates the influence of the district's summer incentive on drawing teachers to the GCSCC. In other words, the summer incentive served as a prompt for teachers to begin searching the collection.

While district incentives effectively drew science teachers to the collections, to what degree did that activity sustain over the course of the following school year? Of those accounts created during the Summer of 2022, 14 enrollments (50%) remained active during the following Fall while the other 14 were never revisited past that summer. During the Fall following the summer surge, teachers created 18 enrollments into the GCSCC. In total, 35 teachers created 46 enrollments during the Summer and Fall following the summer invitation email. Of those enrollments, the majority (n=31; 67.4%) were active for only 1-2 weeks, whereas relatively few of the enrollments (n=5; 10.9%) were active for ten weeks or more. These numbers contrast with those teachers who created enrollments the previous school year, with fewer teachers logging in during only one or two weeks (n=6; 27.3%) and proportionately more accessing the GCSCC over 10 or more weeks (n=5; 22.7%). Teachers who accessed the GCSCC prior to the summer invitation were more likely to sustain use, whereas the majority of teachers who accessed the GCSCC in response to the summer invitation did not use the GCSCC as extensively. This suggests that teachers whose first search of the GCSCC was prompted by the summer incentive may not have used the GCSCC as extensively in their documentational genesis as teachers who accessed the GCSCC over three or more weeks (29.8%). Alternatively, teachers who accessed

the GCSCC during only one or two weeks may have deeply engaged with the GCSCC during that time, possibly resulting in changes to a variety of documents in short bursts.

To test the alternative explanation, I turned to the total number of page views for each user. Table 4 shows a bracketed distribution of the total number of page views per enrollment. As this table demonstrates, the majority of teachers viewed fewer than 100 pages in the GCSCC (n=38, 66.7%). Using the distribution of page views, a few categories of users of the GCSCC become apparent. The majority of the teachers have fewer than 100 page views (n=41; 60.3%); while this may sound like a large number of page views, consider that each page loaded by a teacher in the GCSCC counts as a page view including the landing page, instructions page, and any sub-pages related to lesson plans. Each page that a teacher visits more than once also counts as additional page views. Users with fewer than 100 page views, therefore, represent a relatively low amount of searching within the GCSCC. Four teachers accessed an exceptionally high number of pages with over 2,200 page views (n=4; 6.9%). The middle bracket, then, consists of teachers who accessed between 100 and 1000 pages (n=23; 33.8%).

Table 4. Distribution of Enrollments and Number of Page Views

Page Views	Enrollments
<20	14
20-50	14
51-100	13
101-150	6
151-200	9
201-500	3
501-1000	5
...	...
>2200	4

This bracketing of teachers is consistent with the explanation that the majority of teachers did not use the GCSCC extensively throughout the school year. However, the presence of the four power users with over 2,200 page views suggests that, not only did some teachers search the collections extensively, but also that there was some variation in the ways in which teachers searched the GCSCC. This variation may have resulted in differences in the resources that teachers implemented and the schemes of utilization they paired with those resources. I tested this conjecture through the teacher interviews in Phase 2 of the study.

Trends Across Collections

Analysis of teachers' access to the individual collections revealed differences in use among the collections, with some collections receiving substantially more page views than others. In this section, I compare different groupings of teachers accessing the GCSCC starting with the subject areas. The purpose of this analysis was to identify potential areas where IGIs may have contributed to the differences in engagement in the GCSCC among teachers identified in the analysis of first logins and bracketed engagement. Table 5 contains the data relevant to this analysis, showing the total number of page views and enrollments for each collection over the course of the period of analysis. 6th grade science emerged as the most visited subject, followed by 8th grade, then Biology, and lastly Earth and Environmental Science (EES). Notably, the majority of users of the EES collection accessed the collection during only one week, whereas users of the 6th grade collection accessed the resources over an average of five weeks.

On the surface, the differences in collection access could suggest a difference in IGIs that contributed to these variations. Middle school collections (6th grade and 8th grade) had more

Table 5. Page Views and Users For Each GCSCC Collection

	Page Views	Enrollments
6th Grade	9,715	28
8th Grade	6,407	19
Bio	2,371	13
EES	576	8
Mean	4,753.8	17

users and page views on average than high school collections (Biology and EES). These data suggest that such a variation would likely be independent of state testing; only 8th grade and Biology have a state standardized test, yet the 6th grade collection was the most heavily searched. In addition to generally using the GCSCC more, middle school teachers were more likely to enroll in multiple collections in the GCSCC, whereas high school teachers mostly enrolled in only one collection. Further analysis of this trend reveals that in several cases, middle school teachers explored resources in the Biology and EES collections, yet no high school teachers explored the 6th or 8th grade collections.

These observations could suggest that some difference exists in the way that teachers at these grade levels search for resources or that some IGI shapes these decisions. For example, the middle school science state standards -- an instructional framework IGI -- incorporate a variety of topics that are otherwise separated into different courses at the high school level. The state standards for both 6th and 8th grade have components focusing on energy and matter, yet these topics are typically exclusive to physical science courses at the high school level. This commonality across topics covered in middle school science classes could facilitate a 6th grade science teacher exploring the 8th grade collection looking for resources to teach topics that are

common to both sets of standards. Similarly, an 8th grade teacher may check the Biology collection for resources on teaching ecosystems, which is also taught in 8th grade. Conversely, the state standards for high school courses tend to specialize more into disciplinary topics; students would likely learn about the lithosphere only in an EES course, for example. This specialization could inhibit high school teachers from exploring middle school collections. In other words, the state standards represent an instructional framework that could have influenced the ways in which middle school and high school teachers searched the various GCSCC collections during documentation. From these findings, I developed a conjecture: disciplinary and grade level IGIs can influence the decisions that teachers make when looking for resources; I illustrate evidence of this conjecture in the analysis of Phase 2 findings later in this chapter.

While differences in GCSCC access between middle school and high school teachers could come from differences in IGIs at these levels, an alternative explanation stems from the completeness of each collection. Contrasting the two middle school collections with the two high school collections, the middle school collections have far more completed units and lessons, as demonstrated in Table 6. Collections with more lessons contain more resources from which teachers may draw and more pages for teachers to view, so courses with more pages would likely have more page views. Measuring engagement by page views, therefore, presents a limitation of the interpretation of these findings, as collections with more pages would logically have more page views.

However, the alternative explanation fails to explain the differences between the two high school courses; EES had more lessons, yet Biology had more enrollments, page views, and page views per enrollment, suggesting that the Biology collection was more heavily navigated than the

Table 6. Number of Units and Lessons in Each of the Four GCSCC Collections

	6th Grade	8th Grade	Biology	EES
Published Units	5	5	2	2
Published Lessons	44	38	17	20

EES collection. One possible explanation for this divergence could be that Biology is the only state tested science subject in high schools; teachers of Biology are therefore more incentivized to seek additional resources to improve test scores. In other words, the state test acts as an IGI -- specifically, a student assessment -- that influenced teachers' search of the GCSCC during documentation. As I illustrate in my analysis of the Phase 2 data later in this chapter, qualitative evidence supports this explanation at the high school level. At the middle school level, the subject with a state test (8th grade) had less traffic than the subject without a state test (6th grade), so the completeness argument may override the state testing argument. Alternatively, some difference in IGIs may exist that make 6th grade science teachers more likely to access the GCSCC than their 8th grade counterparts. These competing explanations illustrate the complexity of factors that can contribute to the use of a set of resources like the GCSCC and the importance of a nuanced analysis of the many factors that can shape teachers' documentational genesis.

This analysis further suggests that some difference in search across the collections exists, particularly contrasting middle school with high school subjects. This may imply that something about the IGIs related to each subject or grade level could create this effect, yet the competing explanation that the most searched collections are simply the most complete collections meant that I needed to conduct further analysis through the teacher interviews. In addition to the possible variation of IGIs across grade levels and subject areas, I analyzed variations in teachers'

search of the GCSCC courses at the school level. Each school has its own unique mixture of IGIs including resources, policies, support personnel, and accountability systems. Yet could these differences in IGIs across schools lead to differences in teachers' use of the GCSCC? In the next section, I present my analysis of the GCSCC data related to this question.

Trends Across Communities

Comparing science teachers' use of the GCSCC revealed differences in access patterns among schools and, in many cases, similar access trends emerged between middle and high schools in the same community. Similar to my comparison across subject areas, I separated the aggregate data into categories based on the school at which each teacher worked derived from school and district website information. These categorizations incorporated the data from all four of the collections, so no distinction was made about which collections teachers were accessing in each school. I also included the number of unique teachers who accessed the GCSCC at each school, highlighting which schools had teachers who accessed multiple collections.

These data are presented in Table 7 using numbers to conceal the identity of each school. These numbers are paired in a way such that each middle school feeds into the high school of the same number. For example, students at HS1 primarily attended MS1, students at HS2 primarily attended MS2, and so on. There are two exceptions to this rule. First, HS6 has two middle schools from which its students matriculate; I therefore coded these two middle schools MS6.1 and MS6.2. Second, GCS has two non-traditional programs: the early college and a K-8 virtual school. I maintained these numbers for completeness, but kept them in a separate section titled "special programs" because they draw students from across the

Table 7. Page Views and Users by School and Community

Middle Schools				High Schools				Special Programs			
	Page Views	Enroll-ments	Unique Users		Page Views	Enroll-ments	Unique Users		Page Views	Enroll-ments	Unique Users
MS1	1,229	7	6	HS1	411	4	4	K-8 Virtual	828	4	3
MS2	2,050	2	2	HS2	192	1	1	Early College	232	1	1
MS3	4,667	8	8	HS3	1,646	9	6				
MS4	2,955	12	6	HS4	0	0	0				
MS5	2,474	6	4	HS5	53	1	1				
MS6.1	1,142	5	4	HS6	261	3	2				
MS6.2	929	6	5								
Totals	15,446	46	37	Totals	2,563	18	14	Totals	1,060	5	4

county. Also note that one high school (HS4) had no teachers who enrolled in a GCSCC course, as represented by all 0's in the corresponding row.

Based on the data presented here, teachers used the GCSCC inconsistently across schools. In some schools (e.g. MS4), many teachers accessed the collections, yet did not consistently revisit the collection after an initial flurry of activity. In other schools (e.g. MS3), some teachers sustained the use of the GCSCC over longer periods of time. In some schools (e.g. MS4), teachers accessed a variety of collections whereas in other schools (e.g. MS3), teachers mainly stuck to one collection. Some schools had one exceptional teacher who viewed far more pages than anyone else (e.g. MS5), whereas other schools had more consistent use across teachers (e.g. MS6.2).

While enumerating each of the differences across schools represented in Table 7 could reveal a host of divergences, the fact that these differences exist highlights the influence of local context in shaping the role that the GCSCC takes in these teachers' documentational genesis. However, an additional question arises from this analysis: do these data present sufficient evidence to infer that some similarities may exist between middle and high schools within a community? For example, both schools in Community 2 have the lowest number of teachers accessing the fewest collections in their respective groupings, although the teachers at MS2 used the collection more than the teacher at HS2. Both MS3 and HS3 have the most teachers accessing the collection of any school in their groupings, suggesting that some common influence may exist in this community that promotes the use of the GCSCC. A discrepancy appears to exist in Community 4, where MS4 had 6 teachers enroll in 12 courses while HS4 had no participation in the GCSCC from teachers. Additional discrepancies appear to exist in Community 6, yet the fact that no other community at GCS features two middle schools feeding one high school could suggest that the design of this community sets it apart from the others. These similarities within communities could suggest that some IGI common to schools in the same community could play a role in shaping teachers' documentational genesis such as an instructional oversight used by building administrators or a community-based instructional material.

To further explore the possibility that local IGIs played a role in shaping teachers' documentational genesis using the GCSCC, I selected four schools in two communities in which to conduct further investigation during Phase 2 of this study. First, I selected community 5 due to the fact that between the two schools, only one teacher accessed the collection prior to the summer 2022 incentive, after which four additional teachers created accounts. These teachers

demonstrated relatively low search rates using the GCSCC; I inferred that some IGI or other factor at these schools could contribute to the low rates. I gave these schools the pseudonyms Bridgman Middle School (BMS) and Bridgman High School (BHS). I selected community 3 as the second community for study. Whereas community 5 had relatively low GCSCC usage rates, community 3 had the highest usage rates in their groupings. I inferred that some IGI or other factor at these schools may encourage teachers to use the GCSCC. I gave these schools the pseudonyms Fremont Middle School (FMS) and Fremont High School (FHS).

By selecting four schools from two contrasting communities in this way, I sought to further explore possible differences between middle schools and high schools as well as differences in local context that could encourage or inhibit science teachers' use of the GCSCC. A total of six teachers agreed to participate in the study from these schools, as presented in Table 2, copied here from Chapter 3 for convenience. In the next section, I provide an overview of the findings from these schools.

Table 2. Overview of The Six Phase 2 Teacher Participants

Teacher	School	Subject Taught
Mrs. Meyer	BMS	8th Grade
Mrs. Mason	BMS	8th Grade
Mr. Martinez	BHS	Biology
Mrs. Hughes	FMS	6th Grade*
Mrs. Cook	FHS	Chemistry**
Mrs. Branson	FHS	Biology

Phase 2: Findings From Teacher Interviews

Teacher interviews served as the foundation for Phase 2 of the study, which revealed that beginning teachers interpreted, evaluated, adapted, and implemented the GCSCC resources differently from their more experienced counterparts. As I described in Chapter 3, my use of the term *beginning teacher* here emphasizes teachers who are beginning a documentational trajectory (Rocha, 2018), thereby including both teachers who are beginning their careers and teachers who may have teaching experience but are within the first three years of teaching their current subject area. Conversely, I use the term *experienced teachers* to refer to teachers who have more documentational experience in their current content area. In addition to the differences in documentation among beginning and experienced teachers, findings from Phase 2 revealed a variety of IGIs from all five categories identified by Hopkins and Spillane (2015) that both enabled and constrained this work, often in implicit ways.

The findings from Phase 2 of the study present several points of convergence and divergence from the conjectures formulated from the Phase 1 data. For example, the teacher interviews supported the inference that the state test played a substantial role in influencing teachers' documentational genesis; however, as I will illustrate, the nature of this influence varied between beginning and experienced teachers. The Phase 2 interviews also diverge from the Phase 1 conjectures in that there was more variation in science teachers' documentational genesis within schools than among schools, again specifically between beginning and experienced teachers. One potential explanation for this divergence could be that some schools have more beginning science teachers than others; I could not, however, find a data source to test this conjecture, as state data related to schools and teacher licensure do not provide information disaggregated by the subjects taught by beginning and experienced teachers.

To illustrate these findings, I begin this section with a set of case profiles for each teacher who participated in the Phase 2 interviews organized by community, starting with BHS and BMS, followed by FHS and FMS. I begin each profile by providing a narrative of each of the six teachers including their background and school context, followed by the ways in which the GCSCC influenced their practice, the role that IGIs played in shaping teachers' agency to make those decisions, and concluding with changes in teachers' documentational genesis that surfaced during the Fall interviews. I then provide a cross-case analysis of the documentational genesis differences between beginning and experienced teachers using the GCSCC, thereby answering research question 2: In what ways did science teachers use the resources and / or framework from the GCSCC, if at all? I then present the findings from research question 3: In what ways did IGIs enable or constrain teachers' agency when using the GCSCC resources? To address each of these questions, I synthesized the findings from Phase 2 into a set of claims supported by illustrations from the data presented in the teacher profiles.

Teacher Case Profiles

Mr. Martinez (BHS)

Background. At the time of the interview in Spring 2023, Mr. Martinez had taught Biology at Bridgman High School (BHS) for just one semester. He completed his undergraduate degree and attained his teaching license at the end of the Fall semester of 2021. He then taught for one semester in another district before starting his job at BHS. BHS serves 550 students, over 66% of whom are labeled as economically disadvantaged and 63% of whom are Black or Hispanic. Statistically, BHS fits the profile of an underperforming, under-resourced school with only 10% of its students considered grade level proficient in Biology and over 60% of its teachers classified as "Needs Improvement" in 2023. Students at BHS are suspended at triple the

state average and nearly double the district average; chronic absenteeism at the school presents similar problems, with rates double that of the state average. Despite these challenges, Mr. Martinez expressed that he feels at home in this community, which he sees as tight-knit and supportive. His mentor and administrators check in on him regularly, providing resources and advice.

Mr. Martinez likes to begin his class with a bell-ringer question, then provide an overview of the day followed by an interactive lesson taking the form of a web quest or mini lab. Prior to starting at BHS, he had primarily taught Chemistry and Physical Science. Having taught Biology for one semester in a block schedule format, he decided that he preferred Biology over the physical sciences. In his words,

> It's just interesting learning more about the world and everything. And I guess, with, like, physical science and chemistry, it was more just like, Do this, do that. This is how this works, how that works. But it was cool, like applying it to like, you know, like real-life stuff. But I don't know. Biology is just kind of like this is how your body works. It's like your life works. This is how you get things from your parents and all that. It was something that I liked.

When he started at BHS, his mentor -- a teacher with nearly 30 years of experience -- provided him with a set of Biology resources including mini labs designed to take less than one class period that he now uses regularly. His documentational genesis at this time focused on incorporating more activities into his lessons rather than lectures and paperwork.

> But I try to focus more on just finding more hands on, and inquiry based stuff, cause it's seeming to work really well right now. Last semester, it was more paper than anything else. It worked okay. But it was like a lot of just paperwork for me and the kids. And

> right now it's more just like hands on. [...] And it's really helping them remember a lot for this semester.

He also creates his own web quests -- sets of interactive simulators, articles, and other online resources that students navigate to explore a topic.

> I don't wanna sit up there and talk for like a good 30-40 minutes like I did that last year, and it was draining on both the kids' part and my part. The web quest allows them to be more hands-on, I guess, with their own knowledge, and they have their own responsibility with it.

When creating these web quests, he typically searches Google for pre-made webquests or resources to add to his own. However, he finds that the search for resources when creating these webquests daunting:

> I mean some webquest for DNA, for mutations, if I don't find one, I end up finding some other activity, and then I end up going down a rabbit hole and suddenly I'm like in a bunch of labs or ecosystems it's just like, hey, this will be cool to do this here, and it just goes down like a rabbit hole.

This frustration is further compounded by misalignment between some online resources and the GCS technology infrastructure. For example, "I know a lot of [online Biology simulators] used to be Java and Java don't work no more. And I need some that'll work with their iPad."

Through these statements, Mr. Martinez expressed that he engages in documentational genesis by searching for web quests or additional resources for web quests that he makes himself. As an early career teacher, he has not yet had many chances to refine his documents; the fact that he did not teach Biology before this school year also meant that while he had some experience teaching science, he began his documents anew when hired to teach a subject for

which he had no initial documents. While he regularly uses resources that he received from a veteran teacher, he expressed that he strives to refine his teaching identity and iterate on his practice, thereby actively creating his documentational trajectory. Reflecting on the changes he made that semester:

> I feel way more confident, this semester, teaching it, than last semester. Some of the kids come in. They see it, and they're just like, we didn't do this last semester. It's just like, yeah, I know, I learned. But it's just like, it's fine. You know it; they kinda know it better.

Documentational Genesis with the GCSCC. What role has the GCSCC played in helping him shape this documentational trajectory? Mr. Martinez first accessed the Biology collection early in Fall of 2022, shortly after he began his work at BHS. He returned to the collection several times throughout the semester. He implemented a few resources from the collection, yet only as pieces that he incorporated into his existing classroom structure. In other words, he did not use the full lessons or the framework from the collection; rather, he selected individual components and activities that he thought would help his students prepare for the Biology exam. For example, when teaching enzymes, he incorporated a foldable from the collection into one of his lessons.

> I used to make them do just like a little foldable, but the foldable was kind of confusing, and it was more just like, hey, cut the pieces out, glue them down, you're done. Most of them glued them in a random order, and that was it. But with the little foldable, they had to do it in order, step by step, to get it right. Step one, step two, step three, step 4. And they were forced to come like, draw and answer questions on the back, and everything, and be like, hey, I have to actually pay attention to this. I can't just do it weird, or else

> it'll look wonky. And I told them that, too. It's just like, hey, you gotta do this step by step, cause it's like, if you don't, you won't like… This is the thing you'll be able to use on your test. If it don't look right, you won't be able to get the right answer. Oh, but yeah, I use that hands on foldable. It made them color. It made them answer questions. It was better than the just regular cut out that I had before.

Here, Mr. Martinez expressed an appreciation for the enzyme foldable because he felt that students could better engage with this resource than the resource he had used the previous semester. While he did not share where exactly this activity fit into his lesson, he expressed similar praise for an activity in which students played a Galaga-like game to learn about organelles.

Despite his positive opinion of the enzyme and organelle activities, he expressed that he generally did not find the GCSCC teaching resources useful because "it doesn't feel like me". He described some tensions with the pacing of some of the resources:

> I just felt like it would take forever, because it was paced. Like the lesson would start far into the actual thing. It's just like, observation, observation, observation. And then, near the end, it's just like, hey, let's put this thing together and try to see what you learn. And it's just like it felt like it was taking forever to actually get to the point.

Here, Mr. Martinez expresses his dislike for not necessarily the activities themselves, but the pedagogical model with which the developers aligned the GCSCC lessons: Launch, Explore, Discuss, Land. In this instructional model, lessons follow a consistent sequence that usually involves a hook in which students make observations, followed by a student-driven exploration through which students construct explanations of the phenomenon they observed in the Launch. Such explorations are consistent with reform-based science teaching, which could

tempt the reader into critiquing the decisions that Mr. Martinez made. However, the tension that Mr. Martinez raised about pacing represents an opportunity to explore incoherence among the IGIs that guided his work.

IGIs. The state in which Mr. Martinez works has not adopted a set of standards aligned with the Framework for K-12 Science Teaching (cite). While the state formally adopted a new set of science standards that more closely align with the kinds of teaching outlined in the Framework, teachers would not implement those standards until two school years after this interview. Adopted in 2012 -- just one year after the publishing of The Framework -- the older state standards represent a more content-focused vision of science teaching, with each Biology standard using verbs like *summarize, explain,* and *analyze.* The structure of these standards communicates a vision of science instruction which positions students as memorizers of information. As the only high school science class with a standardized state test, administrators often place Biology teachers under more of a microscope, as these test scores affect the overall rating and subsequent funding of the school. This test therefore represents an IGI that can play a significant role in shaping the instructional decisions of Biology teachers.

As an example of the degree to which the state test influences Mr. Martinez's instructional decisions, he noted a pressure to maintain a certain pace of instruction to ensure that he could cover all of the content on the test in a semester.

> It definitely influences my schedule and all that because I have to keep pace. I try to keep at least in my head or on a calendar at least 2 weeks of review, but that's also like my buffer days which I always need in the end.

He also described changes that he made to his web quests in order to better support students' literacy development.

> We already have a low reading level, but looking at those tests, it's just like, hey, we definitely need to read more. That's why I'm trying to do the web quests more. It's just like, it gets them reading. It gets them reading those weird questions, those weird, like wordings of everything, and going to the websites and everything, and makes them read more than just one version of the word.

Here, he expresses a shift toward using more resources aligned with supporting literacy because he believes that literacy development will help students perform better on the state test. In order for students to express their mastery of the state standards, they must first read and interpret a question before identifying the correct answer. In other words, a student who misinterprets a question will likely answer the question incorrectly even if they understand the scientific concept being addressed. To quote Mr. Martinez, "I have to increase their reading level for them to actually understand the final, because if I don't, it's just that they'll get to it, and it'll just feel wonky."

To support students' literacy development, Mr. Martinez not only incorporated more reading into his web quests, but also shifted from using his own assessments to using a platform called Mastery Connect.

> I'll use [Mastery Connect], and it's a good resource, because the wording is similar to that on the final. [...] It works with them, and it's good, but whenever they do their tests for me, they always look at me like Mr. Martinez, this is worded so weird. It's just like, I don't know what it's asking, but whenever we do review they're perfectly fine, because I'm the one who worded those questions. I ask [more] straightforward questions than their final does. But it does it in a weird way, and it's just like it's just trying to get used

to reading that weird spelling and all that, or words that they haven't seen before, which is weird and intense.

Using Mastery Connect as an assessment platform allowed him to support his students with interpreting test questions that align with the state test. This vision of teaching contrasts with that of the GCSCC lessons, which position students as explorers and observers.

This highlights an example of incoherence between two IGIs that shape Mr. Martinez's work. Mr. Martinez's performance as a teacher is, in part, determined by his students' performance on the state test. He therefore has diagnosed issues that prevent students from performing well on the state test and has adjusted his documents accordingly. Mr. Martinez perceives this test as conflicting with the pedagogical model guiding the development of the GCSCC lessons. He perceives these lessons to take too much time for student observations, leaving less time for the kinds of instruction that he believes will help students perform well on the test. In this case, his desire for students to perform well on the test superseded the potential offerings of the GCSCC, even if those lessons may have helped reduce his work load by providing him with a set of initial documents upon which he could build, particularly at this early stage in his teaching career.

Despite this incoherence that Mr. Martinez perceived between the GCSCC resources and the state test, Mr. Martinez frequently used the GCSCC for another purpose: as a guide to help him align his own lessons with the state standards.

I try to keep the same pace, like the same order. They start with something, I start with that. They end with something, I try to end somewhere near. If they start with biomolecules, I start with biomolecules, just trying to keep everything there, because I

know, the actual state stuff like the benchmarks and all that, they follow that pattern and everything. So I try to keep it there. But that's as most as I use it.

Here, Mr. Martinez describes using the GCSCC to inform how he should sequence and pace his units. He later shared that he also uses the lists of vocabulary terms in the GCSCC to ensure that he teaches his students the vocabulary they would need for the state test. Notably, at the time of this interview, no other district pacing guide, curriculum guide, or vocabulary list existed for Biology. In this way, Mr. Martinez used the GCSCC as a stand-in for a missing set of IGIs. I will return to this concept in a later section of this chapter in which I explore the results of the Fall 2023 follow-up interviews which occurred after science coaches at Frontiers developed and implemented new IGIs including a pacing guide.

Fall Update. When I interviewed Mr. Martinez the following Fall, he still taught Biology at BHS. Having taught there for over one year, he expressed feeling more comfortable in his school based on his experience. He described several new resources he was using, including a greater focus on Gizmos simulators. Much like the previous spring, he chose these alternatives over the resources from the GCSCC. Instead, the GCSCC continues to serve as a reference for pacing and content.

It’s more me using it to figure out what order I need to go in because it kind of helps with that. It's just looking at what other teachers do like on Canvas and stuff, or even like the district, how they come out with the pacing guides and even the unpacked standard, which I need to follow. But it kind of helps in the way they organize it to be like, oh, this year I can move this over here and it would probably make it a little bit more sense. And just to cut things up and just make them into a more bite size unit. So that's really the only way I've used those resources. Just to kind of help me pace everything.

Much like the previous year, Mr. Martinez felt that he received minimal communication about the GCSCC at the district level.

> The only time it was ever mentioned, at least to me, it was mostly during our PD meetings. We don't really talk about it at all during, like, our BT meetings and even then the first time I heard about it was when we went over to Frontiers that they told us, hey, here's what's gonna be the new standards for next year for the subjects. Here is a collection of resources we kind of came up with, the and that they were more inquiry based than anything else that that pretty much was it.

In these two quotes, Mr. Martinez described some of the district's new approach to supporting science through a suite of new IGIs. These IGIs included a pacing guide, aligned standards, and periodic district-wide professional development focused on science instruction through inquiry-oriented teaching practices.

One way these IGIs influence his practice was his use of the pacing guide alongside the GCSCC to continue to refine his pacing and sequencing of instruction. While he was the primary Biology teacher at BHS, two other teachers now teach one section of Biology each. One teacher had not taught Biology for several years, and the other was a new teacher. Together, they actively negotiated ongoing tensions around the pacing and sequencing of instruction.

> It's like the other teachers were also stressed out because they were just like, how are we supposed to teach this in six days and expect the kids to know everything on these standards? Like they started seeing the problems and it's just like, this is why I kind of spend a little bit more time on one subject than the other and less on the lesser known standards, the one that don't really need to know a lot. [...] Cells is not supposed to be a month, but I group every single thing I can into it, but even then. I followed this other

> teachers pacing guide that I found online and she took a whole month on cells and I didn't think that was necessary. I tried it and it felt like I was just wasting time. So I so like last week I started cutting it and started doing my own thing again and everything's kind of been going a lot better.

Along with his two fellow Biology teachers in the department, Mr. Martinez used the new IGIs along with his past experiences and supplementary materials that he sought himself to negotiate tensions around the sequence and pacing of his content.

> OK, so we tried to follow the pacing guide. UM this semester and it was more just like, normally we do, we follow, we follow like the subjects and the standards, but we don't follow the days and it was more just like we try to keep up with the days. We didn't do any intro stuff with the kids and we just went straight into the curriculum, like this pacing guide we were given. And it was, it felt awkward because I didn't take the time to know my students and because of that it felt like I didn't know how they learned. And it wasn't until like about, when we started the cells unit that I added more hands on stuff instead of just like notes because they like hands on and stuff.

Consistent with the previous spring, their use of the pacing guide came at the behest of the school administration team in response to the previous year's test score results.

> OK, so we decided that we were going to try to stick to the pacing guide just cause it was more of an admin thing. They wanted us to try it, to like boost our scores up and everything, because even though we got more proficient scores than we did last year, we didn't do great. And I understand that. So we were just trying to stay with the pacing guide to see if it was something like that.

In this way, the state test represents an IGI that continues to influence Mr. Martinez's documentational genesis. Along with requirements to use the district pacing guide, the BHS administration team expressed that Mr. Martinez should use both the state benchmarks and the newly-developed district common formative assessments (CFAs) in order to provide feedback about students' progress on mastering content that the test would contain. On the district level, teachers of tested subjects typically complete either the district benchmarks or the CFAs, but the administration team at BHS saw value in the Biology teachers completing both. These interactions with his administrators illustrate how teachers of tested subjects can receive different instructional oversight than teachers of untested subjects, with some teachers of tested subjects receiving a greater level of scrutiny than their untested counterparts. Despite this greater instructional oversight, Mr. Martinez still exercised his agency by opting to use the district's new 5E-aligned lesson plan template rather than the template used by the rest of BHS. He made this decision independently from the administration team, but as of the time of the interview, "they haven't told me, no, I can't do that."

In addition to the pacing guide, CFAs, and lesson plan template, Mr. Martinez described a set of resources developed and shared by the Frontiers staff during their monthly professional development meetings.

> That Google folder was there in our PD meeting, I think last time at Frontiers, and they told us hey, we have a bunch of resources here. Here is the new standards for Bio or use the old standards. We piled up resources and here's a file with the standards and you can click them for resources or investigations that people liked. And I just have not been paying attention to those whatsoever. [...] But I also was told that they're more for next

year because of the new standards for Bio. So I haven't really paid much attention to the resources they gave us.

Here, Mr. Martinez describes the district's alignment of resources with the newly-developed state standards that would be implemented statewide the following year. While teachers had the opportunity to opt into using the new standards, the state test aligned with the previous standards, inhibiting Biology teachers from making the transition. The district's approach of aligning the available resources with the new standards therefore inhibited Mr. Martinez's use of these resources. Still, the creation of this system of resources aligned with the state standards represents a competing set of resources with the GCSCC. Given that the initial vision for the development of the GCSCC was for a set of resources aligned with the state standards that teachers could use, this new suite of resources that the Frontiers staff promoted during monthly professional development represents a competing set of resources that may take priority over the GCSCC for teachers' documentational genesis. Just as the active promotion of the GCSCC led several teachers to investigate the resources it contained, the greater emphasis on this new set of resources at the monthly meetings may lead teachers to spend more time searching through these resources than the GCSCC. Furthermore, when all teachers in the state transition to the new state standards, the GCSCC will no longer align with the standards teachers use, potentially limiting its usefulness for teachers even further. This may be especially true for teachers who use the GCSCC primarily for support with content pacing and sequencing like Mr. Martinez.

Mrs. Mason (BMS)

Background. Mrs. Mason began her career trajectory interested in going to medical school. After majoring in Biology in college, she decided instead to become a teacher. She began her teaching career at Bridgman Middle School (BMS), where she has worked for eight

years. As the primary feeder school to BHS, BMS serves the same community and has a similar student demographic composition. Like BHS, BMS suspends its students and experiences chronic absenteeism well above state and district averages. Science instruction at BMS achieves levels slightly closer to the state average than BHS, with 45% of students labeled as proficient in science compared to the state average of 67%. Likewise, the state designated 21% of BMS teachers as "Needs Improvement" compared to the 60% rate of BHS. BMS also employs an above average number of beginning teachers, with 20% of the teachers at the school working in the first three years of their career.

As an experienced teacher, Mrs. Mason takes on leadership roles in her school, serving on the teacher-led design team -- a team of teachers at each GCS school that sets and monitors school-wide goals annually. She helps inform decisions about the allocation of funding toward instructional resources, including advocating for a school contract with Kesler Science (https://keslerscience.com), which was adopted by the district one year later. Kesler Science contains a library of instructional resources for science aligned with state standards and tuned to specific grade levels. Similarly, she piloted a set of science inquiry kits through CIBL (https://ciblearning.org) during a summer teaching experience for students; the district purchased a contract with CIBL to implement these kits across the district the following year. In this way, Mrs. Mason exercises agency not only in her own classroom practice, but also in shaping school-wide decision making about instructional goals and the resources that the school acquires. While Mrs. Mason only taught 8th grade science during the 2022-23 school year, she had previously taught all three grade levels at BMS. Over her time teaching these courses, she has built up a robust set of documents from which she draws when she teaches:

> I've already taught sixth grade plenty of years, and 8th grade plenty of years, and seventh grade plenty of years. So I already have pretty much the curriculum down, you know. I've already got the assignments. I've already got the assessments, already got everything that I need. And it was just a matter of setting up the class, so that all the classes are doing warm up. All the classes are doing vocab on Fridays. [...] You have to be very, very structured in order to be able to do it. And it's just a change of like these words versus these words. And this concept versus this concept, you know, if we're doing a lab, we're going to do a lab in all 3 classes on, you know, it's just a change of what exactly the lab is.

She describes a typical day in her classroom in this way:

> We do about a 10 minute warm up, and then typically, well, it just kind of depends on the day. So if I'm going to teach, I'll do about, you know, 20, 30 minutes whole group teaching, and then the kids will either have one assignment that's kind of longer, or a lab, or they'll have 2 smaller assignments. [...] I can break it up into 30 minute increments. So we do usually about 3 different activities in a 90 minute period.

When she searches for new resources, she typically has a clear vision of what she wants to add to her lessons:

> The first thing I'll do is pull a video, and then I'll pull a reading assignment, and then I will take what I've got and whatever's missing from those things. That's what I'm gonna put in Powerpoint, you know, to kinda teach the kids. So pretty much all of my lessons are gonna have a video for my kids who cannot read very well. And a reading assignment to supplement. [...] So really all I already know what I want to teach, and I already know what words I'm looking for -- the vocabulary, that kind of thing. I'm just

> looking for something that's gonna be fun and engaging so that I can keep their attention long enough for them to do it.

Here, Mrs. Mason paints a vision of how she likes her classroom to flow and how she structures her documentational genesis to support that flow. She has specific categories of activities with which she likes students to engage broken up into 30-minute time periods. Her years of experience working at the school have given her a robust set of resources which drive her daily instruction. When she perceives a need to bolster a lesson, she seeks resources that align with these categories and fit into her overall scheme while aligning with what she perceives as an appropriate level of complexity for her students and provides sufficient interest to keep students engaged. However, she also tries new things; during the interview, she expressed satisfaction with the interactive notebooks filled with guided notes that she tried for the first time that year.

While she has a clear vision of how she likes to teach, Mrs. Mason works closely with another 8th grade science teacher, Mrs. Meyer. During the summer of 2022, BMS used funding from a state program to pay Mrs. Mason and Mrs. Meyer to work for a couple of weeks developing lesson resources. Together, they crafted the entire 8th grade science curriculum for the following year, which they were able to share with the remaining 8th grade science teacher who was in his first year of teaching. This summer planning session played a major role in shaping Mrs. Mason's engagement with the GCSCC.

Documentational Genesis with the GCSCC. Mrs. Mason first accessed both the 6th and 8th grade science collections during the summer of 2022. She returned to these courses in August, yet found them largely empty.

> It was empty, so they'd say, Oh, yeah, it's all there. [...] And I go, and it would be empty. So at the beginning of the year we looked, and it was empty. And I said, Okay,

> well, that's a waste of my time. So I didn't even go back to look at it until about 3 weeks ago, when someone was like, Oh, yeah, no, there's stuff there. And I was like, Huh! No, I don't believe you so I went.

Here, Mrs. Mason describes the prompts that led her to investigate the GCSCC. After finding the collection empty, she deemed the collection to be a waste of her time until another colleague again prompted her to check out the collection. This interaction demonstrates the significance of not only the level of completion at the time of the launch of the GCSCC in shaping teachers' perceptions of its value, but also the role that colleagues can play in prompting teachers to explore its resources.

However, the addition of these resources came too late for Mrs. Mason to find them useful for her work that year:

> I didn't do a whole lot of looking in there, because we already have the entire year setup [...] Being a Title I school, they can pay us for planning over the summer. So we planned the first 2 units over the summer, and we've planned all year long. So by the time it was time to look in the curriculum, I literally only had one unit that is not completely planned, and I already have the test. I've already got all of the supplemental materials that I'm gonna use. I just haven't written up the jargon yet. So I haven't used a whole lot from that, just because I've already planned for the year, and finding the curriculum or finding the information this close to the end of the year is not really helpful for me.

When asked about the Launch-Explore-Discuss-Land framework that guided the development and structure of the GCSCC lessons, Mrs. Mason expressed an interpretation of this framework as a rebranding of the 5E that the district had promoted in the past.

> But to be completely honest, like everything in education, it's all the same. It's just different words. Give a different word so that I can sell my product. But it's always gonna be the same thing. You know what I mean? There's nothing different about the two. It's just different words. So I can resell it like changing a drug just a little bit so that I can get that patent. That's all it is.

Despite the 8th grade collection resources arriving too late for Mrs. Mason to find useful for this year, she and Mrs. Meyer implemented one activity from the collection: the mystery of the bones. In this activity, students sort pictures of bones to explore homologous structures and create their own customized animal. Like Mr. Martinez, Mrs. Mason used only the part of this activity that she found useful:

> I almost never use anything that's as written, because, to be completely honest with you, usually the lessons that they put together are way too long and I don't need a 5 hour lesson. I've already got one that I don't use, so I just pick and choose the fun cutesy stuff, and then I do my own stuff for the other stuff, you know.

Here, Mrs. Mason demonstrates the role that her existing documents play in shaping her decisions about whether and how to use this resource. Having already developed and refined a set of documents over her years of teaching experience, she expresses a view of the GCSCC as resources that can provide supplemental support to the resources she already uses rather than as a set of resources that can serve as the basis of new lessons. In other words, she tried the GCSCC activity to see how it aligned with her vision of teaching. This point was further compounded by her reflections on the effectiveness of the mystery bones activity:

> That was nice. I'm not 100% sold that it actually taught them what they needed to learn because what they were working on was homologous structures leading to a common

ancestor. So they got to put together some bones, and I mean it was a fun activity. I don't know if I'll use it again.

Again, Mrs. Mason demonstrates the role experimentation plays in her documentational genesis. Along with Mrs. Meyer, she decided to try an activity from the collection, pulling only a piece from the overall lesson to fill a similar role to a resource she had used in the past. However, she doubted the effectiveness of this resource in meeting her learning objectives and may revert back to a previous resource in the future. As of the time of this interview, she had not used any other resources from the GCSCC.

IGIs. In the previous sections, I described some IGIs that shaped Mrs. Mason's work with resources. Specifically, Mrs. Mason has exercised agency over some of the instructional materials that the school and district provide. She also contributes to decision making about her school's annual goals, thereby contributing to the instructional frameworks and instructional oversight that follow. The timing of the added resources to the 8th grade science collection also conflicted with her previous summer work with Mrs. Meyer in which they established the majority of the resources they would use and how they would use them for that year. Her use of the GCSCC resources was further limited by competition from other district resources like Kesler Science and CIBL kits. These IGIs all created incoherence with the GCSCC, limiting Mrs. Mason's agency in using the resources. Here, I will add two additional sources of incoherence that Mrs. Mason highlighted.

Like Mr. Martinez, state standardized testing often plays a role in Mrs. Mason's documentational genesis. Students in her state only take one standardized science test in middle school which falls at the end of 8th grade. Like the Biology test, the 8th grade science test plays an outsized role in determining a school's effectiveness for teaching science. As an 8th grade

science teacher, Mrs. Mason aligns much of her instruction with the test, often using the state standards document as a guide. This year, she and Mrs. Meyer created and implemented a set of small-scale tests, each aligned with a learning objective from the state standards documents. She administered these tests every 2-3 days and used them as a data source to revise the curriculum that she co-developed over the previous summer. If students performed poorly on one of these tests, should would find new resources like videos and articles to reteach the content. In this way, her instruction and assessment aligned with the learning outcomes of the state test.

Also like Mr. Martinez, Mrs. Mason views literacy as a critical element for students to perform well on the state test:

> To be completely honest with you, my goal will always be to increase their reading proficiency, because science is a, what? It's a reading test. To be completely frank, it's a reading test. If they know their vocabulary, and they can read, they're going to pass. If they don't know their vocabulary, and they can't read, there's no hope for them, whether they know their science. I've always at the end of the year I can look at you and tell you exactly who in the room knows the science, and it's gonna be most of them. But most of them won't pass, because they can't read the questions, or they just look at it, and it's overwhelming, and they won't read the questions, And that's, you know, it is what it is. So my job is to help them read.

In alignment with this view of literacy as a critical element for success on the state test, she assigns students at least one article to read for each learning objective. She also uses the vocabulary that is often found on the test as a driving factor for her documentational genesis, selecting resources that contain the vocabulary she wants to teach. "If they don't have the vocabulary, they lose, and that's all there is to it. So anytime you have any kind of digital fun,

flashy game, competition, kind of situations, any resources that offer that for vocabulary. That's gonna be a hit."

Mrs. Mason's view of the significance of the state test and of literacy development as a key skill for students to succeed on this test mean that she selects resources that she believes will best help students build the literacy skills to perform well on the test. While the delayed release of the 8th grade science resources to the GCSCC played a substantial role in facilitating her overall disengagement with the resources it contains, her statements about the test suggest that she would likely reject any resources that did not directly align with her goal of helping students succeed on the test. As she mentioned in the context of the mystery bones activity, she did not believe that the activity helped students master the test-aligned learning objectives as well as her past resources. Furthermore, she expressed that she would rarely consider using an entire lesson from the GCSCC given their relatively long duration and focus on observation and inquiry. The test therefore serves as an IGI that limits her agency for documentational genesis, creating incoherence with the structure of the GCSCC resources.

In addition to the state test, Mrs. Mason further described a professional learning IGI that plays a powerful role in her school. In response to the relatively large number of beginning teachers and low test scores at BMS, the school decided to use state funds to contract with an outside agency to provide professional development for all teachers in the use of the Understanding by Design framework. In this framework, teachers begin their lesson planning by identifying the desired learning outcomes, develop assessments aligned with those outcomes, then conclude by developing lessons aligned with those assessments. This approach to documentational genesis represents a specific philosophy that could provide incoherence with a set of fully-designed lessons like those in the GCSCC. Administrators also required all BMS

teachers to regularly submit lesson plans reflecting this process, representing an instructional oversight IGI that could further limit a teacher's use of the GCSCC.

Despite this set of IGIs, Mrs. Mason did not feel that the Understanding by Design professional development significantly impacted her work. "So, yeah, we do have a specific way that we are expected to plan this year. Now they haven't really pushed me and the other science teacher very much, just because we already do it in the backward design. You know we already do that." Indeed, the approach that Mrs. Mason and Mrs. Meyer used when developing their units the previous summer embodies the backward design philosophy, starting with the state learning objectives aligned with the test, creating small tests for each objective, and designing and redesigning lessons that aligned with those assessments. However, her statement implies that, had Mrs. Mason's lesson planning process misaligned with the Understanding by Design framework, the instructional coaches at the school may have intervened to ensure alignment, as Mrs. Mason later described beginning teachers at the school experiencing. The level of accountability to which this IGI holds teachers may cause this IGI to play a more significant role in teachers' documentational genesis than the GCSCC. Whereas the GCSCC served as an optional set of resources which teachers could select and use or abandon without consequence, a school requirement that all teachers must use a specific lesson planning process and lesson plan template likely means that, should a BMS teacher perceive a conflict between the GCSCC and the Understanding by Design process, the teacher would likely give priority to the latter, again limiting their agency to use the GCSCC resources.

Fall Update. After the Spring semester of 2023, Mrs. Mason moved out of the district and therefore did not participate in a follow-up interview that Fall.

Mrs. Meyer (BMS)

Background. Mrs. Meyer has taught science and math at BMS for three years, before which she taught in Louisiana for nine years. After initially studying in college to become a pharmacist, she decided to pursue a career in education. She earned an undergraduate degree in Biology, then completed a Masters degree in Secondary Education: Biology. Despite earning her credentials for high school education, she decided that she preferred teaching middle school. She described the decision this way:

> I know this sounds silly, but I like the challenge. Everyone says how rough middle school is. And I myself, I feel like if I just had the adults, the teacher, the mentor, the somebody in middle school that was there for me, you know, that you know you don't have to lie. You don't. You can do great things and be yourself. If I just had that one person, then I think I would have, instead of me trying to figure this out in high school, you know. Then I would have been better off overall, so I know that I am that person, that I can be that person. And I love science, I mean, it's awesome. I've taught math. It's too structured. I'm a great math student, but I'm a better science teacher, and my numbers reflect this.

At BMS, she teaches both 7th grade math and 8th grade science. Her administrators made this decision after seeing her test scores in science:

> Last year, they had me teaching math because they thought I worked miracles. I guess my first year here, they thought I worked such miracles, like they went from like 3 students passing the [state science test] to like 60%.

However, her students' math scores did not meet the same levels as her previous science scores, so the administrators moved her back into science.

As a science teacher, she believes that reading should play a central role in her instruction, although for different reasons than those related by Mr. Martinez and Mrs. Mason. Her family immigrated to the United States from Vietnam, receiving their citizenship status when she was in fourth grade. Growing up as a speaker of English as a second language imbued her with a passion for reading that shapes her instruction:

> My parents did not speak English, when I was growing up, anyway. So I know that I love books, and I know that if I push the reading with my students, then they will get sharper. It's just without question. So I like articles, and I love readworks.org. I love all of their articles because it comes with questions and not just multiple choice, which is the format of [the state test]. It's also hitting them with vocabulary which we need to do that. And a couple of questions of comparing, and then a couple of short answer.

She also uses tools like ReadWorks to help her make decisions about the appropriateness of articles for her students. Her undergraduate focus on Biology gave her a rich depth of content knowledge, although this created some challenges when she tries to align instruction to her students' developmental stages.

> I used to vet my own articles, and that's where I've gotten, you know, some criticism, because I have my biology degree. So I will teach a lot of times a lot higher than where I need to be. So Actively Learn and Read Works, they keep me at the middle school level instead of me vetting articles that are collegiate peer reviewed. Come on, yeah, I'll read that, you know. So it definitely keeps me, yeah, it kinda keeps me in my the correct level.

Her time teaching in Louisiana made a significant impact on her teaching style. During the last few years of her time in her former school, she received training on phenomenon-based instruction through OpenSciEd (https://www.openscied.org).

> You start the day with the phenomenon or the unit with a phenomenon. They watch it, and they start to, the students start throwing ideas around. And then you come up with a question, right? An overarching question for the unit, and then you spend the entire unit trying to answer that question and gathering evidence and doing all these different activities to answer the overarching question for the unit, right? That's OpenSciEd.

Through this training, she developed a passion for pushing students' thinking beyond content knowledge toward evidence-based argumentation. This view positions the purpose of science instruction as moving beyond content knowledge toward scientific disciplinary practices. For example, she uses the claim-evidence-reasoning framework (CER) in labs to help students develop evidence-based argumentation skills.

> And then we work on CER, and I know they're not testing CER. But I need my students to be on that level. They need to rise to the occasion, because I need for them to explain to me how they got an answer with any kind of evidence. And it's not just science that does that. It's ELA, too. So I know we're not testing on that. But they need to do it so that way, at the end of the school year I can push them into CER land.

She described a typical day in her classroom in this way:

> So I know my structure is the bell ringers, which you know it's just review questions for me. And then vocabulary, foursquare, and like a video with notice / wonders. I push that because I feel that it's content. The videos that I'm specifically looking for are full of content that I need them to know. And so we're noticing things and wondering things. We do that together, modeling it together on the board. Pause the video, I'll type. They'll type, I mean, or they'll type or write. Depends if they want to be on their ipads or their in their interactive notebooks. And then they take a picture and they submit

it to me. They've done their work. And then, after that, if any kind of activity to support this content, so whether it's articles or activities.

She often uses videos as a launching point for her units, beginning with an interest-catching phenomenon about which she invites students to make observations and ask questions. However, she rarely revisits these phenomena later in the unit unless students ask about them specifically, representing a point of divergence from a typical phenomenon-based unit. I will return to this point in my analysis of the IGIs that shape her instructional decision making.

As a teacher who works closely with Mrs. Mason, Mrs. Meyer's interview presents insight into how two teachers can perceive and interact with the same set of resources and IGIs differently. Both teachers use the same instructional materials that they developed together the previous summer, yet their pedagogical views differ. Whereas Mrs. Mason's characterized her instruction in a way that emphasized success on the state test, Mrs. Meyer focused more on students' scientific thinking. In the following sections, I highlight how Mrs. Meyer's view of the mystery bones lesson and the IGIs that shaped the instructional decisions converge and diverge with those of Mrs. Mason.

Documentational Genesis with the GCSCC. Like Mrs. Mason, Mrs. Meyer had previously explored the GCSCC and found it empty. Mrs. Shore - a former district Math coach who had changed roles to become the beginning teacher coach that year - served as the prompt for Mrs. Meyer to re-check the GCSCC for resources. Mrs. Shore had worked with Mrs. Meyer previously in her capacity as math coach, but they still interact when Mrs. Shore visits BMS to check in on the early career 8th grade math teacher. During these visits, Mrs. Shore regularly shares district-purchased resources and ideas with Mrs. Meyer, including the GCSCC.

> So then she goes. Well are you on, how about the Canvas page? And I said, I was honest with, you know, the last time I looked it didn't have anything in those folders. She goes, no, if you go look now, it's been updated. Teachers have been adding on to it during, it's a working, you know, it's an active, live, working situation, so as they get to it, they're putting stuff in so that, oh, okay. And this was, I think, January, February. So that's when I put in all of the, I think it's Unit 5, in Unit 6. That stuff. That's what I took. That's what I took from the Canvas page so far.

Like Mrs. Mason, Mrs. Meyer had dismissed the GCSCC as empty based on her previous experiences. Only after Mrs. Shore prompted her to re-explore the GCSCC did Mrs. Meyer find the resources that the developers later added. This interaction again illustrates the influence that colleagues can play when encouraging teachers to use specific resources, particularly those sponsored by the district.

When exploring the resources in the collection, Mrs. Meyer used a focused approach, searching for resources that aligned with specific standards. From those lessons that align with the standards she seeks, she pulled individual activities from the lessons rather than using whole lessons themselves.

> Because I have what I'm working with, and I know the standards, and I know what I have to hit. So from the standard. I'm getting the vocabulary, you know. [...] It'll tell you what vocabulary words, what you need to hit, and it'll tell you what not to hit. So then, I make sure to kind of stay in that. And so then with that framework, that's when I start gleaning activities here and there.

Like Mrs. Mason, Mrs. Meyer expressed frustration that the addition of these resources came too late for her to find much use for them that year. However, she and Mrs. Mason used the mystery bones activity. Mrs. Meyer described what drew her to this particular resource:

> I run out of ideas. I mean, I have some, but it doesn't really appropriately hit. So there's a couple of things that the GCSCC offered. So here's the mystery bones. And it starts off by telling you things about it. But they answer questions, they tell you what to do. I like this because they're predicting right there. So they're gonna try to put this animal together. And then it'll ask them questions, you know, asking questions about the activity. These are normally my prompts. But it's better if I don't talk. It's it's best, you know. Just do it. You do it.

Mrs. Meyer's appreciation of the predictions that students make in this activity aligns with her philosophy that students should learn scientific practices like evidence-based argumentation, making this an appealing activity for her instruction.

When implementing the resource in her class, she chose to take a different approach from Mrs. Mason by modeling an incorrectly-assembled dinosaur.

> I'll show them mine, because, you know, I'm good at modeling. I'd like, I put my option up. But my Dino had two wings, two sets of wings. And they're like, Mrs. Meyer, what? And I'm like, I know! [...] It's okay for me to model a bad, you know something. And then it makes them turn around and like, 2 wings Mrs. Meyer? I'm yes, yes, two. And I get a student across the room. He's like, Mrs. Meyer, that's totally the tail. Do your second is a tail. And mine's got two tails and you know, so it gets really exciting right? This, this right here. I don't know if you see it's this long bone over here tell me why sir, they put 2 of these bad boys in here. To confuse them! Because when

you're at a dig site, you may get extra bones, and you don't know where it came from. So yes, my 2 pairs of wings was supposed to be, one of them supposed to be the tail.

By using a feature of the resource -- the inclusion of a second tailbone -- Mrs. Meyer engaged students in a thinking process that mirrored what a paleontologist might consider during a dig. This implementation of mystery bones activity diverged from that of Mrs. Mason. In other words, despite using the same resource, Mrs. Meyer's document differed from Mrs. Mason's because they used different schemes of utilization. Mrs. Meyer's scheme of utilization connects directly with the significance she places on teaching students scientific thinking and argumentation.

Reflecting on the overall usefulness of the GCSCC, Mrs. Meyer expressed enthusiasm about using some of the other resources in the collection.

> Big time upgrade, because last year there was nothing. You opened those, and it was empty. But this year, they've got three or four things in each folder. And I'm glad, because for me, that was enough, because I had other things. Now for a new teacher, looking at that, there's only a couple of resources. And that won't, three resources will not take you through a week and definitely on our schedule, which is an hour and a half for each class. That wouldn't have been enough. So definitely more, if they can push it.

Like Mrs. Mason, Mrs. Meyer leans on her past documentational genesis work to serve as the backbone of her instruction while incorporating resources to meet specific needs. While the schemes of utilization guiding the implementation of these resources may differ from Mrs. Mason, the role that these resources play in Mrs. Meyer's documentational genesis remains similar, serving as supplementary materials that add to her instruction rather than redefining how she teaches through the redevelopment of whole lessons. While differences in pedagogical

philosophy can explain the different schemes of utilization that Mrs. Meyer and Mrs. Mason used during implementation of the mystery bones resource, IGIs can serve as a lens to further explore what led to these differences in vision.

IGIs. On the surface, the IGIs guiding the work of Mrs. Mason and Mrs. Meyer appear identical. They teach the same subject in the same school, work with the same set of resources, and even co-plan to develop the same lesson plans. However, Mrs. Mason and Mrs. Meyer's documentational trajectories look distinctly different. Whereas Mrs. Mason began her career at BMS, Mrs. Meyer spent 10 years teaching in Louisiana. Mrs. Meyer described several differences between her past and current contexts during our interview. For example, while discussing the UBD professional learning opportunities at the school, Mrs. Meyer expressed a tension when considering its value for her work:

> So I'm sitting here, just, I didn't need it. But I guess learning more about our state and teaching. I didn't need it, but my colleagues did. Because they, I learned about lateral teaching. Not everyone has a master's. Not everyone has even a teaching degree. I know that sounds so, duh! Yeah, but not to me. Where I came from, everyone had a master's, everyone. Everyone in my science department had a masters. It was cutthroat. And then I come here, and they tell me about lateral learning, and some teachers are not turning in their lesson plans, and some are even turning in mine, and I type my own, and that is the mood. You just take stuff from people. So that is very new. Wow! So different here.

Her perception of the UBD professional development provided by the school signifies that this IGI does not significantly influence her documentational genesis despite the fact that BMS administrators require all teachers to use the framework and submit weekly lesson plans to a Google Drive folder. This may be due to the fact that, as Mrs. Mason indicated, Mrs. Meyer's

practice already appears to align with the lesson planning model presented through this professional development. The relatively low impact of this IGI on Mrs. Meyer's documentational genesis contrasts with the OpenSciEd professional learning opportunities she received in Louisiana, the impact of which resonates through her documentational genesis process.

> In my first 10 years of teaching, I did have like notes on Powerpoint, and we'd spend 30 minutes, for if I missed them copying it down. And they didn't really do anything. And then, do you know, they didn't retain it, unless they studied. And before Covid, in Louisiana, I had students that actually looked at their work and studied. And then I come here, and they don't study. They don't want to look at their notes. Even my AIG cluster, they will not look at that. Interactive, way more interactive than what we were doing. And OpenSciEd allowed us to do that, too. So I definitely took that from the OpenSciEd model, which is more discovery, exploring, hands-on.

Even when the infrastructure changed after moving to a new state, the training she received through OpenSciEd continued to shape the instructional decisions she made. As she shaped her documents to align with this pedagogical model, she continued to use the model rather than to re-align with a more test-focused approach shared by some of her peers. Whereas her peers used the test as an IGI that shaped decisions about which resources to use and how to use them, Mrs. Meyer lamented the test's incongruence with what she sees as good science teaching.

> It's multiple choice. There's, all 65 questions are multiple choice. And you know, in real life, science doesn't really, you don't get choices. And the science, you know, when it comes to making money. Anyway, you need to be able to make it plain I'm a big fan of CER, claim evidence based reasoning. And you really need to. If you make a claim, you

> need to have evidence to back that and provide reasoning. And this is more, questions are more open-ended, but they're actually deeper, deeper, like higher order thinking. So, eventually, we need to evolve to that, in that direction.

This is not to say, however, that Mrs. Meyer dismissed the test. During the interview, she expressed that she planned to spend the last two weeks of the semester doing test review through skill and drill type questioning. Still, the resources she uses in her teaching attempt to balance the deeper-level thinking like CER with more test-oriented skills. The OpenSciEd training represents an IGI that significantly shaped her beliefs about good science instruction, yet this pedagogical model creates incoherence with the state test due to a misalignment in the value placed on different kinds of knowledge and skills. Whereas the OpenSciEd training inspired critical thinking and evidence-based reasoning, the state test contains multiple choice questions focused on content knowledge retention. Mrs. Meyer's documents, which incorporate both elements of rote memorization and inquiry-driven learning, reflect efforts to resolve this incoherence. Working with a different set of IGIs such as the absence of a mandatory test structured around content knowledge, her instruction might look different, focusing more on inquiry learning than rote memorization.

Fall Update. During the follow-up interview in Fall of 2023, Mrs. Meyer described a transition in her documentational genesis in response to district training around supporting academically and intellectually gifted students. In this new approach, she organizes her instruction into three tiers aligned with the varying needs of students in her classroom.

> I need to look at what I'm doing and break it up into 3 levels and tier it. I need to differentiate. So I've differentiated in the past, but it's always like a high and a low and

> now we're really pushing an on a lower and a lowest. I say lowest, but that's not what I'm looking for. I'm looking for like, intensive. We're going intensive with it.

When the district added access to Defined Learning for teachers - a resource that helps teachers manage project-based learning units around central themes organized into different tiers of instruction -- Mrs. Meyer felt that “the stars are aligning”.

As one of the science-specific IGIs launched that school year, the new pacing guide features alignment between the suggested content units and some of the district resources, including Defined Learning and CIBL kits for middle school science teachers. While Mrs. Meyer uses these tools actively in her documentational genesis, she describes the insufficiency of these resources alone to completely teach her content.

> You can look on the scope and see, there's not a Defined Learning for every week that I'm teaching. There might be, what, two per quarter so 8-10 [weeks], you know, and that we have a lot. We have 30 weeks, you know, so I can assign the assignment, but it's only one assignment that they can do in one day. So it's all supplemental. Like the CIBL kits, they only last a week. And when I say a week, it could be four days, you know.

Here, she expressed that she sees the limitation of these resources as stemming not from their design or functionality, but from a sense of frustration that they do not provide sufficient material to fill an entire semester. Similarly, she expressed some frustration around the sequencing of the units in the district pacing guide. Given that the 8th grade state standards cover a variety of science topics including matter, energy, earth systems, ecosystems, and genetics, a teacher of 8th grade science could reasonably sequence instruction in different ways. The sequence outlined in the pacing guide misaligned with how Mrs. Meyer historically sequenced her units, resulting in some frustration.

Despite these limitations, Mrs. Meyer reiterated a deep appreciation for the alignment across the pacing guide, these resources, and her use of a three-tier instructional model.

> I think, you know, more videos has helped me. But you can tell that the children barely tolerate the videos as they are, like they're more hands on. So the project based learning, the CIBL kits, any hands on, they're more that this year. Last year, videos, videos, videos. They like watching. They don't wanna listen to me. I don't want to listen to me. But they're more hands on this year, so I'm just glad that, I feel like the stars aligned. All the CIBL kits, all the Defined Learning, project based learning, it just lined up to what I needed this year. This year I need all the hands on and that's this year.

Collectively, these instructional materials and the teacher professional learning opportunities she received created a cohesive picture for her instruction, supporting her use of these resources toward her instructional goals. The alignment among the pacing guide, the instructional materials, and the framework she sought to use in her teaching helped streamline her documentational genesis process, reducing the amount of time Mrs. Meyer spent adapting resources to align with one another and her context. This resulted in a feeling of enthusiasm for this new system: “It is fire, sir. [...] The district released the science scope and sequence and it has all of that in it.”

Even when these IGIs misaligned with some of those she experienced at the school level, Mrs. Meyer expressed enthusiasm for the new systems. For example, the 5E lesson plan template promoted by the district did not align with the four-phase template the administration team expected her to use at BMS.

> Ohh so this year, at the beginning of the school year, they had a meeting at the district level, and they want us to switch to the 5E model. Which, we should have been on that

> 5E model. This is a timeless, timeless template. [...] But I was really upset because, you know, every year they've got a new template.

After meeting with her administrator about this misalignment, she concluded that she could mostly relabel the headings from her previous template to align with the 5E template. To be clear, the district did not implement a requirement for teachers to use this template, leaving decisions about whether to require lesson plans and their formatting in the hands of building-level administrators. However, the monthly professional development delivered by Frontiers aligned with the new 5E template, so science teachers were incentivized to use the 5E model.

What role did the GCSCC play in her documentational genesis using the new IGIs? Mrs. Meyer shared that she still uses the GCSCC resources that she tried the previous year, yet has not added any new resources from the GCSCC to her teaching because no new resources have been added.

> I'm still using some resources that I got from there, but they've not from what I've seen, they've not added to it. [...] I'm not saying that it's outdated or anything like that. None of it is worth using or whatever. No, some of it is wildly still viable. You know, I know that science, we're evolving, but when it comes to fossils, which is a standard we're still using, I still plan to use it. I think the kids would love the mess out of that.

Not only did the GCSCC contain the same resources from the previous year, but none of the IGIs with which Mrs. Meyer worked -- the pacing guide, Defined Learning, CIBL kits, the three tier instructional framework, the 5E lesson template -- directly aligned with the GCSCC. For Mrs. Meyer to use the GCSCC resources in this new instructional paradigm, she would need to spend time translating those resources into these new systems. Even if she deemed the GCSCC resources worthy of use, the time required to do this work may make the GCSCC resources seem

undesirable compared to the alternatives that already demonstrated greater alignment with one another and with her three-tier instructional framework. These findings underscore the significance of alignment among instructional materials and other IGIs for streamlining teachers' documentation work and promoting the use of certain resources and instructional techniques over others.

Mrs. Cook (FHS)

Background. Mrs. Cook teaches Chemistry and Physics at Fremont High School (FHS). After starting her career as a long-term substitute teacher in New York, she accepted a job at FHS where she has taught nearly every science subject at some point over the 23 years she has spent there. Whereas BHS and BMS serve a suburban community whose population continues to decline, FHS resides in a more agriculturally-driven part of the county. Their student body counted over 1000 students in 2023 with 55% of students designated as economically disadvantaged - just 3 percentage points higher than the state average. While their suspension and absenteeism rates remained lower than those of BHS, their overall teacher effectiveness was comparable with 74% of teachers designated as "Needs Improvement" and 21% of students designated as proficient in Biology based on the state exam. While their academic outcomes remain similar, the differences in size, location, and demographics between the Bridgman and Fremont communities provide opportunities to explore how these differences play out in school infrastructure.

Mrs. Cook earned an undergraduate degree in Chemistry and Teaching and has nearly completed her Master's degree in Instructional Systems Technology. While she has taught most science subjects, she recalls that she was the only teacher at the school who really wanted Chemistry. As a teacher of a non-tested subject, Mrs. Cook spends less time concerned about

state tests and more time shaping instruction around what she believes students need to know. She described a typical day in her class in this way:

> Generally, I have everything up on Monday. So today, on Friday afternoon everything was up and ready to go, and it showed up on their stuff. I show them everything we're doing for the week and divide up based on the skills that are involved. So it might be, here's the vocab. So Monday, for what I would consider the unit itself starts, you're talking - here's the important vocab. Here's what it looks like. Here's where to find it. You do a little practice with it. I've been focusing heavily on what I call chemistry skills, where this vocab can be memorized. But I do enough so that I call it enough, so you'll know what I'm asking you. So, first thing I do is the vocab and what it looks like. After that it can be, usually we have labs based on it. Pushing CER. There's usually some sort of short video clip showing where things are used or how it expands from the high school level. Like, what does this look like in the real world? To kind of meet that question of why do I have to know this? Or, why do I have to do this? Here's places like this. We have activities. I usually try to leave 15 minutes, sometimes a half hour, just independent practice through the end of class with a wrap-up of whatever it is we are doing that usually has a link back to, like the last 5 to 10 minutes has some sort of link back to prior information of how this fits into the bigger picture of things already done. [...] Every Friday usually is what I call a work day. Let's clean up any work you haven't done. Let's go through and do like get help with things you didn't understand throughout the week.

Fostering critical thinking skills has become a central focus of Mrs. Cook's instruction. "A few years ago, I started adjusting my lessons to include a whole lot more CER, because the critical

thinking skills were not there. They were satisfied with simple answers." As an example of a typical CER lab, she provides students with water samples and a hypothetical scenario about an elderly woman who thinks a neighborhood kid may have poisoned her well. Students must use flame tests to test the samples for the presence of metals, then argue whether the water is safe for the woman to drink. While this lab originally came from the American Chemical Society, Mrs. Cook adapted the resource to fit her context and equipment by altering the prompt and the materials with which students work.

When searching for new resources to add to her curriculum, Mrs. Cook takes a cautious approach.

> If I felt something was successful, it's very hard to shove me off of it. [...] I don't do the thing like some of our teachers did, where you pull out the exact same thing at the exact same time every year. I am constantly looking for something new, but it doesn't always mean that I'm using it.

This approach signifies that Mrs. Cook continually evaluates the effectiveness of her documents for meeting learning objectives and only replacing those that could benefit from improvement.

To determine the effectiveness of these lessons, Mrs. Cook developed a set of question banks aligned to each topic she teaches. She uses these banks to administer a weekly "check up" to students consisting of 15 randomized questions from the relevant question bank for the week. Students can retake a checkup, but the fact that the questions are randomly drawn from the question bank means that not two students will answer exactly the same set of questions. She also asks students open-ended questions about how they feel they did that week and to rate their level of understanding of that week's learning objectives. Assessing students this way, she argues, helps make grading more objective and preemptively resolves issues of students asking

for higher grades, which she expressed as a frustrating problem in the past. "Why did I get a 94, and they got a 95? Nobody argues with a test. Nobody's. Why did they get this? Well, they got it wrong."

In addition to seeking new resources to further her practice, Mrs. Cook uses the websites of nearby universities to identify the chemistry content that students should master before applying for their program. While she sometimes contacts professors directly, she often uses chemistry placement exams to ensure that the content she teaches adequately prepares students for these programs. "The truth is that you can be out of touch with a lot of things, and I need to know that they're still teaching what I think they are." This statement underscores the significance of how the IGIs with which she interacts diverge from those of tested subjects -- a fact I will revisit and expand upon in my analysis of how IGIs shape her documentational genesis.

Documentational Genesis with the GCSCC. Despite almost exclusively teaching chemistry -- a subject for which the GCSCC has no Canvas collection -- Mrs. Cook spent some time exploring the EES GCSCC resources. When asked about her thoughts on what she saw, she commented:

> It looked good for someone starting, but I found it difficult to adapt to what I would currently put in if I was teaching that subject. I did Earth Science, because that was my most recent and closer to Physical Science. It did not allow for much adaptation. [...] I think it could be very useful with those who need more of that structure.

This perceived value of these resources for newer teachers led Mrs. Cook to share the GCSCC with a first year Biology teacher whom she mentors at FHS. In particular, she saw value in using the organization Launch-Explore-Discuss-Land framework for helping new teachers learn how

to structure a lesson. “And I've just been trying to reinforce, like, you know, you really gotta have 4 parts to this to get them. You know, you need to be able to explain where this is going at the end of it.” Despite the value she perceives in using this framework with her mentee, she views the framework as a rebranding of other frameworks the district has used in the past.

> But it's a new name for the same thing that's been taught for over 20 years. I know, and it's been, I'd call it streamlined into 4 pieces, whereas it was taught as a regular 5 or 6 piece lesson, even as a teacher in college 25 years ago. It's the same thing, different name. Maybe you call it less parts, but it's the exact same thing.

By describing the framework in this way, Mrs. Cook positions herself as an expert in her craft with a wealth of documentational experiences that have shaped her beliefs and values. While she sees the framework as unoriginal, she still sees enough value in its organization to share it with her mentee. This evaluation of the framework reflects her overall opinion of the GCSCC: she doesn’t see it as useful for her practice, yet finds value in the GCSCC as an organizing framework for teachers who have not had as many documentational experiences as her. She further codified this view when I asked her whether she would return to the GCSCC if she again taught one of its subjects.

> I would definitely go back there. There's never a harm in looking. I mean, we cull through resources all the time looking for a new shiny, or maybe a different way of looking at the same matter. I have no problem taking ideas from other people and then trying to tweak them into something that makes it my own. So there's not a problem with doing that. [...] And I like that they did have a standardized format from one page to the next. I just don't know. I just don't know what I would take from it, because I haven't seen anything that was useful to me.

While Mrs. Cook did not see the GCSCC having a strong impact on her work due to the relatively high value she placed on her existing documents, she compared the GCSCC to similar collections from nearby school districts that she had accessed in the past. She saw a greater value in these collections due to more variety of resources, more adaptability, alignment with benchmark assessments developed within the district, and an organization of the lessons based on topics rather than standards. She expressed an interest in seeing the work of developing the GCSCC continue based on the success of these collections from other districts. She saw constant updating as a critical element of the success of this endeavor.

> Keep it current and make sure it's visible that this has been refreshed. Like, these were looked at. And make it open, where you can have people submit to add their own ideas to it. You can get a lot of people to do it for free, because we're not all that bright. We're like, no, no, I wanna help you. So if you have people where they can add their own tweak on something that might help. [...] But get the new people in there looking at it, too. They have different insights, and are much more in tune.

IGIs. The absence of chemistry resources in the GCSCC presents a problem for analyzing the influence that IGIs had on her documentational genesis using these non-existent resources. However, the prominent role that state testing played on the decisions made by Mr. Martinez, Mrs. Mason, and Mrs. Meyer creates an opportunity to explore how the test affects these teachers' documentational genesis as a whole -- a topic that Mrs. Cook addressed directly. For example, she expressed a view that her focus on skills development through CER was enabled only by the removal of a formerly-used state standardized chemistry test.

> I get the good kids, the smart kids, because I teach upper level classes. They are great at spitting back information and memorizing it. But as far as applying it, they really

> struggle with that. So I was able to shift because [...] any standardized test is all about spitting back memorized information. Very little application. I focus my teaching much more heavily on skills, whereas when there was a state test at the end, I had to focus very heavily on vocab. And not just the vocab. You need to be functional. I treat vocab more, almost immersion. Like, here's the stuff you need to know to be able to understand what I'm talking about. And then I just keep using the terms over and over again. Now, instead of parts of the atom, and who discovered what, now I can spend real time building up their math skills in terms of, well, how do you know which gas law you need to use? Which equation do you need to use? How do you set up stoich problems with dimensional analysis? Why is it important to set it up this way? [...] So I focus much more on performance skills, critical thinking. Where, when we had state exams, it was very, very surface, and it mattered beyond all difference that Rutherford had the gold foil experiment. That's, yeah. That's not very useful information in terms of performance. It's just a random memorized fact.

The absence of a standardized Chemistry test also enables Mrs. Cook to incorporate more sources of information about what she should teach such as her use of nearby college chemistry placement exams. In her words, "I invest a lot of time looking into it and asking professors, but I doubt people are as extra as that most of the time. They're just like yeah, I'm gonna do what the state says." Additionally, whereas some IGIs like lesson plans, school instructional frameworks, and required professional learning play a significant role in shaping the documentational genesis of teachers at BHS and BMS, Mrs. Cook expressed none of these factors as influential in her work. In this way, the absence of certain IGIs has enabled Mrs. Cook to exercise more professional agency in selecting resources and how to use them. Thus, whereas these IGIs

created incoherence for teachers at BHS and BMS when using the GCSCC resources, Mrs. Cook anticipated that she would simply choose not to use the resources because she had already refined her documents to a level that she preferred, thereby exercising professional agency.

Fall Update. When I interviewed Mrs. Cook the following Fall, she described several changes in her context that led her to make some changes in her curriculum. Of those changes, larger class sizes seemed to have the most substantial impact on her documentation.

> So in terms of planning, the planning and the resources I'm using, I've had to adjust labs. The lab I just did on density is no longer 6 items or a full mystery. I do more of what I consider lab activities. The lab I did wasn't a full lab, but instead I had 18 mystery blocks and do more comparison, but it's no longer. Everyone gets the same stuff and see what's going on, because I simply don't have enough and we're sharing equipment between, uh, five other teachers.

In addition to adjusting her lab investigations to accommodate more students in her classes, she also expressed considerations for safety and the feasibility of labs given the space. To help her plan these activities, she largely relied on resources from the American Chemical Society and the National Science Teaching Association -- both resources she has used extensively in the past and come to rely on. She also looked through previous lessons, using an activity involving photoluminescent paper to demonstrate the energy of different colors of light. This lab, she argued, was safer and easier to conduct with large groups of students than the activity she had implemented the previous year.

> I'm trying a little of that "what if" factor, when you try something new. I wouldn't exactly call this under duress, because at this point, you just kind of go with it and hope

> for the best. But I would say anxiety-inducing because this year, the number of kids… It's when you don't have much space, and they want to squirt water at each other.

In this way, her past documentation gave her experiential knowledge that resulted in engrained pathways that led her to instructional materials that she used to adjust to changes in her context. The GCSCC, however, did not play a significant role in making these adjustments because no Chemistry resources were added.

When Frontiers rolled out the new science IGIs at the beginning of the year, Mrs. Cook similarly appealed to her past experiences to interpret the new circumstances. For example, during the initial meeting at Frontiers, teachers explored the new state standards that would be implemented the following year. Mrs. Cook, however, saw little change in these standards from what she had taught before. Similarly, the district implemented a new PLC framework structured around periodic meetings within science departments at each school, which she likened to a model the district had used 15 years prior.

> With the county redirecting PLC's to be more like what they should have been and used to be when we first started, probably a good 15 years ago, I would guess… It's got to be at least 15 years ago that we started PLC's. The forced common planning, if you want to know the truth, that does not really help us because we collaborate anyhow. [...] I mean, we usually try to sit down and work through stuff. Or hey, I've got this lab. Do you wanna look at it? [...] At this point, we can see where it's going, but we've just started the PLC frameworks that the county is putting out at this point. It is mainly just another meeting for us.

She also noted that the CFAs implemented by the district did not provide her with much support as the only Chemistry teacher at her school. Despite these IGIs bearing little impact on her practice, she saw value in their design and implementation.

> If you and I were both teaching chemistry here, if you're teaching it one way and I'm teaching the other… [...] If you're stronger at stoich than I am, what are you doing different? How can I capitalize on that? Can we talk co-teaching? That's what I'm taking, cause we're just skimming the surface of it now to go in. But, most of us old people, we're doing the same thing that we first did in PLC, which is how can we collaborate? Where am I falling apart as a teacher without having a whole data room?

Here again, Mrs. Cook expresses an optimistic outlook on the direction that support for science instruction is moving in the district, appealing to her past teaching experiences using similar IGIs.

During this interview, Mrs. Cook also reiterated the impact that not having a tested subject has on her documentation. Without a state test, she can select and use resources without the same pressures like instructional oversight that Biology teachers face.

> Oh yeah, our poor biology people cause. I mean, yeah, for the rest of us, it's terrible. We don't like it, but. Biology is the tested course. If I screw up, there's not much recourse other than do better. But when all of the testing falls to them, it's awful. [...] So I am rolling with the new standards, but I gotta be honest, until testing comes back I will do my job and I will cover what I need to cover. However, I'm not gonna cover it like we used to have to for a test. I'm gonna cover this: what is the most useful is problem solving skills. By far outweighs stupid memorization tricks.

In this way, Mrs. Cook selects and implements instructional materials that align with her primary instructional priority: supporting critical thinking. Whereas the content on a test might act as a filter for some teachers, her evaluation of instructional resources privileges those resources that provide opportunities for her students to analyze and solve problems. While the GCSCC did not contain a Chemistry collection, Mrs. Cook would likely have applied this prioritization of student reasoning to resources from any source. Had she deemed the GCSCC resources to insufficiently support this instruction priority, she would likely have privileged other resources from sources that she had used in the past to achieve her desired outcomes.

Mrs. Branson (FHS)

Background. Over her five-year career at GCS, Mrs. Branson has taught at three different schools. After earning a degree in Biology, she spent some time working in a warehouse while her sister worked as a teacher at a nearby school. Assisting as a volunteer in her sister's classroom sparked Mrs. Branson's interest in helping children. She first taught at GCS middle school for two years, then transitioned to the district's virtual school where she taught 6th grade science. One year later, she moved to FHS, where she is in her second year teaching Biology, AP Environmental Science, and Marine Science.

During our interview, Mrs. Branson noted differences across the schools at which she has worked. For example, she enjoyed the level of collaboration with colleagues when she taught at the middle school level; by contrast, she feels that her current high school position gives her fewer opportunities for collaboration.

> I really liked how collaboration worked when I was in middle school. We could build new things. We could really work well together, because it didn't feel like, oh, this was all on me. We could spread the load and not have to work so hard by ourselves. And so

that was really nice, having that team that I could depend on. But I do like high school kids better. So I will take the working alone than the team for the student population.

Further illustrating this relative isolation, she described efforts to collaborate with other Biology teachers during weekly department meetings, only to find resistance. Conversely, at the virtual school, she felt she had a wide range of instructional support staff with whom she could collaborate even while working from home.

Despite her feelings of professional isolation, Mrs. Branson inherited a set of resources from the Biology teacher whose positions she filled when that teacher retired. These resources include guided notes that she uses to structure her instruction. She described a typical day in her classroom in this way:

> So typically, when we start a unit, we go over some notes to supplement them. And other activities, like, I use Gizmos, which is a, almost kind of like a digital lab type of platform. Our school has purchased that for science and math teachers, so it's been something that I like to implement and use. And the kids like to reference it too, so that's something that I've noticed. And I like that they have another resource that they can use other than notes, or me, or other things. So, usually we start with notes and we'll move into doing a worksheet together, just to, you know, kind of show them their gauge, their understanding. See what they've picked up, and then they maybe, like the next day or so, they would move on to doing something like a Gizmo by themselves to try out what the new material that they've learned. [...] Yeah, and like, I try to start the first… It's like the warm up page. We'll start that together, and then I will set them free, and if somebody needs more assistance, I'll go to that student specifically and kind of help them get

started. But I think they kind of like having that start with me. It makes them feel more confident to do it by themselves.

In addition to guided notes, online simulators, and worksheets, she implements some hands-on activities with students.

> I try to do as many [labs] as I can, but with time constraints, you know. Sometimes I don't do as many as I would like. For some of my Bio labs, I've done like looking at osmosis with a gummy bear watching it grow overnight, and then adding salt to it and watching it shrivel. They found that really cool and interesting and then something I do with the very beginning is they compare a gummy worm, earthworm to each other, and kind of look at the characteristics of life, and just kind of do a kind of experiment. See whether that worm likes a rough surface, or smooth, wet or dry. You know. Just kind of just getting their interest in. Yeah, this is the start of a school year. Try to get them hooked into Bio hopefully.

While she incorporates some hands-on experiences for students, she expressed some discomfort with the idea of giving students autonomy with physical materials. For example, she described some hesitancy with using one lesson from the GCSCC that used socks to simulate chromosomes.

> I taught one section last year of biology. And then this year, I've taught it a little bit more, and so I'm getting more comfortable and more confident in it. [...] It's just been kind of a growing process of how to adapt things and perfect my biology before I start going more out of my comfort zone. So I feel like now that I would be ready to do a little bit more of the, you know, building things with socks and have chaos in my room, and be able to handle it. Now that I feel a little bit more confident in it. But yes, there are some things

> that I have been hesitant, just because I was still trying to get my footing with my biology. [...] So, yeah, I just, I wasn't quite sure how the kids would do, because, you know, they throw pencils at each other. So hitting each other with a sock. So I just wanna be a little bit more in my element before we venture there.

By expressing a desire to build more of a comfort level with biology before venturing outside of her comfort zone, Mrs. Branson illustrates how her previous years of teaching middle school and at the virtual academy did not provide her with a set of documents that she could easily translate into this context. In some ways, her professional work restarted when she began both teaching a new content area and with a new age group all without the social support structures to which she had become accustomed in her previous contexts. This need for foundational resources to establish an initial set of documents set the stage for her use of the GCSCC.

Documentational Genesis with the GCSCC. Mrs. Branson's depiction of her use of the GCSCC positions her as a power user, accessing and implementing resources extensively in her work. She first learned of the GCSCC during a beginning teacher meeting while working at the virtual academy. Having had few prior resources from which to draw for her 6th grade curriculum, she found the 6th grade science collection vital to her work during that time.

> Not having any background in teaching sixth grade, it was an awesome resource to get my footing and kind of to build my own lessons and build what I, you know… Like teaching about the eye. I had forgotten everything about the eye. So I had, you know, it was really cool to have resources to start with, and then I was able to find my own and build from there. So it was good to also see what I needed to teach and what the highlights were. [...] It was nice to feel like I had something to lean on whenever I was

definitely home by myself teaching something new. So that was really something nice there!

Her use of the GCSCC in this way largely mirrors the vision for its use shared by others in the district like Mr. Collins and Mrs. Cook. Having no foundational set of documents from which to build, Mrs. Branson used the GCSCC's resources as a starting point to build documents, adding on to the lessons with her own resources to meet the specific needs of her context.

While the GCSCC served as the foundation for her work with the 6th grade science curriculum, she found the Biology collection less impactful. She largely attributed this to the fact that the 6th grade collection contained more resources covering more of the state standards than the Biology collection.

> It does feel like the biology content, more so than others, I feel like, maybe it doesn't hit all of the standards. But, like I said, I'm still trying to perfect my biology teaching. So they might know something I don't know, or I might be doing too much. I would like to see if that, if the collection is built towards what the kids just need to know for the exam, or if it's built to pique more interest. [...] When I go there, and I'm looking for a resource sometimes, I don't even see it in the collection. So I'm kinda like, oh, well, do I need to be teaching that? So that's one thing that I do question because I like, I was teaching dihybrid crosses, and that's not on the exam. And I did not know that. And so then I was like, oh, well, I don't have to teach that. That's great, because that is a monster. Oh, it's not! It's easy. Once you've sat down and done it a couple of times. But to get the kids to buy into that was, it was a little challenging. So it was nice then another teacher was like, hey, they don't need that. And I was like, Oh, thank gosh! Because I didn't know."

The relative incompleteness of the Biology collection presented challenges for her documentational genesis not only by providing fewer resources than the 6th grade collection, but also by challenging Mrs. Branson's understanding of what content she needed to teach. Having leaned on the 6th grade collection to inform her comprehension and organization of the curriculum, she found that the Biology collection's relative incompleteness confused her efforts to make sense of what concepts she needed to teach.

The comparative usefulness of the two collections used by Mrs. Branson sheds some insight on a finding from Phase 1 of this study; teachers engaged with the four collections to different levels, with the 6th grade collection having the most page views and the EES collection having the fewest. This finding can in part be explained by the fact that the 6th grade collection has the most resources, while the EES collection has the fewest. A collection with fewer pages would naturally have fewer page views even if the levels of traffic in each page across the collections was similar. Yet Mrs. Branson's frustration with the unavailability of Biology resources that cover every state standard demonstrates that a mechanism exists by which the degree of completeness may correspond to the degree of usefulness, particularly for teachers looking for a foundational set of resources from which to establish their documents. Her reliance on the 6th grade collection illustrates how a more complete Biology collection may have contributed not only to a greater number of available resources, but also resolving some ambiguity about the scope and sequence of a curriculum she had never previously taught.

While the incompleteness of the Biology collection presented some challenges for Mrs. Branson, she still actively uses the resources in her teaching. Unlike other teachers I interviewed, she both pulled pieces from the collection and used full lessons as written.

> For the most part I can usually mostly use it as is, but there are times when I'll tweak it, or not use all of it, or just use part of it. [...] I think they had several things on earthquakes, but I had only picked the ones that I had really liked, that I thought would build the kids' interest. So I would definitely use, sometimes I'll use all of it. But majority of the time, I would just pull pieces that I thought would benefit my kids. [...] And the bio curriculum. I usually, if I find a resource, I usually kind of can use it as is.

After establishing her initial set of documents, her use of the Biology collection transformed from a set of resources to more of a reference, ensuring that she taught each component of a standard.

> If I'm wanting to supplement something, I do still use it now, if I feel like I need it, or if I just want to see what they have laid out for that concept or unit. I do like to just kinda to reference it sometimes, just to make sure that I'm hitting all the high points. But I don't actively use it a lot as much as I did when I first started teaching that subject. But it is a good reference point that I do use from time to time.

In this way, Mrs. Branson used the Biology collection extensively to establish her initial set of documents when she taught the subject for the first time. After she had created her first set of documents to teach the course, her use of the collection shifted from a set of instructional materials to more of a guiding framework for her teaching. Like Mr. Martinez, she used the collection to compensate for a lack of a school or district curriculum or pacing guide.

IGIs. Like other teachers I interviewed, the state test plays a substantial role in shaping Mrs. Branson's decisions about what resources to use and how to use them. For example, when discussing her use of the Biology collection, she appealed to the exam when considering dihybrid crosses. When a colleague informed her that the state test did not cover this topic, she

felt relief because she no longer felt the need to teach that topic. Similarly, when discussing the hands-on resources she hesitated to use, she mentioned time pressure as a major influence on her decision-making about which resources to use. She later elaborated on the source of this pressure:

> But definitely, there are some resources that are hands on that I want to explore more, but I have been a little reserved, as trying to get through the pressure of getting through content for the [state exam], and things like that. I'm gonna be honest, the first time I taught it, we did not get through nearly as much as I had wanted to. And then, previously, last semester, I got, we did better, but I still spent way too long on cells. And so I definitely saw that I needed to shorten that. And then this semester has been a lot more smooth. Hopefully, we should get through all the highlights, all the main units before the [state exam] this time. So that makes me feel much better.

This quote illustrates the tension she feels between the pedagogical practices she would like to use and the amount of time available to cover all of the content on the state exam. While she felt some reservations about some GCSCC resources due to behavior concerns and feeling outside of her comfort zone, those factors remain within her influence as a teacher and may evolve as she gains experience. However, the state exam represents an IGI over which she has no influence. She therefore feels the need to make decisions about her own practice, prioritizing a breadth of content coverage over resources that she believed would prove less effective for helping students prepare for the exam. This mirrors a similar tension experienced by Mrs. Meyer, whose background using phenomenon-based teaching did not translate directly into her current context due to incoherence with the state test. Had the GCSCC more explicitly aligned

with the learning objectives tested by the state exam, these teachers may have implemented more of its resources.

In addition to the state exam, Mrs. Branson discussed another IGI that directly influenced her use of the GCSCC. Namely, Gizmos served as a set of instructional materials that directly competed with the use of the GCSCC. The time pressure Mrs. Branson experienced meant that she needed to make critical decisions about which resources to use during the limited time in which she had to teach. She indicated that school administrators put some pressure on teachers to teach with Gizmos: "Since they've purchased it, they definitely want us to use it." Additionally, the readily-available worksheets included with the platform gave Mrs. Branson a set of resources that she could quickly deploy with little adaptation, much as she did with the 6th grade science GCSCC collection at the virtual school. Whereas administrators encouraged her to use Gizmos, she did not indicate any direct pressure to use the GCSCC resources. In this way, a set of instructional materials directly competed with her use of the GCSCC.

Fall Updates. While Mrs. Branson drew extensively from the GCSCC during the previous school year, she had largely moved away from using the resources at the time of our Fall 2023 interview. A veteran teacher began teaching Biology at FHS, and she shared an extensive set of resources with Mrs. Branson. While she felt that these resources could feel "kiddish" at times with cartoony animations, she appreciated that the new resources expanded her pedagogical horizons.

> You try something new. As I told the kids, because I'm doing it, I'm doing it very differently than I thought last year. So I'm out of my comfort zone a little bit, but we're making it work.

As an example of her implementation of this new curriculum, she described a scientific method activity that she had used the prior year. She felt that the activity took too much instructional time, so instead of adapting or reusing the lesson, she tried a new activity that taught similar concepts using a simulation on Gizmos.

> I think the kids kind of had a little bit more fun manipulating that, because before, we just grew bacteria and compared it with hand sanitizer versus soap. That's pretty cool, but I feel like it took days and it took a lot longer. This way, we're not wasting time about something that's less important, so I do like that. We're maybe taking out a little bit of the fun, but they're having fun in their own ways. I fear that kids don't like Gizmos too much. But then I see them going back and using it, like when they're doing other assignments, and then I actually heard a kid say that they secretly like Gizmo. So that made me feel a little bit better.

Mrs. Branson's characterization of this activity also belies the tension she feels about the time it takes to implement lessons that she believes students will enjoy. She forewent one such lesson in favor of a lesson that took less instructional time, allowing for more time to focus on tested content.

Further elaborating on this tension, she described her documentation process with her Marine Science class which not only does not have a state test, but also does not have a set of state standards. Instead, she provides students with the opportunity to advocate for what they want to learn about Marine Science. She then seeks resources primarily through Google to teach students about the concepts that they surface. Having no specific curriculum or testing pressure helped her feel more relaxed in her documentation for this course.

> I feel like it's a little less constrained. Like if they are really interested in something, we can dive deep in it, and we can spend as much time as we want on it, versus I feel like I'm in this little box that I've got to make sure that we get through on the timeline in regular biology, because I think they said that they give us five days to teach those. So I'm trying, you know, that's five days of, you know, in a test and review and all that's got to be in there too. So it's a, it's a bit different. I can't, if they're really interested in prokaryotic cells, we can't dive deep into learning about the history of the prokaryotic cell versus, you know, they are really interested in megalodons. You know, we learned about the history through time. That we can dive deep into megalodons and learn about all the things that they want to learn about them. But so that is, I do like that it's feel is very free, more flexible. We can kind of learn what they want to learn, so I do, and I try to make it that way so that they are invested.

Further contrasting her Biology and Marine Science courses, she indicated that the district communicated an expectation that all Biology teachers follow the new pacing guide during an initial meeting of GCS science teachers at Frontiers .

> They kind of mandated it district wide this year, like this is what you need to be teaching and when you need to be teaching it so that, if students move around, that they can follow and let you know we're all on the same page so someone doesn't get taught evolution twice or cells twice.

This requirement to follow the pacing guide may have directly influenced Mrs. Barnson' use of the GCSCC. While many beginning teachers used the GCSCC as a guideline for content and pacing, the new pacing guide did not necessarily follow the same sequence and structure as the GCSCC. As a result, she only visited the GCSCC once that semester prior to our interview and

did not use any resources she found. As a means of instructional oversight, the district expressed a requirement that all Biology teachers use the CFAs they developed. At the time of this interview, Mrs. Branson had not yet implemented any of these assessments.

This departure from her previous patterns may also be explained by changes in her school IGIs. She noted that a new principal had started at FHS that year who required all teachers to incorporate six teaching practices like writing learning objectives on the board and using exit tickets as a form of formative assessment each day. These objectives did not directly align with the structure of the GCSCC, and some objectives like exit tickets directly conflicted with the structure of some of the multi-day lessons the GCSCC contained. Any GCSCC resources that a FHS teacher wanted use, therefore, would require significant adaptation to incorporate into their context. Further supporting this view that the GCSCC resources did not readily fit into her context, Mrs. Branson described ideas that she felt would make the collections more useful for her teaching.

> So maybe having standards there with what we're teaching, that would help. And then maybe even have additional resources for if you didn't like what they had already planned out, that other interesting things that they have that could still be used, or, you know. Even websites that we could go and reference because, you know, sometimes it's just, even if a new teacher comes in, just having a place to start, a place to begin. So that's really nice too. But yeah, just having some, maybe more supplemental resources. Because they have some, but it's not nothing that I would go home and talk all about.

Her desire for the resources to connect explicitly to the state standards may help more readily align the resources with the pacing guide, which lists the standards that teachers should incorporate during each instructional unit. Similarly, adding alternative resources can make the

collections more adaptable. As Mrs. Branson gained experience and familiarity with her content, she expressed a desire to try new ideas and resources in her work. She believed that, rather than a single robust lesson for each standard, the collections should align standards with a selection of resources, allowing her to select and try new resources that may better align with her context.

Mrs. Hughes (FMS)

Background. At the time of our Spring interview during the 2022-23 school year, Mrs. Hughes approached the end of her first year as a teacher. While she taught 6th grade science for one semester to cover for a vacancy the previous fall, she primarily teaches math at Fremont Middle School (FMS). Despite similar demographic data, students at FMS generally perform better in science than at FHS with 64% of students achieving science proficiency - only 3 percentage points below the state average. Additionally, 47% of teachers at FMS are designated as "needs improvement" -- far fewer than at FHS. As with other parts of the county, however, Mrs. Hughes reported relatively high levels of teacher turnover and difficulty filling vacancies. When a 6th grade science teacher retired at the end of the 2021-22 school year, the position remained unfilled for an entire semester.

As the teacher who taught one 6th grade science class in addition to her three math classes while administrators searched for a teacher to permanently fill the vacancy, Mrs. Hughes found herself working with 40 students in a classroom as a teacher in the first semester of her career. She studied Middle Grades Math in college, so other than enrolling in a few college science courses during her undergraduate studies, she had little experience with science instruction. To support her during this time, another science teacher in the building provided her with teaching resources that she could use as well as ongoing support with their implementation.

> So we're split into 2 teams. So there's, each of the core subjects on one team, each of the core subjects on the other. And a science teacher on the other team, she gave me a lot of her resources that she had just accumulated. Because she's close to 10 years, I think, in teaching.

While she used these resources extensively during the semester, many of the resources did not align with her beliefs about teaching.

> But then her teaching style and mine did not match up. [...] For an example, she would have a Powerpoint, I know, and have a couple of words on it. And it'd be like alrighty, I can say those words. But then it'd be like, okay, I need to expand. But I don't know enough science, so I cannot expand on this to be able to do that. Or it would be like, she had the kids cutting stuff and gluing. I'm sorry. No, we are not cutting and gluing. This is not our class, like I'm just not built for that. And I know that's so simple. But that activity then was supposed to take one or two days. Well, now I have a two day gap that she has, that I don't.

In addition to this illustration of her philosophical differences with her partner, she described tensions around the role that technology played in her classroom: “I am anti-technology pretty hard. So then I would be like, no, we're not gonna do a video collage thing because we don't have my iPads in my class.”

Reflecting on her experiences teaching science during that Fall semester, she expressed a generally positive attitude.

> I feel like with science, you have a lot you could do. So much, you know, like I feel like you have a lot of really cool opportunities in science. And like for me, like since it's not like my most favorite thing having to sit down and figure out what’s gonna be most

> beneficial was the biggest struggle. And to, like, figure out I want to do for labs. I want the kids to be hands on. But figuring out how to do that is just, I just, I couldn't figure it out. I can't. I mean, my brain just does not process that, so I think it's cool when people are able to do that and show kids that because I think science is a great culmination of the math and the ELA, because you need both of those to be able to do that. [...] I think my math classes had a lot more structure, and that was designed because math, I feel like is very structured. You're right or you're wrong. Like it just is what it is. And then science, because I went into knowing I wanted them to do labs, knowing I wanted them to engage and do stuff with their hands like actually be a part of it, there was a lot less structure in the class where they could kind of be free and try those things.

Her characterization of science instruction communicated admiration for the subject as well as a fuzzy vision of what she wanted her instruction to look like, focusing on hands on labs. As a first year teacher who primarily studied math instruction, she felt unable to create the kinds of experiences that she wanted students to have. Negotiating her need for science instructional resources with philosophical differences with the resources used by her fellow science teacher, Mrs. Hughes turned to the GCSCC.

Documentational Genesis with the GCSCC. Mrs. Hughes turned to the GCSCC as a means to learn the basics of science instruction as she temporarily filled in for a course to cover a vacancy.

> I needed stuff to come up with, and I would dig through the science stuff that they have provided, and I would use that as a resource that way, trying to navigate where we were like where the science teacher was and then where like the module that matched.

For Mrs. Hughes, knowing that the resources were curated by the district influenced her decision to explore its resources.

> I knew, like, this resource had been approved by the district, so it had merit. I knew it was gonna be good. And so, like, just Googling stuff is not the best, especially if you don't know how to filter out the garbage, which I don't with science. So I use it as a good way to filter. Ok, oh, so this is how this and this works. This is how this works. So it helped me gain an understanding as well as it helped me get some ideas and help push off for the next few days.

While navigating the GCSCC, she experienced a number of navigational barriers that inhibited her ability to access some of the resources.

> The clicky buttons weren't working like on the home page. If you're like, resource modules, like some of them, work where if you click on the module picture, it'll take you there. But you just have to go to the modules, and it shows up.

Even when she found the resources she was looking for, she experienced difficulty interpreting the information due to the size of the collection.

> But then, like if you click on like lesson one, for example, there's a lot of lesson materials and resources in a huge old list. And like, I remember thinking even back then, like looking through it, it's a lot to digest. As well as like, how many days is it supposed to be? It's less than one. Only one day. Is it multiple days? And just breaking that down and seeing, what are the keynotes, was the hardest part. [...] It's just a lot to digest all at once. That's like my biggest thing, I think. Looking at it, you can tell it's well put together. There's a lot of thought, a lot of effort and good content. It's just a lot to digest. Knowing where to start was the hardest thing with it.

For a teacher with no prior experience in science education to navigate a large set of resources proved overwhelming for Mrs. Huges, especially given her unfamiliarity with the content and state standards. The challenges presented by navigating and interpreting these resources limited the impact that the collection had on her actual instruction.

> It's why I didn't probably use it as much as I could have. It's like, what? Okay, so Monday, what am I doing? Tuesday? And I know like it varies and stuff. But like even just knowing, this is a 3 day lesson. This is a 5 day lesson. That kind of stuff, I think, would have been helpful in seeing that breakdown even more so.

As a result of these challenges, Mrs. Hughes primarily used the collection as a set of guideposts for her to develop her instruction.

> Yeah, it was mostly inspiration if we're being honest. [...] It's a lot to digest, which is a good thing, because there's a lot of detail. But there's just a lot to digest. So, knowing me and knowing how overwhelmed I was at that time, and I was like, no, okay, I see this idea. I can do this. We're good for another day or two. Like, I can supplement here and there.

In addition to the navigation issues and challenges with interpreting the large volume of information contained in the GCSCC, Mrs. Hughes also encountered similar differences of pedagogical philosophy with the GCSCC as she did with her fellow science teacher. Specifically, Mrs. Hughes prefers analogue resources over the digital resources that permeate throughout the collection.

> Digital citizen is, I know it's a big buzz thing in all of education right now. They need to use good technology and all that stuff. It's just so not me. So not me! Part of it is I may be new, and I don't know how to tell when they're doing what they're supposed to on their

> iPad. I'm gonna be completely honest. But part of it, too, is, I think, they're on their iPads too much, and they use them as a crutch to do other stuff. And I think that there is so much benefit of paper - pencil in terms of just memory, in terms of this, that, and the other. That, yes, there is a place for technology, but I don't think it should be the center of class every day all the time.

According to Mr. Collins, the lesson developers for the science GCSCC intentionally included digital resources as a means to leverage the technology that the district had invested so much money into and to ensure that any teacher could use the lessons regardless as to which classroom resources they had access. This inclusion of digital resources created a tension point for Mrs. Hughes, contributing to her relatively low levels of use of the GCSCC lessons.

IGIs. The tension that Mrs. Hughes experienced with the substantial focus of the GCSCC on digital resources highlights one way in which an IGI influenced the development of the GCSCC in a way that limited its use by Mrs. Hughes. As Mr. Collins described, the district invested a substantial amount of resources into developing its technology infrastructure by ensuring every student had a device. Whereas each student had a MacBook Air when the technology initiative began, the cost of the devices led the district to move to iPads instead. Since that time, much of the district messaging about resources has focused on digital resources, encouraging teachers to leverage the iPads in their instruction. While the district purchased some science-specific digital resources like Discovery Education and Gizmos, much of the professional development and purchased resources emphasized utility across the disciplines. This approach to professional development and resource access represents a prioritization of efficiency over discipline-specificity, favoring the purchase and use of fewer, more robust resources over discipline-specific resources. Not all teachers had access to the same

lab equipment in their schools, so the district encouraged GCSCC developers to use resources that they could guarantee all teachers would be able to access. Yet this prioritization of technology and scalability resulted in a tension between the available resources and Mrs. Hughes's vision of what good science instruction should look like, contributing to a limited use of the GCSCC's resources.

Despite the role that a technology focus played in limiting Mrs. Hughes's use of the GCSCC, she characterized her science teaching as giving her more agency than she found in her math teaching. In an effort to improve math scores across the district, GCS purchased a math curriculum that gave teachers 80% of their curriculum, only allowing them to implement resources of their own choosing 20% of the time. By contrast, no district policy explicitly limits science teachers' agency over which resources they use and how they use them. Like other teachers I interviewed, Mrs. Hughes could choose whether or not to use the GCSCC resources; yet incoherence with her own beliefs and other IGIs led her to use the GCSCC primarily for inspiration instead.

Her alignment with the other science teacher and unfamiliarity with the science curriculum also played a role in her use of the GCSCC.

> I had to go at the pace of the other science teacher. So when she told me it was okay to move on, that's, we completely, like, I had to wait for her. She told me at the beginning, there are some standards we're not gonna cover because we don't have to cover them. And I was like, alright. I don't know what those are. I don't know how it's gonna look, but alrighty. And then, because she knew all that extra information, I had to come up with things here and there. So like we did like a review game, or like a reading activity on the scientific method, for example, that she didn't initially do, and that kind of played into

> some other stuff just because we couldn't move on yet, because we hadn't been given her resources. Nor did we know where we were moving on to, the next thing. Like, I had no idea. Like, okay, we did the scientific method. For all I care, let's do space. Like I don't even know if that's a sixth grade thing.

Had the other science teacher encouraged her to use the GCSCC resources or refrained from insisting that they maintain pace, Mrs. Hughes's documentational genesis may have differed. Furthermore, her description of her science teaching that semester suggests that she received little direct guidance on state standards or curriculum, let alone pedagogical best practices specific to science instruction. This left Mrs. Hughes with only a vague understanding of what she was expected to teach and how. An IGI designed to support her with exploring and learning about the 6th grade science curriculum may have alleviated her feelings of overwhelmedness at the sight of the GCSCC, thus removing a barrier to its use. Instead, Mrs. Hughes struggled to gain her footing while teaching an unfamiliar subject.

Further complicating these factors that limited her use of the GCSCC was the fact that she had little prior teaching experience, coming straight out of an undergraduate education program. This meant that not only did she need to establish an initial set of documents for the science course, she also simultaneously established her documents as a math teacher. She alluded to the tensions this caused when asked whether she might use the GCSCC differently if she taught science again:

> But now that I know what to expect a little bit better with math, I can kind of put that on a back burner. So I can really focus in on the science and see, ok, pacing guides suggest this, this, and this. I need to have this and this, and I can make these connections. I can draw here. So I would really look more into that, the provided curriculum, as well as

what else exists. [...] So I would do that much differently, just because I could make it more of a priority than I have been able to.

Mr. Collins indicated that he envisioned the GCSCC serving the greatest purpose for those teachers who found themselves in positions like Mrs. Branson and Mrs. Hughes. While the collections provided different kinds and levels of guidance for these teachers, factors including other IGIs created incoherence that limited its usefulness for these teachers. Attention, then, should be given for similar projects to ensure that the design and layout of resources meets the needs of teachers in these situations.

Still, Mrs. Hughes spoke highly of the GCSCC. The simple fact that it existed gave her some comfort with the knowledge that the district provided resources to support her work.

I do have to say it was, even though I didn't maybe use as much as I could, it was nice, knowing that the county had something prepared for me. And knowing that, like, looking at, it wasn't garbage that was prepared for me, like knowing it was something of quality, something that looked like it could be done. I think if I had been given a little bit more, like if the other teacher hadn't maybe told me to wait for her, and that kind of thing, I would have probably followed it one and beyond. [...] Specifically, because of the way it's set up, it looks like it should flow. Well, and it looks like, it took a weight off my shoulders, walking into it, knowing like, this is not something I know anything about, or feel any confidence. So like having that there is definitely appreciated, especially as a first year, or someone who's new to the profession just that way. They have that support in place, you can always go back and look at it. And I mean, even me. I could go back and look and see, oh, they've learned about this, this, and this, and I can steal stuff from it even from a math perspective. To say you learned about rocks or whatever, and I can tie that into whatever it is we're doing. So having that is appreciated.

Fall Updates. After teaching science during the Fall 2022 semester, Mrs. Hughes did not teach another science course and therefore did not participate in the follow-up interview the following Fall.

In what ways did science teachers use the resources and / or framework from the GCSCC, if at all?

The findings from Phase 2 of this study highlighted key differences in the ways in which beginning and experienced science teachers used the GCSCC. For beginning teachers and teachers who had little or no experience teaching a specific subject, the GCSCC provided a framework for organizing their curriculum whether these teachers used the resources or not. When new IGIs were implemented at the beginning of the 2023-24 school year, these teachers' use of the GCSCC shifted to align with the new IGIs. For experienced teachers who had already established documents in alignment with their curriculum, the GCSCC served as a place to try a new resource or two with little overall impact on their practice. In the following sections, I outline how beginning teachers used the GCSCC differently than their more experienced counterparts including the prompts that led them to search the GCSCC, the ways in which they interpreted its resources, the adaptations they made, and the ways in which they implemented the resources they found.

Beginning Teachers' Documentation Using the GCSCC

Of the six teachers who participated in interviews for this study, three had fewer than three years of prior experience teaching their current subjects. Mr. Martinez taught full time during the Spring of 2022 in another district before starting his first full year of teaching Biology at BHS that Fall. Mrs. Branson had taught science for several years before starting her position as a Biology and Marine Science teacher at FHS, but her prior experience was spent in middle

schools including a traditional and a virtual school; transitioning to high school Biology required her to establish new documents, as her old documents did not translate readily into her new context. Mrs. Hughes primarily teaches math at FMS, although she taught 6th grade science for one semester during Fall 2022 to cover a vacancy at her school. In this way, each teacher began the school year with a similar need: to establish an initial set of documents that they could use to teach their content in their new context.

As they began their documentational trajectories, each of the three beginning teachers received support from other teachers in their building. Mr. Martinez received a set of instructional resources from a 30-year veteran teacher at his school who served as his mentor, checking in on him periodically throughout the year. Mrs. Hughes not only obtained a full curriculum from the only other teacher at her school teaching 6th grade that semester, but also received ongoing mentorship with the expectation that she would teach at the same pace as her partner teacher. While Mrs. Branson found herself in a less collaborative environment, she also inherited a set of teaching resources from the teacher whose position she filled due to the former teacher's retirement. While the three teachers received resources, each of them noted tensions around the use of those resources. Mrs. Hughes generally avoided using iPads in her teaching, yet her partner teacher used them regularly. While Mr. Martinez used the resources he inherited, he indicated that many of the resources focused on mini labs which he did not yet feel comfortable facilitating. Mrs. Branson expressed a similar discomfort with hands-on activities, feeling a lack of confidence in her ability to manage a classroom during such lessons. In this way, all three teachers felt the need to find more resources to guide their instruction and help them establish their initial documents, leading them to the GCSCC.

As they searched the GCSCC, they interpreted the resources in varying ways and implemented those resources to different degrees. Mrs. Branson had used the collection extensively when she taught 6th grade science at the virtual school: "Not having any background in teaching sixth grade, it was an awesome resource to get my footing." This familiarity and trust with the resources led her to implement many of the Biology collection's lessons, often using complete lessons as-written with minimal adaptation. However, the Biology collection did not contain resources for all of the Biology curriculum's learning objectives. This incompleteness led her to search for additional resources from a district Gizmos pilot, which she came to rely on more than the GCSCC due to its coverage of all of the state standards. This meant that the GCSCC became relegated to reference resource rather than the foundation for her documents like she had found when she taught 6th grade:

> I do like to just kinda like to reference it sometimes, just to make sure that I'm hitting all the high points. But I don't actively use it a lot, as much as I did when I first started teaching that subject. (Mrs. Branson, Spring 2023)

In this way, Mrs. Branson evaluated the resources as being of use to her documentational genesis based on her experiences with another subject. However, when it came to establishing her initial documents to teach Biology, the collection's incompleteness limited her implementation of its resources.

Mrs. Hughes similarly viewed the collection as a good foundation, trusting in the district's endorsement of the collection as evidence of the strength of the lessons. Having no formal training in science education, she doubted her ability to search for and evaluate resources on her own. In her words:

> I knew this resource had been approved by the district, so it had merit. I knew it was gonna be good. And so, just Googling stuff is not the best, especially if you don't know how to filter out the garbage, which I don't with science. (Mrs. Hughes, Spring 2023)

However, her inexperience with science content knowledge also led her to feel overwhelmed while searching and interpreting the collection, resulting in her implementing few of the actual resources in her teaching. "Yeah, it was mostly inspiration if we're being honest. [...] It's a lot to digest, which is a good thing, because there's a lot of detail. But there's just a lot to digest." The time investment required to interpret the GCSCC resources led Mrs. Hughes to seek other resources that required less interpretation, thereby impeding the GCSCC's usefulness for her documentational genesis.

Mr. Martinez similarly implemented few of the resources he found in the collection, citing concerns about his interpretation of the amount of class time required to implement the lessons. When he taught Biology for the first time during the Fall of 2022, he ran out of time in the semester and could not teach all of the content in the curriculum. As he browsed the GCSCC resources, he interpreted the Launch-Explore-Discuss-Land framework that structured the lessons as too time-consuming, leading to his evaluation that the resources would not help him meet his goal of covering all of the state standards.

> I just felt like it would take forever […] It's just like, observation, observation, observation. And then, near the end, it's just like, hey, let's put this thing together and try to see what you learn. And it just felt like it was taking forever to actually get to the point. (Mr. Martinez, Spring 2023)

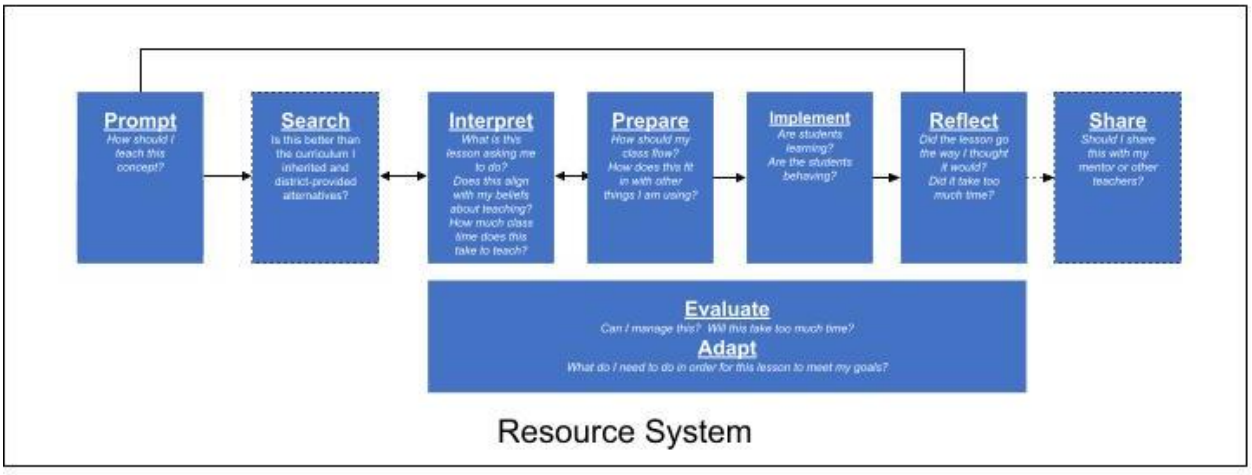
This tension was echoed by Mrs. Hughes and Mrs. Branson, both of whom wanted to teach more "hands-on" lessons that incorporated more student exploration and laboratory materials, yet felt

tensions around the time such lessons would take and their own classroom management abilities. While all three teachers' interpretations of the GCSCC resources surfaced different barriers to their use, each teacher evaluated the resources to be similarly misaligned with their goals for documentation.

Despite these challenges for the implementation of the resources, the three beginning teachers found a different use for the GCSCC. All three beginning teachers described using the GCSCC as a guide for interpreting the scope, sequence, and vocabulary for the curriculum they taught. While the three teachers had different levels of teaching experience and familiarity with the science content they taught, each teacher found themselves needing to establish a new set of documents for teaching a new subject. They discovered that part of establishing their initial documents meant establishing what concepts their resources should and should not include. I will return to this point in a later section exploring the role that IGIs played in shaping their documentational genesis. I mention this point here to highlight how the usefulness of the GCSCC for the three beginning teachers' documentational genesis did not align with the initial vision of providing teachers with a set of resources that they could readily implement with the exception of Mrs. Branson's use of the 6th grade collection in her former context. Instead, the GCSCC served as more of an IGI for these teachers, shaping their documentational genesis with other resources that the teachers evaluated as being more fit for their practice. The teachers based this evaluation on one or more features of the GCSCC that they interpreted as misaligning with their instructional goals and requiring too much time to adapt relative to other resources.

To illustrate how the beginning teachers' decision-making processes can influence each stage of documentation, I created Figure 8 by adding guiding questions that surfaced in the

Figure 8. Beginning Teachers' Documentation Using the GCSCC



interviews with beginning teachers to the logic model in Chapter 2. I will contrast this model with that of experienced teachers in the next section.

Experienced Teachers' Documentation Using the GCSCC

Whereas the beginning teachers' documentational genesis using the GCSCC as a guideline to establish initial documents, the experienced teachers I interviewed demonstrated a general evaluation of the GCSCC as having value for their documentational genesis. Mrs. Mason and Mrs. Meyer worked on the same team teaching 8th grade science at BMS where they co-planned lessons and assessments. Mrs. Cook taught science for over 23 years during which she taught most science subjects, although mostly taught Chemistry at FHS at the time of the interviews. While a set of Chemistry resources were never developed for the GCSCC, Mrs. Cook spent some time exploring the EES collection and shared her thoughts on these resources.

Having taught their subjects in their contexts for several years, these teachers had developed a familiarity with the curriculum and had a substantial amount of time to refine their documents by experimenting with resources and teaching strategies. As Mrs. Mason described,

> I've already taught sixth grade plenty of years, and 8th grade plenty of years, and seventh grade plenty of years. So I already have pretty much the curriculum down, you know. I've already got the assignments. I've already got the assessments, already got everything that I need. (Mrs. Mason, Spring 2023)

In other words, these teachers had progressed farther along their documentational trajectory and learned more about the resources that worked in their context through instrumentation.

Despite having a foundational set of documents, each of the three experienced teachers expressed an openness to trying new ideas and regularly searched for new resources to refine their documents. This mindset led each of the three teachers to search the GCSCC when the district announced its launch. Mrs. Mason and Mrs. Meyer worked during the summer of 2022 to co-plan their instruction for the following year. When they checked the 8th grade science collection in the GCSCC, however, they found it empty. Mrs. Mason recalls the story this way:

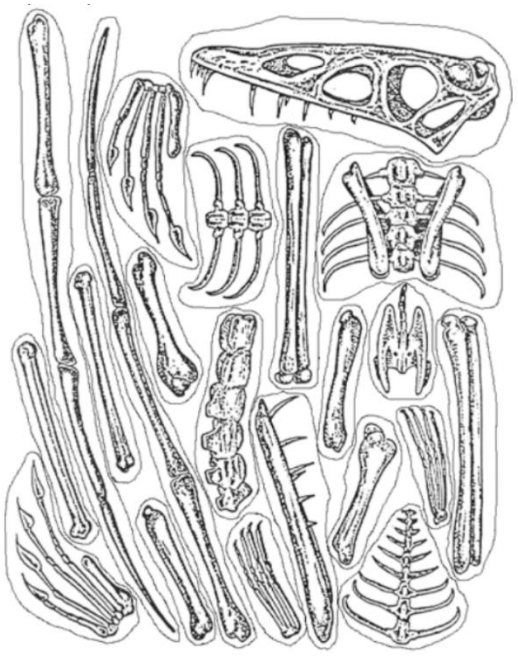
> So they'd say, oh, yeah, it's all there. [...] And I go, and it would be empty. So at the beginning of the year we looked, and it was empty. And I said, Okay, well, that's a waste of my time. So I didn't even go back to look at it until about three weeks ago, when someone was like, oh, yeah, no, there's stuff there. And I was like, huh! No, I don't believe you. So I went. (Mrs. Mason, Spring 2023)

The “someone” who prompted them to recheck the GCSCC was Mrs. Shore -- the district beginning teacher coach who they happened to run into while she was meeting with another teacher in the building. When Mrs. Mason and Mrs. Meyer searched the collection in response to Mrs. Shore’s prompt, they found that resources had been added to the 8th grade science collection. However, having planned out their instruction the previous summer, they had few opportunities to implement the resources that year without revising the documents they already

created. This story illustrates the significance of the timing of the prompt for the impact on their documentational genesis. Because the prompt to re-explore the GCSCC had come after they had co-constructed their documents, they had little incentive to try the GCSCC resources. Had the resources been available when they had co-planned the units, they may have used more of its resources.

Despite the challenges with timing, they decided to implement one activity found in the collection focusing on homologous structures in evolution. Their interpretation of the resource led them to the conclusion that the entire lesson would take too long to implement, so they adapted the lesson by using only one component and aligning the activity with their typical daily instructional flow. This Mystery Fossil Bones activity put students in the role of paleontologists, cutting out pictures of fossils they uncovered in a hypothetical dig and negotiating in teams how those bones should connect with each other and what they can infer about the animal to whom the bones belonged. The bones from this lesson are shown in Figure 9.

Figure 9. Bone Cutouts For the Mystery Fossil Bones Activity



While Mrs. Mason largely used this activity as written, Mrs. Meyer made an in-the-moment adaptation while implementing the lesson by using a tailbone to build a dinosaur with two sets of wings, prompting her students to consider what she had done wrong. Mrs. Meyer noted that, not only did this adaptation mirror an authentic problem that paleontologists face when digging for fossils, but it also aligned with two pedagogical practices she values: modeling and building excitement for students. She reflected on this adaptation in this way:

> I'll show them mine, because, you know, I'm good at modeling. I'd like, I put my option up. But my dino had two wings, two sets of wings. And they're like, Mrs. Meyer, what? And I'm like, I know! [...] It's okay for me to model a bad, you know something. And then it makes them turn around and like, 2 wings Mrs. Meyer? I'm yes, yes, two. And I get a student across the room. He's like, Mrs. Meyer, that's totally the tail. Your second is a tail. [...] So it gets really exciting, right? (Mrs. Meyer, Spring 2023)

Mrs. Meyer's adaptations illustrate how, even when two teachers engage in documentational genesis using the same resources and discussing their planned implementation with each other, divergences in the scheme of utilization for the resource can still occur as teachers adapt the resources to align with their perceived classroom's needs and instructional priorities.

Reflecting on the Mystery Fossil Bones lesson, both teachers indicated that students enjoyed the activity, but that they weren't sure that the resource was an improvement over resources they had used in the past. As Mrs. Mason described, "I'm not 100% sold that it actually taught them what they needed to learn [...] So they got to put together some bones, and I mean it was a fun activity. I don't know if I'll use it again." While Mrs. Mason left the district the following year, Mrs. Meyer indicated during the Fall 2023 interview that she planned to

continue using the Mystery Fossil Bones activity, yet had no plans to incorporate more GCSCC resources into her practice because no new resources had been added to the collection since she had searched it the previous year. Mrs. Meyer had already incorporated the resources that she thought would improve her instruction into her documents and decided not to use the remaining resources in her future documentational genesis unless more resources were added.

Mrs. Cook had a similar experience while exploring the GCSCC. While the district never successfully recruited developers for the Chemistry collection, she spent some time searching the EES collection, which she predicted to be the collection most aligned with her Chemistry content. She expressed a similar openness to trying new resources, yet her time refining her documents also shaped her outlook on resources:

> If I felt something was successful, it's very hard to shove me off of it. [...] I don't do the thing like some of our teachers did, where you pull out the exact same thing at the exact same time every year. I am constantly looking for something new, but it doesn't always mean that I'm using it. (Mrs. Cook, Spring 2023)

When asked about her opinion of the collection, she said

> It looked good for someone starting, but I found it difficult to adapt to what I would currently put in if I was teaching that subject. [...] It did not allow for much adaptation. [...] I think it could be very useful with those who need more of that structure. I just don't know what I would take from it, because I haven't seen anything that was useful to me. (Mrs. Cook, Spring 2023)

Like Mrs. Mason and Mrs. Meyer, Mrs. Cook interpreted the GCSCC resources through a lens of experience, evaluating the resources against those that she used in the past. Despite her lack of interest in using the resources in her own teaching, she shared the collection with a colleague in

their first year of teaching. By sharing these resources, Mrs. Cook underscored her evaluation that the GCSCC resources provided value, but not for her own documentational genesis.

Having added and removed different resources from their documents over time gave these three teachers a wealth of experience through instrumentation that shaped their interpretations of the usefulness of the GCSCC. These teachers' experience became apparent in their interpretations of the Launch-Explore-Discuss-Land framework that shaped the GCSCC lessons. All three teachers indicated that the framework directly mirrored others that they had used in the past, most notably the 5E framework. As Mrs. Cook described,

> It's a new name for the same thing that's been taught for over 20 years. I know, and it's been, I'd call it streamlined into four pieces, whereas it was taught as a regular five or six piece lesson, even as a teacher in college 25 years ago. It's the same thing, different name. Maybe you call it less parts, but it's the exact same thing. (Mrs. Cook, Spring 2023)

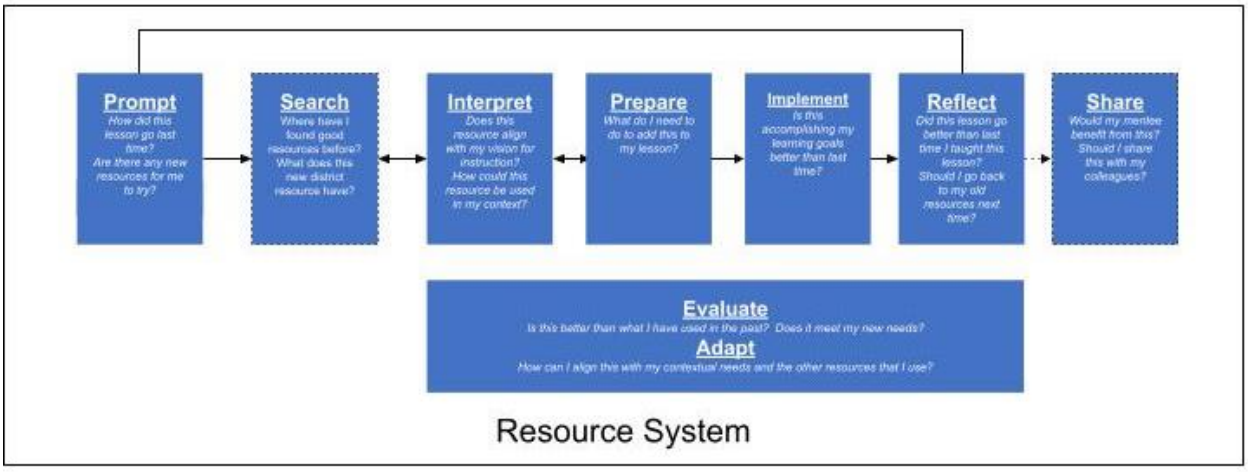
This interpretation of the GCSCC framework illustrates the degree to which these teachers' past documentational experiences shaped their interpretations and evaluations of the usefulness of the GCSCC for their current documentational genesis.

Whereas Figure 9 represents what a typical beginning teacher might consider while engaging in documentation using the GCSCC, Figure 10 represents some of the decisions that experienced teachers considered when using the GCSCC.

Discussion

These findings illustrate not only that teachers implemented the GCSCC resources to different degrees and in different ways, but that the experience level of the teachers played a role in interpreting and evaluating the resources. Generally speaking, the beginning teachers found

Figure 10. Experienced Teachers' Documentation Using the GCSCC



more use from the GCSCC. Some of the beginning teachers used the collections as the foundations for their initial documents, while others used the collections primarily as guides for determining the scope, sequence, and vocabulary that they should incorporate into their lessons. By contrast, experienced teachers found the GCSCC considerably less useful for their own practice than the beginning teachers did. While some of the experienced teachers used a resource from the GCSCC that they adapted to fit their typical instructional sequence, not all teachers found use in the resources. None of the three experienced teachers mentioned the scope, sequence, or vocabulary components of the GCSCC lessons in our interviews, suggesting a level of familiarity with the content which the beginning teachers found novel and useful.

The differences in the documentational processes between beginning and experienced teachers working with the GCSCC is represented in the differences between Figure 9 and Figure 10. These two figures illustrate how the considerations that guided beginning teachers' use of the GCSCC diverged from those of teachers with more experience. For the beginning teachers without a foundational set of documents to serve as a frame by which to compare resources, questions that drove their documentation using the GCSCC tended to emphasize seeking

alignment among the resources, their contextual demands, and their pedagogical beliefs. While experienced teachers still sought to align their documents with their context and beliefs, their past documentational experiences helped them learn how to do this work through instrumentation, streamlining the alignment processes and shifting their focus more toward whether the new resources were better than their existing resources. In other words, as teachers gain documentational experience and develop their documents, their focus shifts from asking "Is this a good resource to use?*"* toward "Is this resource better than what I have already been using?".

These differences between beginning and experienced teachers may also shed light on one of the conjectures from Phase 1 of the study, specifically regarding differences in GCSCC use among schools. According to state data, nearly all of the GCS middle schools employed more beginning teachers as a percentage of the teaching staff than the high schools, potentially explaining why middle schools often had more teachers using the GCSCC and more page views than the high schools. However, these figures include all teachers working at each school and could not be determined for science departments alone. Moreover, these numbers do not account for the number of teachers who teach a science class out of field, like Mrs. Hughes. Caution, therefore, should be exercised in this interpretation of this finding, which may serve more as a direction for future research.

While documentational experience played a role in shaping teachers' documentational genesis using the GCSCC, IGIs other than the GCSCC also shaped teachers' documentation with the GCSCC by both enabling and constraining their agency for using its resources at varying stages of the documentation process. As I illustrate in the next section, several of the other

school and district IGIs played a substantial role in shaping teachers' interpretation, evaluation, and implementation of the GCSCC resources.

In what ways did IGIs enable or constrain teachers' agency when using the GCSCC resources?

While attending to teachers' documentational genesis explains some of this variation by positioning teachers' practice along a documentational trajectory, variables external to the teacher also influenced the choices that teachers made about using the GCSCC's resources. Collectively, these external variables represent the infrastructure of the schools and district in which they worked. Among those elements of infrastructure, I specifically selected IGIs due to their explicit relevance for shaping teachers' practice. These IGIs included instructional frameworks, instructional materials, student assessments, instructional oversight, and teacher professional learning. As I illustrate in this section, IGIs from each of these categories played a role in shaping teachers' documentational genesis with the GCSCC by enabling and / or constraining teachers' agency for using these resources.

To be clear, none of the six teachers whom I interviewed indicated any explicit limitations to their agency for selecting and using resources from the GCSCC. I found no evidence that any of the schools' administrators implemented a policy that expressly discouraged teachers from using the resources, and all of the teachers had access to the resources through their district-issued laptops and Canvas accounts. Some of the teachers I interviewed who also taught math contrasted their relatively large degree of agency when engaging in documentational genesis for their science courses compare with their math courses; for math teachers, 80% of the resources are provided by a heavily structured curriculum, only allowing teachers to select resources for 20% of their "supplemental" instructional time. Instead, the IGIs that limited

science teachers' agency for using the GCSCC resources did so in more subtle, implicit ways that only the interviews with teachers surfaced. I have organized this section around each of the five IGI categories identified by Hopkins and Spillane (2015), providing examples of how IGIs from each of the five categories enabled and constrained teachers' agency for using the GCSCC. A summary of these IGIs is provided in Table 8.

Table 8. A Summary of IGIs From Teacher Interviews

IGI Category	Example IGIs That Enabled Agency for Using the GCSCC	Example IGIs That Constrained Agency for Using the GCSCC
Instructional Framework	State Standards TSL Lesson Plan Templates	5E Lesson Plan Templates GCS Science Instructional Framework District Pacing Guides
Instructional Materials	iPads Physical Materials	Competing District Resources
Student Assessments		State Standardized Tests Common Formative Assessments
Instructional Oversight	Coaches & Beginning Teacher Mentors	School Administrator Instructional Requirements
Teacher Professional Learning	Beginning Teacher Meetings Science Department PD	Misaligned UBD Professional Development Science Department PD

GCSCC (Mis)Alignment With Instructional Frameworks

Instructional frameworks played an influential role in shaping teachers' documentational genesis by providing teachers guidance on what and how to teach their content, thereby shaping the kinds of resources that teachers searched for and implemented. This category of IGIs includes the state standards, which provide guidelines for the content that teachers should teach and, by extension, the resources they should use. Experienced teachers did not talk about the standards as often in their interviews, likely due to their familiarity built over years of experience. Mrs. Meyer expressed her familiarity with the standards in this way:

> I have what I'm working with, and I know the standards, and I know what I have to hit. So from the standard, I'm getting the vocabulary, you know. [...] It'll tell you what vocabulary words, what you need to hit, and it'll tell you what not to hit. So then, I make sure to kind of stay in that. (Mrs. Meyer, 2023)

Conversely, all three of the beginning teachers described efforts to make sense of and align their documents with the standards. For example, Mr. Martinez expressed considerations for prioritizing the standards to ensure that he could reach all of his learning objectives by the end of the semester:

> It's like the other teachers were also stressed out because they were just like, how are we supposed to teach this in six days and expect the kids to know everything on these standards? Like, they started seeing the problems and it's just like, this is why I kind of spend a little bit more time on one subject than the other and less on the lesser known standards, the ones they don't really need to know a lot. (Mr. Martinez, Fall 2023)

This pressure to cover all of the standards dissuaded Mr. Martinez from using the GCSCC resources; as I illustrated earlier in this chapter, Mr. Martinez's documentational genesis was

often shaped by concerns over his interpretation of how much class time a resource would take to implement. In this quote, he added clarity to that influence: the state standards served as a metric by which he gauged the pace of his instruction. As I will illustrate later in this chapter, these standards also provide teachers of tested subjects with guidance on the content knowledge that they will be held accountable for teaching students through the state test, adding to the perceived time pressure.

While limitations on time added pressure for beginning teachers, the GCSCC's lessons aligned directly with the standards for each course, allowing teachers to quickly identify the lessons that align with the standard of interest. In the absence of a district pacing guide during the Spring 2023 interviews, several of the beginning teachers also interpreted the sequence of the GCSCC lessons as the order in which they should teach the content within and across standards. Mr. Martinez described his use of the Biology collection in this way:

> I try to keep the same pace, like the same order. They start with something, I start with that. They end with something, I try to end somewhere near. If they start with biomolecules, I start with biomolecules, just trying to keep everything there, because I know, the actual state stuff, like the benchmarks and all that, they follow that pattern. (Mr. Martinez, Spring 2023)

In this way, the three beginning teachers used the GCSCC as a guide for determining their pacing, sequencing, and content.

When GCS published the science pacing guides during the Fall of 2023, however, the guide often conflicted with the GCSCC. While the pacing guide organized teaching into units of instruction explicitly aligned with the standards, the standards did not always follow the same sequence as the GCSCC. Some of the pacing guides also split standards across multiple

units. This misalignment between the pacing guide and the GCSCC increased the workload required for teachers to use the GCSCC resources in accordance with the sequence recommended by the guide. During a meeting of all GCS science teachers at the beginning of the Fall 2023 semester, science coaches from Frontiers communicated that all teachers should follow the pacing guide so that any students who transfer schools within the district midyear can, in theory, pick up where they left off. This messaging communicated that the pacing guide took priority over other ways of sequencing and pacing instruction including that of the GCSCC.

This misalignment between the GCSCC and the pacing guides as well as the district messaging prioritizing the pacing guides led many of the beginning teachers who initially relied on the GCSCC for guidance on the sequence, scope, and pacing of their content to instead rely on the pacing guides. When asked whether she still used the GCSCC during the Fall 2023 semester, Mrs. Branson said "I went onto the resource page one time so far, just trying to make sure and follow, you know, just checking in and doing things." In this way, while teachers were still technically free to use the GCSCC's resources, the science instructional frameworks promoted by the schools and district shifted into misalignment with that of the GCSCC, thereby limiting teachers' ability to quickly and easily use the GCSCC resources to meet the requirements of the new instructional frameworks.

In addition to the state standards and the district pacing guides, all three teachers from BMS and BHS reported using lesson plan templates provided by their respective principals, the format of which serves as an instructional framework to which principles expect each of the teacher's lessons to adhere. In my analysis of the GCSCC in Chapter 3, I described the instructional framework (Launch-Explore-Discuss-Land) that the lesson designers used to organize the resources included in the collections. Notably, this same framework was used for

the development of all of the GCSCC collections, not just science. The framework was therefore discipline-agnostic, representing a generalized approach to instructional design apart from disciplinary science practices.

For teachers at BMS, the organization of the GCSCC framework directly aligned with the lesson plan template that building administration required all of its teachers to use during the 2022-23 school year. The alignment between these two frameworks meant that the GCSCC lessons align with the IGIs with which teachers interact on a daily basis, promoting the use of the GCSCC by reducing the amount of work that teachers must complete in order to prepare for instruction. As I described earlier in this chapter, however, the teachers I interviewed from BMS found limited use for this due to the fact that they had already created most of the lesson plans for the year during a work session the previous summer.

This alignment between frameworks contrasts with the 5E lesson plan template that BMS switched to the following year. Despite the similarities between the GCSCC and the 5E frameworks identified by the experienced teachers, even small misalignments between the two frameworks meant that teachers must invest extra time into translating the lessons into the new framework. Additionally, the simple act of changing lesson plan templates creates additional work for teachers to achieve compliance with the new expectations even if they do not actually change what resources they use or how they use them. As Mrs. Meyer described,

> This year at the beginning of the school year, they had a meeting at the district level, and they want us to switch to the 5E model, which we should have been on that 5E model. Sir, this is a timeless, timeless template. [...] But I was really upset because, you know, every year, they've got a new template. But my assistant principal [said] I've seen your

> work. [...] I bet you have all the parts in there. You just need to rework it. (Mrs. Meyer, Fall 2023)

By changing lesson plan templates at the behest of the district, BMS created a misalignment with the framework used by the GCSCC, limiting its ability to directly translate into teachers' practice. This move to the 5E lesson plan template also represents a pivot in district strategy from discipline-agnostic frameworks toward science-specific frameworks. Alongside the lesson plan template, the district published an 11-page document detailing a vision for science instruction in the district including guidance on the use of the 5E model for lesson design.

These examples illustrate the significance of alignment and misalignment among instructional frameworks. Science teachers at GCS interacted with instructional frameworks at the state (standards documents), district (pacing guides), and school levels (lesson plan templates). When these frameworks aligned with one another and with the GCSCC framework, teachers could more readily incorporate the resources from the GCSCC into their documentational genesis, thereby enabling their agency for using the GCSCC. However, when other frameworks with which teachers interacted did not align with the framework that organized the GCSCC, teachers often deemed the additional work required to adapt the GCSCC resources to align with other frameworks to be too great of a time cost to make the resources worth using. In other words, the more the frameworks misaligned, the more the teachers would need to adapt the resources, prompting the teachers to instead use other resources that required less adaptation.

Competition with Other Instructional Materials

Science teachers at GCS expressed having access to a wide variety of instructional materials. While some of these materials aligned well with the GCSCC, many of these materials

directly competed with each other for teachers' attention during documentational genesis, inhibiting their use of the GCSCC. As I described in Chapter 3, GCS has historically invested much of its funding for instructional materials into technology and digital resources including iPads for every student. With few exceptions, these materials are discipline-agnostic; in other words, few science-specific resources are provided by the district. Notably, this prioritization of technology resources has largely come at the cost of physical materials like labware and other science supplies. Among the teachers I interviewed, only Mrs. Cook mentioned frequently using laboratory materials as a core part of instruction.

This technology-focused approach shaped not only the district's acquisition of instructional materials, but also the design of the GCSCC lessons. The teachers who developed lessons for the GCSCC intended their lessons to be used by teachers across the district regardless of the physical materials to which teachers had access. At the time of its development, GCS offered no standardization of the physical materials available to all science teachers, so the lesson developers relied heavily on the technology tools to which all teachers in the district had access. Any physical materials used in the GCSCC lessons could be found in a typical home or easily acquired at a grocery store. This approach to the lesson design resulted in a set of lessons with minimal material requirements, promoting the use of its resources by all teachers regardless as to the lab materials or space to which they had access.

While the intentionally minimal use of scientific disciplinary materials by the lessons lowered barriers to their use, thereby promoting teachers' agency with using those resources, the district also offered a wide variety of other instructional materials that teachers could use. Prior to the 2022-23 school year, many of these sources provided materials for all content areas including those outside of science. Starting in the Fall of 2023, the district began investing into

more science-specific materials in alignment with and at the recommendation of the Frontiers staff. For example, the district acquired a license for Kesler Science, which contains a repository of science lesson plans aligned with the 5E framework. Middle school teachers received access to CIBL kits, which contain nearly-complete sets of physical materials for inquiry-oriented laboratory investigations complete with student handouts and teacher usage guides. GCS science teachers also received access to Defined Learning, which provides project-based learning units for all core science content areas. Teachers across the district could also opt into a pilot program for using Gizmo simulators which also include student handouts and teaching guides. In nearly all of my Spring and Fall interviews, teachers spoke of using one or more of these or other resources provided by the district.

The provision of science-specific physical and digital materials created a vast resource system for GCS science teachers, reflecting the district's new approach to supporting disciplinary instruction. While the addition of these resources gave science teachers options as to the kinds of materials they wanted to use, these resources provided direct competition for those included in the GCSCC. The originality requirement of the GCSCC lesson meant that, while the lesson developers could incorporate some limited external resources, the majority of the lessons represented original material. Given that none of the science collections were ever fully completed with a set of lessons aligned with every standard taught in their respective courses, the external resources that contained complete curricula could resolve some of the tensions experienced by the beginning teachers about finding resources to supplement those missing in the GCSCC. Further limiting the usefulness of the GCSCC in the context of the newly-expanded science resource system, the science pacing guides launched to the district that year included links to the CIBL kits and Defined Learning projects that aligned with each

instructional unit. The pacing guide, therefore, presented not only an instructional framework that the district wanted teachers to use, but also provided easy access to resources that aligned with that framework, thereby creating an alternative to the GCSCC that still fulfilled the original vision described by Mr. Collins: "If you were a new teacher to our district, that we would have district-curated stuff K-12 for everything."

In this way, GCS science teachers engaging in documentational genesis had access to a suite of digital resources. Because the schools and district did not require teachers to implement GCSCC lessons into their work, the GCSCC was just one of many sources of instructional materials in teachers' resource systems. As I illustrated in the previous section, when teachers engage in documentational genesis, they often select resources that they believe best align with their instructional frameworks and personal goals. If teachers interpret the alternative instructional materials as having better alignment with these frameworks than the GCSCC materials, then the teachers would be less likely to use the GCSCC.

Student Assessments: The Driving Forces of the State Test and District CFAs

Among all of the IGIs described by the teachers I interviewed, perhaps none played such an influential role in shaping teachers' documentational genesis with the GCSCC as the state standardized test. Teachers of tested subjects selected resources and schemes of utilization focused largely on the question: *will this help my students perform well on the test?* In contrast, teachers of untested subjects felt greater agency for selecting resources and schemes of utilization that aligned with other priorities like application and critical thinking. In both cases, many of the teachers I interviewed interpreted the GCSCC resources as providing too little support for helping students prepare for the test or too little alignment with their own instructional priorities.

In the state in which the study took place, students take state-mandated standardized tests in 8th grade science and Biology. For other science courses, teachers have autonomy over whether and how to test students unless the district or school at which they work has specific requirements. Along with other state tests, the 8th grade science and Biology tests serve as a publicly-reported metric of each school's instructional effectiveness. Teachers of these two subjects therefore often receive more attention from district and school administrators and instructional support staff than other teachers. While this attention can provide these teachers with more instructional support, the added accountability can add substantial pressure to teachers of these subjects. As Mrs. Cook described, "Oh yeah, our poor Biology people [...] Biology is the tested course. If I screw up, there's not much recourse other than do better. But when all of the testing falls to them, it's awful." Given the large number of schools at GCS with well-below-state-average test scores in science, teachers of tested subjects at GCS can feel immense pressure to align their documents with the state test.

All four of the 8th grade science and Biology teachers I interviewed indicated that the state test played a significant role in their documentational genesis, shaping both the resources they selected and their schemes of utilization. These teachers subjected every resource they considered for their instruction to a filter during documentational genesis; if they believed a resource or instructional strategy would help their students perform better on the state test, they would use it. Otherwise, the resource was cast by the wayside, even if they otherwise liked the resource.

For example, the three teachers I interviewed at BMS and BHS reported a movement among their building administrators to promote literacy for all subjects and courses. They reasoned that a significant part of succeeding on the state test came from reading and interpreting

questions, so when students entered their schools with below-grade-level scores in literacy, they decided that promoting literacy would also help students perform better on all tests. This literacy-focused initiative meant that the teachers I spoke with selected and used articles and literacy strategies in their regular instruction. In the words of Mr. Martinez,

> We already have a low reading level, but looking at those tests, it's just like, hey, we definitely need to read more. That's why I'm trying to do the web quests more. It's just like, it gets them reading. It gets them reading those weird questions, those weird, like wordings of everything, and going to the websites and everything, and makes them read more than just one version of the word. (Mr. Martinez, Spring 2023)

While Mrs. Meyer spoke of literacy as a priority for her practice regardless of the implications for the state test, both Mrs. Mason and Mr. Martinez connected literacy solely to improving test scores during our conversations. In their interpretations of the GCSCC, these teachers evaluated the resources to contain too little literacy support to meet their instructional goals, thereby inhibiting their use of the resources. Specifically, these teachers sought more articles for students to read and more questions aligned with the format and syntax used on the test.

Similarly, the three beginning teachers I interviewed reported feeling pressured for time to cover all of the state standards during the semester. Mrs. Branson described the pressure this way:

> But definitely, there are some resources that are hands on that I want to explore more, but I have been a little reserved, as trying to get through the pressure of getting through content for the [state exam], and things like that. I'm gonna be honest, the first time I taught it, we did not get through nearly as much as I had wanted to. [...] Hopefully, we

> should get through all the highlights, all the main units before the [state exam] this time. So that makes me feel much better. (Mrs. Branson, Spring 2023)

These teachers then sought resources and instructional practices that they could use to ensure that they maintained a pace that could allow them to discuss every state standard that would likely be on the test. The pacing guides developed by Frontiers served as a tool to support teachers in this endeavor. In the words of Mr. Martinez,

> We decided that we were going to try to stick to the pacing guide just cause, it was more of an admin thing. They wanted us to try it, to boost our scores up and everything, because even though we got more proficient scores than we did last year, we didn't do great. And I understand that. (Mr. Martinez, Fall 2023)

For Mr. Martinez, the new science pacing guides filled the role for which he previously used the GCSCC, mitigating its former usefulness.

This testing pressure also influenced the ways in which teachers selected and used student assessments. Several teachers reported using the online assessment platform Mastery Connect for student assessments specifically because its questions aligned with the format and tone of the questions on the state test. GCS also developed a set of common formative assessments (CFAs) using the state digital testing platform for teachers to gauge their ongoing progress and make adjustments to their instruction. They envisioned using these CFAs to identify areas of strength for each teacher, enabling teachers to address their own instructional challenges by learning from other teachers. Notably, these CFAs also aligned directly with the new pacing guides. While the district planned to create CFAs for all subjects, they only existed for 8th grade science and Biology at the time of this writing, illustrating the outsized value the district places on supporting teachers of tested subjects.

Conversely, teachers of subjects without a state test expressed feeling less pressure to align their instruction with the test. For example, while Mrs. Branson felt pressured to align her Biology teaching with the test, she reported a much more relaxed approach to her Marine Science course which has neither a specific set of state standards nor a state test. Near the beginning of the semester, she allowed her students to indicate what they would like to learn about the subject, then sought resources to provide students with exploration opportunities for those topics. Similarly, Mrs. Cook focused her instruction on what she described as critical thinking skills using laboratory investigations built around a claim-evidence-reasoning framework rather than rote memorization of content. Having taught both tested and untested subjects, she provided the greatest insight into the varying levels of agency that teachers of these subjects experienced:

> I get the good kids, the smart kids, because I teach upper level classes. They are great at spitting back information and memorizing it, but as far as applying it, they really struggle with that. So I was able to shift because [...] any standardized test is all about spitting back memorized information. Very little application. (Mrs. Cook, Spring 2023)

Here, Mrs. Cook expressed a misalignment between the state test and what she believes good science instruction should look like in her context. She believes that the state test emphasized memorized information rather than application, which she identified as a need among the students she teaches. She contrasted these competing visions of what test-aligned and application-aligned instruction should look like in this way:

> I focus my teaching much more heavily on skills, whereas when there was a state test at the end, I had to focus very heavily on vocab. [...] Now, instead of parts of the atom, and who discovered what, now I can spend real time building up their math skills in terms of,

> well, how do you know which gas law you need to use? Which equation do you need to use? How do you set up stoich problems with dimensional analysis? Why is it important to set it up this way? (Mrs. Cook, Spring 2023)

In the absence of the state test as an accountability measure, Mrs. Cook felt that she possessed sufficient agency to focus her instruction more on her application-aligned instruction rather than her perception of test-aligned instruction.

> So I focus much more on performance skills, critical thinking. Where, when we had state exams, it was very, very surface, and it mattered beyond all difference that Rutherford had the gold foil experiment. That's, yeah. That's not very useful information in terms of performance. It's just a random memorized fact. (Mrs. Cook, Spring 2023)

In this way, teachers of untested subjects could make value judgments about the significance of different concepts within their disciplines. While state standards still guided this work, the absence of the accountability structures that teachers of tested subjects faced meant that teachers of untested subjects faced little or no consequences for inserting their own priorities into their own teaching. This degree of agency could pose challenges for beginning teachers who might feel uncertain about what to teach or teachers who may need additional support developing their practice. However, for veteran teachers like Mrs. Cook, teaching an untested subject removed some of the accountability pressure, allowing for instructional flexibility and intellectual risk-taking.

How did these differences in documentational genesis in response to the presence or absence of state testing influence teachers' use of the GCSCC? Several of the teachers of tested subjects believed that the GCSCC provided insufficient alignment with the state test despite its alignment with the state standards. For example, Mr. Martinez felt that the Launch-Explore-

Discuss-Land framework took too much time. Fearing that he would run out of time to cover every standard before the end of the semester, he used the GCSCC as more of an organizational reference tool -- a need that the pacing guide later filled. While some of the GCSCC lessons included articles that could support the literacy goals of the BMS and BHS teachers, these teachers opted instead for other sources of articles with more robust sets of augmentation tools such as the ability to align articles with specified lexile scores. Unlike Mastery Connect and the district CFAs, the GCSCC lessons often incorporated open-ended student assessments which did not reflect the format of the questions on the state test.

Mrs. Meyer, who received training in phenomenon-based instruction when she began her career in a different state, lamented these limitations presented by the test:

> All 65 questions are multiple choice. And you know, in real life, science doesn't really, you don't get choices. [...] You need to be able to make a claim. I'm a big fan of CER - claim, evidence-based reasoning. [...] If you make a claim, you need to have evidence to back that and provide reasoning. And this is more, questions are more open-ended, but they're actually deeper, deeper, like higher order thinking. So, eventually, we need to evolve in that direction. (Mrs. Meyer, Spring 2023)

Like Mrs. Meyer, several of the teachers expressed frustrations, wanting to use more inquiry-oriented teaching practices like those included in the GCSCC yet feeling constrained by one or more of the pressures they felt the state test imposed.

In this way, the state test limited teachers' agency for using the GCSCC. Importantly, this limitation was not explicit; rather, the presence of the test and the accountability measures for teachers and schools that stemmed from poor performance on the test limited teachers' agency in implicit ways that were not readily apparent. On the surface, the GCSCC's alignment

with the state standards suggests that these resources would readily fill the instructional needs of teachers of tested subjects, yet misalignment between the test and the GCSCC resources appeared in other ways like time constraints and limited literacy support. As teachers of tested subjects interpreted and evaluated the GCSCC resources, many teachers determined that the resources would not help the students perform better on the test than alternative resources, thus limiting the impact of the GCSCC on these teachers' documentational genesis.

Adapting the GCSCC to Align With Instructional Oversight

Much of my discussion about IGIs to this point has alluded to the role that instructional oversight played in shaping teachers' documentational genesis with the GCSCC. At some schools, building-level administrators required teachers to submit lesson plans to ensure that they aligned with the instructional frameworks they wanted teachers to use. Low scores on standardized tests can add pressure to administrators to implement interventions, requiring teachers to align their instruction with certain priorities like literacy. Here, I will add one additional instructional oversight IGI that teachers described as influencing their documentational genesis: the tensions that arose when the GCSCC resources misaligned with specific building-level instructional expectations.

While the instructional coaches, mentors, and beginning teacher coaches promoted the use of the GCSCC, building level factors sometimes superseded the usefulness of some of the resources. In addition to the lesson plan templates that some administrators required teachers to use, teachers at three schools reported that administrators required all teachers to implement specific instructional strategies like a daily exit ticket for students, assessing what students learned at the end of the day's instruction. Some of the GCSCC lessons were designed to take multiple days to complete, and many do not include exit tickets. This means that a teacher at

these schools would need to develop their own exit ticket in order to use these lessons. While this incongruence in itself may not deter a teacher from using a lesson, Mrs. Branson reported that a new principal at FHS implemented a set of six "non-negotiables" that all teachers must use in their lessons. If these non-negotiables do not align with the GCSCC lessons, teachers may decide that adapting the lessons to align with these non-negotiables could make the resource less desirable than an alternative that better aligns with these requirements.

Some schools used their own funds to purchase resources for teachers, resulting in explicit and / or implicit pressure for teachers to use these resources. Mrs. Cook recalled one such example of administrative pressure to use a specific resource at FHS:

> I remember when Kahoot came out, and the schools paid for it. It was, well, could that be done as a Kahoot? [...] That's why I hate it now. If you weren't doing it at least once a week, more like two to three times a week, well, why not? You really could have done this as a Kahoot, you know. (Mrs. Cook, Spring 2023)

She later added that their inclusion of Kahoots played a role in how school administrators provided feedback during teacher evaluations. In this example, Mrs. Cook may have found more value in the GCSCC if it included Kahoot during the time in which her school promoted the resource. Alternatively, if the resources or practices promoted by a person in a position of power do not align with the GCSCC, then the resources promoted by immediate supervisors would likely take priority during documentational genesis.

This highlights a key aspect of the limited uptake of the GCSCC among science teachers: while the district offered a one-time financial incentive to search the resources, no instructional oversight directly incentivized teachers to implement the GCSCC resources. Unlike other resources and instructional practices, teachers were neither rewarded for implementing the

GCSCC resources nor punished for failing to use them. The district presented the GCSCC as one set of resources that teachers could use among many in a larger resource system. While the development of the GCSCC sought to fulfill a district vision of having a ready-made set of resources for new teachers, teachers retained the agency to reject these resources in favor of alternatives, often provided by the district. Had an instructional oversight layer been added to the GCSCC like a requirement for teachers to use some or all of the resources, then the uptake would likely have been greater, as demonstrated by building-level expectations to use specific resources or practices. However, adding an instructional oversight requirement would have problematically restricted teachers' agency for documentational genesis, thus creating a challenging question: would restricting teachers' agency in order to see greater use of the GCSCC yield desired outcomes? For GCS district leaders, at least, the answer was no.

Teacher Professional Learning, But Not For the GCSCC

Of the five categories of IGIs in this study, teachers directly mentioned professional learning the least. However, the absence of discussion about professional learning may indicate a potential for a new IGI to promote the use of the GCSCC. As I described in Chapter 3, GCS leaders sent limited district-wide messaging to teachers about their vision for teachers' use of the GCSCC. Much of the communication about the GCSCC came from building-level instructional coaches and beginning teacher mentors. In the case of Mrs. Meyer and Mrs. Mason, they learned from an instructional coach that resources had been added to the collection -- a fact that was not shared through any district-wide communication. Similarly, beginning teachers often learned of the GCSCC from meetings with a district beginning teacher coach like Mrs. Shore.

Further illustrating the relative silence from the district about the GCSCC, science teachers from across the district began meeting monthly at Frontiers during the Fall 2023

semester to receive science-specific professional development opportunities, as described by several teachers during the Fall interviews. During the first session, Frontiers staff mentioned the GCSCC as one element in a list of resources that teachers could use for their practice. However, the GCSCC was not mentioned again in subsequent sessions, with training focusing more on pedagogical practices and some of the newer resources like the pacing guide, CFAs, CIBL kits, and Defined Learning.

None of the teachers I interviewed received formal support with the interpretation and implementation of the GCSCC resources. While the district paid a stipend from a grant to teachers who explored the GCSCC during the Summer of 2022, teachers received little guidance during this exploration as to the structure and intended use of these resources. As other studies have illustrated (e.g. Brunner & Abd-El-Khalick, 2019; Penuel et. al, 2011), rollouts of resources experience the best results when teachers receive not only the resources, but also guidance on how to use them. From a DAD perspective, this means that teachers not only have access to the resources, but also receive support with the intended schemes of utilization and modes of adaptation. In the case of the GCSCC, no teachers indicated any such formal support. For Mrs. Hughes, this lack of support severely limited the usefulness of the resources:

> But then, like if you click on lesson one, for example, there's a lot of lesson materials and resources in a huge old list. And I remember thinking even back then, looking through it, it's a lot to digest. As well as like, how many days is it supposed to be? It's less than one. Only one day. Is it multiple days? And just breaking that down and seeing, what are the keynotes, was the hardest part. [...] It's just a lot to digest all at once. That's like my biggest thing, I think. Looking at it, you can tell it's well put together. There's a lot of

thought, a lot of effort and good content. It's just a lot to digest. Knowing where to start was the hardest thing with it. (Mrs. Hughes, Spring 2023)

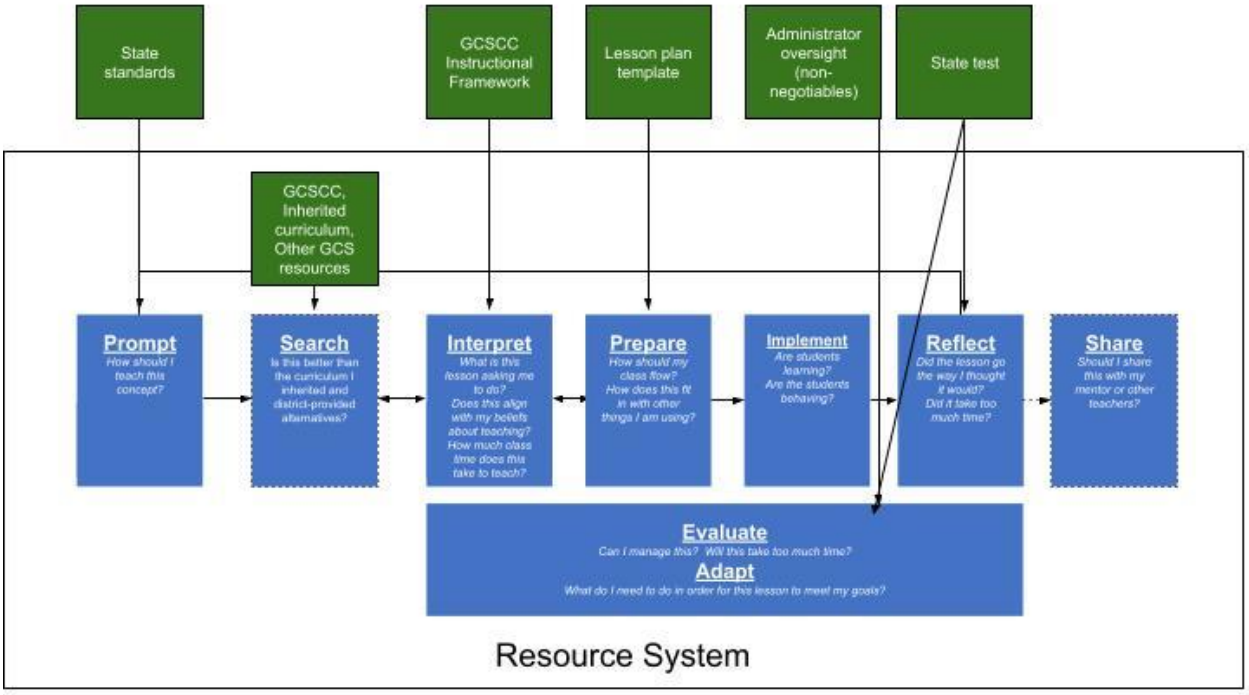
These reports about the rollout of the GCSCC signaled the role that the GCSCC played in the resource system for science teachers: as just one set of resources in a menu of options. Had the district provided guidance on how to align the resources with other IGIs like instructional frameworks and the state test, teachers may have perceived the resources to be more useful and easier to incorporate into their documents. The fact that the GCSCC will receive no new resources while IGIs like the pacing guides and CFAs continue to receive attention and revision suggests that, for those teachers who felt that they already extracted as much as they believed that they could use, the GCSCC would remain a latent resource.

Discussion

Together, all of these IGIs paint a complex picture of how the GCSCC fits into the larger narrative of science teachers' documentational genesis at GCS. Some of the IGIs promoted the use of the GCSCC's resources by prompting teachers to explore the collections, aligning instructional frameworks with that of the GCSCC lessons, and minimizing any additional material requirements that teachers might need in order to implement the lessons. Conversely, other IGIs inhibited teachers' use of the GCSCC including competing resources, perceived pressure to prepare students for standardized tests, and misalignment between the resources and instructional expectations communicated to teachers.

While none of these IGIs explicitly required or prohibited the use of the GCSCC, each played a role in shaping teachers' perceived agency when deciding whether to use its resources. In other words, the IGIs often played an implicit role in shaping teachers' agency rather than an explicit one. To illustrate the role that these IGIs played in shaping the

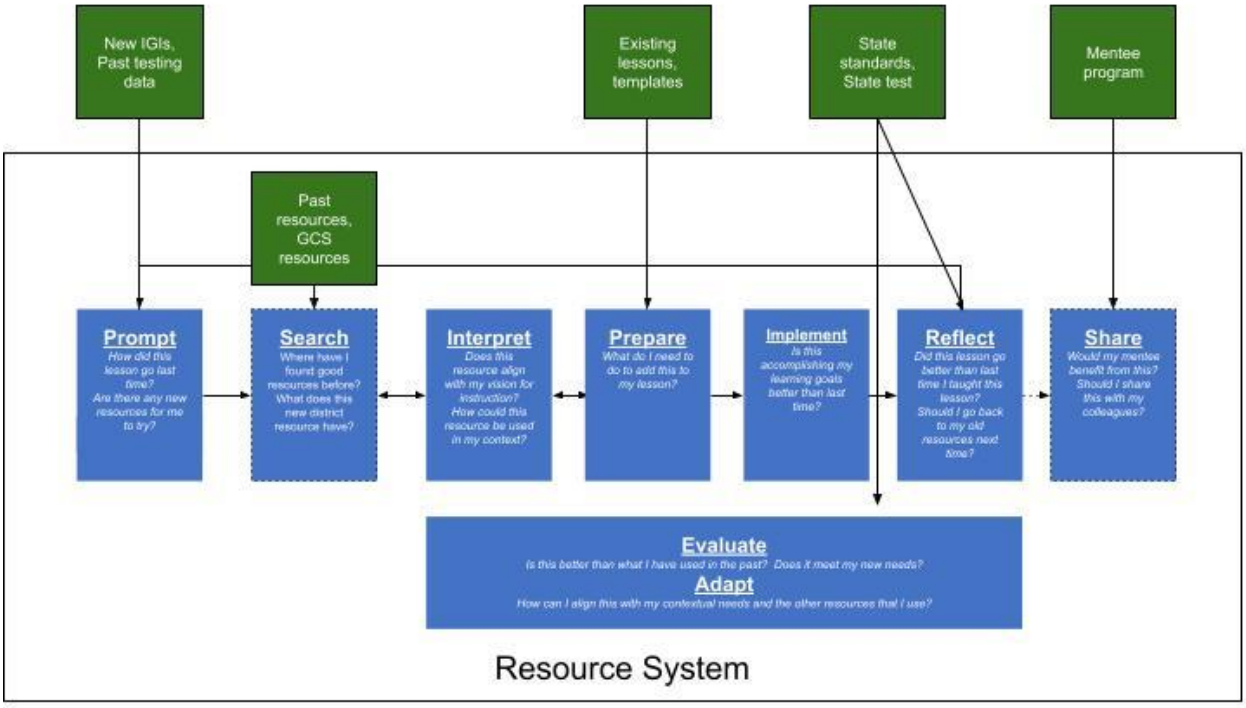
Figure 11. Some IGIs That Influenced Beginning Teachers' Documentation



documentational genesis of teachers, I added some of the IGIs that influenced the documentation of beginning teachers and experienced teachers represented in Figure 8 and Figure 10. These diagrams are represented in Figure 11 and Figure 12, respectively.

These findings underscore the significance of teachers' perceptions of these IGIs and their own agency to make decisions about the resources they use. Two teachers may work with the same set of IGIs and, based on their perceptions, come to different conclusions about the usefulness of a resource. For example, Mr. Martinez limited his use of the GCSCC to that of an organizational framework that was later replaced by the pacing guide; conversely, Mrs. Branson taught the same subject and worked with a very similar set of IGIs, yet used the GCSCC resources extensively in her teaching. Mr. Martinez perceived the GCSCC as misaligning with the needs of his context, whereas Mrs. Branson came to the opposite conclusion. This point of divergence may suggest that an additional IGI may have helped teachers implement the GCSCC

Figure 12. Some IGIs That Influenced Experienced Teachers' Documentation



resources by demonstrating the ways in which the resources aligned with state, district, and school IGIs. Such support may take the form of a guiding document, a training session, or simply an expanded list of resources for each standard from which teachers could select.

In addition to the ways that teachers' past documentational experiences can shape the way they interpret IGIs, the findings from this phase of the study underscore the significance of the district's change in approach from generalized, discipline-agnostic IGIs toward disciplinary science IGIs. Starting in Fall 2023, GCS science teachers received access to a pacing guide with aligned resources, CFAs, a mandate to use these structures, and periodic meetings to discuss science pedagogical practices and support this work. In other words, teachers received a suite of IGIs including an instructional framework, instructional materials, student assessments, instructional oversight, and teacher professional learning, respectively. Importantly, Frontiers staff developed these IGIs to explicitly align with one another. As a result, science teachers

received a vision for science instruction in the district and a set of tools to accomplish this vision. Mrs. Meyer described this effect as "the stars aligning". This represents a marked change in approach from the district's earlier instructional support strategy that emphasized discipline-agnostic instructional materials and an instructional framework that was applied to all content areas. While more time is likely needed to realize the full impact of this suite of IGIs on teachers' documentational genesis, results from the Fall teacher interviews suggest an immediate impact that promoted the use of the new IGIs, ultimately resulting in a general abandonment of the GCSCC by both beginning and experienced teachers.

Many of the teachers I interviewed expressed a desire for a system like the GCSCC, but that includes options and alternatives rather than a single lesson for each learning objective. Such a desire reflects teachers' simultaneous desire for structures to guide their work and for agency when using those structures, demanding a balance between structure and agency that neither leaves teachers in a sea of ambiguity nor in a role as deprofessionalized technicians. Together, these findings illustrate the challenges of designing systems that provide the right balance of structure and agency for supporting the documentational genesis of beginning and experienced teachers alike and that align with state, district, and school-based infrastructure.

CHAPTER V: DISCUSSION

Introduction

The purpose of this study was to explore ways in which instructional guidance infrastructure (IGIs) enable and constrain science teachers' agency when selecting and using district-developed resources. As instructional resources become increasingly available online, many teachers have adopted a role as critical curator, finding and using a suite of resources that the teachers adapt to meet the needs of their context. While analyses of this work through the lens of documentational genesis have revealed ways in which teachers engage in this work, such analyses generally assume that teachers have sufficient agency to make decisions about which resources to use and how to use them. School and district infrastructure bear particular significance for shaping the agency of science teachers whose work often depends on the availability of physical materials such as lab space, disciplinary tools, and safety equipment. Through the previous four chapters, I have illustrated ways in which IGIs can shape the documentational genesis of science teachers working with a specific set of resources: the Grantham County Schools Curriculum Collection (GCSCC). Three research questions guided this work:

1. What patterns exist in science teachers' access to the GCSCC, if any?
2. In what ways did science teachers use the resources and / or framework from the GCSCC, if at all?
3. In what ways did IGIs enable or constrain teachers' agency when using the GCSCC resources?

In this chapter, I provide a summary of the findings from this study including an interpretation of the findings through the lens of incoherence. I then overview the contributions to the literature as well as limitations of the study. I conclude with a set of recommendations for future research.

Review of the Study

The findings from this study illustrated differences in the ways in beginning and experienced teachers used a set of resources intentionally designed to align with their infrastructure. Despite this alignment at the design phase, teachers experienced barriers to using these resources due to inconspicuous conflicts with other IGIs including the state assessment, school-based instructional expectations, and the district pacing guide. These findings contribute to our understanding of how infrastructure can shape teachers' documentational genesis at specific phases of the documentation process as well as how teachers' progression along a documentational trajectory for the specific content they teach can mediate these interactions.

While the GCSCC metadata suggested that differences in IGIs at the community, school, and subject levels might have contributed to teachers' documentation using the GCSCC, the teacher interviews surfaced teachers' experience with the content and in classrooms as a critical factor not captured in the Canvas metadata. Beginning teachers at GCS generally used the resources more extensively than experienced teachers, although the nature of beginning teachers' use varied from direct use of the resources to use of the GCSCC as a guide for content and pacing. This finding aligns with the concept of documentational trajectory (Rocha, 2018). While beginning teachers may inherit a complete set of resources from a district-provided curriculum or a fellow science teacher, beginning teachers or teachers teaching a new subject for the first time have spent less time generating and refining documents than their more experienced colleagues (Gueudet & Trouche, 2011).

Beginning teachers may struggle to establish an initial set of documents as they make sense of their content and context, just as the beginning teachers in this study actively negotiated the role of the GCSCC amid the IGIs with which they interact. Conversely, teachers with more experience have spent more time refining their documents by testing new resources and instructional strategies. Whereas a beginning teacher may see a new set of resources as a potential foundation for the establishment of their documents, experienced teachers with a tried-and-true set of documents may see the same resources as simply something new to be tried in the context of their usual instruction. In other words, as teachers gain experience and develop their documents, their focus shifts from asking "Is this a good resource to use?*"* toward "Is this resource better than what I have already been using?". This dynamic adds to our overall understanding of how teachers' progress along a documentational trajectory can shape their documentational genesis as exemplified by Mrs. Cook, who relied heavily on past documentation to adapt to the implementation of the new IGIs during the Fall semester of 2023.

The significance of these questions increased as teachers navigated changes in their infrastructure. For example, the implementation of a new suite of IGIs for science teachers at GCS served as a prompt for teachers to re-examine their documents to ensure that their resources aligned with the new IGIs. For Mrs. Meyer, this meant relying on her past training in phenomenon-based teaching as she adapted to a new set of district resources. Just as Mrs. Cook revisited some older lessons to adjust for larger class sizes, experienced teachers could appeal to latent resources (Navy et al., 2020) that they had used in the past to realign their documents with this system, whereas beginning teachers struggled to adapt their current documents to the new IGIs. As the documentational approach to didactics (DAD) predicts, teachers learn and develop professionally through instrumentation as they engage in documentational genesis (Remillard,

2005; Trouche, 2004). In other words, working with resources helps teachers learn more about what kinds of resources and practices will most likely achieve the desired learning outcomes. While experienced teachers' capacity to predict the outcomes of the use of a resource in a particular way may vary, their perceptions of the resources and practices they have used in the past can influence the decisions they make in the present.

Data from Phase 2 of the study also revealed that teachers' interactions with the GCSCC were both enabled and constrained by various state, district, and school IGIs. For example, teachers who taught 8th grade and Biology considered the resources they selected and used from a different lens than teachers of 6th grade science and Earth and Environmental Science (EES) due to the presence of a state standardized test. For teachers of the tested subjects, their perceptions of the demands of the test acted as a filter for resources and practices. Some of the teachers in this study avoided certain resources and practices because they determined that the resource or practice was unlikely to help students succeed on the state test due to factors like misalignment with the language used on the test; the time it would take to use the resource; or the alignment of the resource with specific needs like promoting literacy. In some cases, teachers of tested subjects also experienced more administrative oversight compared to teachers of untested subjects, many of whom expressed having more agency in selecting and adapting resources that aligned with other goals like critical thinking or scientific practices. In this way, the test acted as an IGI that presented an implicit limitation of teachers' agency. This finding aligns with existing research on ways in which standardized testing and accountability can limit teachers' professional agency (Buchanan, 2015).

While no IGI explicitly required or forbade the use of the GCSCC, teachers perceived alignment with the test as more significant than any IGI that may have encouraged the use of the

GCSCC resources, thus experiencing an implicit limitation to their agency to select resources. This finding builds upon other studies of the factors that predict what kinds of resources teachers may use (e.g. Ottenbreit-Leftwich et al., 2010; Waight et al., 2014). Teachers are likely to select and use resources that they feel will have desired outcomes. For the teachers in this study, some of the teachers' evaluation of resources focused largely on the resource's perceived ability to help students perform well on the test.

Findings from Phase 2 also revealed that several teachers used the GCSCC as a substitute for other IGIs often designed to support beginning teachers that were missing from their context such as a curriculum guide, pacing guide, and vocabulary list. When the district developed and implemented these IGIs, the GCSCC became relegated to an occasional reference source for these teachers. When the infrastructure changed, teachers analyzed their documents to determine whether their documents aligned with the new context. Such changes can serve as a prompt to access latent resources, seek new resources, try new schemes of utilization, or abandon a resource currently in use.

Contributions to the Literature

The Role of Incoherence in Limiting Agency

This study's findings about the IGIs that implicitly limited teachers' agency align with studies of incoherence. When IGIs align with one another, they can create and communicate a coherent vision for what teaching should look like in a given context. Hall et al. (2021) define coherence as:

> the process by which stakeholders (e.g., district leaders, schools, departments, and teachers) work together to craft or iteratively negotiate the fit between larger visions of

> teaching and learning articulated in educational standards or policy documents and the goals and strategies employed in daily work in districts, schools, and classrooms (p. 3).

As an illustration of the role that coherence can play in teachers' documentation, Hopkins et al. (2013) describe the relative success of an initiative in which teacher leaders co-designed IGIs with district leadership to promote coherence among classroom, school, and district infrastructure. For science teachers at GCS, the development and implementation of the new suite of science IGIs by Frontiers represented an intentional step toward greater alignment among the IGIs with which the teachers worked, thereby promoting coherence.

Alignment among IGIs alone, however, cannot fully explain GCS science teachers' widespread decision to use alternative resources rather than those of the GCSCC. The resources contained in the collections were designed by teachers in the district who aligned each lesson with state standards and other district infrastructure like student iPads and the Launch-Explore-Discuss-Land framework that served as the foundation of some schools' lesson plan templates. Despite this alignment, the metadata revealed that most teachers in the district only visited the collections once or twice, and most of the interviewed teachers did not use many of the resources, if at all.

This finding supports the idea that alignment alone cannot guarantee teachers' uptake of a resource (Penuel et al., 2009). Instead, teachers construct coherence by selecting resources and schemes of utilization that align with their instructional goals and adapting those resources which do not immediately align (Honig & Hatch, 2004). Revisiting a quote from Chapter 2, Davis et al. (2016) describe teachers' work with resources as "a difference reduction process in which the teacher will try to reduce the differences between their current state (their available personal resources and curriculum materials) and the desired state of instruction, through making

adaptations to the current state." (p. 147) In other words, when a resource misaligns with an IGI, teachers must determine whether to adapt the resource to provide coherence or use an alternative resource. While the GCSCC provided surface-level alignment with several critical IGIs like the state standards and school lesson plan templates, most of the teachers interviewed in this study determined that alternative resources better met their instructional goals. This finding contributes to the DAD literature by illustrating that teachers can determine whether to adapt a resource in order to create coherence with other IGIs during documentation or abandon the resource in favor of alternatives that may require less adaptation to provide similar levels of coherence.

In addition to supporting the view that teachers craft coherence during documentation, this study highlighted how incoherence can arise in inconspicuous ways. Building on their definition of coherence, Hall et al. (2021) argue that incoherence often arises when IGIs at the classroom, school, and district levels do not align. For example, Heredia (2020) found that incoherence due to school- and district-level changes played an inhibiting role in teachers' uptake and use of resources for the design of formative assessment provided as part of a multi-year professional development program. She further found that discussing issues of incoherence among teachers presented opportunities for teachers to grapple with the sources of incoherence and engage with the targeted resources. As an example of incoherence that surfaced in the present study, several GCS science teachers of tested subjects interpreted the GCSCC resources as misaligned with the skills that they believed students needed to perform well on the state test. Teachers provided a variety of rationales for this perception including the amount of instructional time required to implement the resources and a lack of explicit literacy support. In this way, teachers' interpretations of the GCSCC resulted in evaluations of its resources as too

incoherent with the student assessment that was tied to their instructional oversight. Other sources of incoherence that teachers described included lesson plan templates, instructional requirements by administrators, the new pacing guide, and competing resources. While professional development for the use of the GCSCC may have alleviated some of these concerns by demonstrating how the GCSCC aligns with other IGIs, such professional support does not always result in the uptake of resources among teachers (Heredia, 2020; Penuel et al., 2009). This finding illustrates the potential power of incoherence among IGIs in shaping the ways in which teachers select and use resources, even when the sources of incoherence are not obvious.

Importantly, teachers' perceptions and interpretations of (in)coherence within their infrastructure influenced their resource use. While a district leader or outside observer may see coherence where a teacher sees incoherence, in the absence of some level of instructional oversight requiring teachers to use a specific resource or practice, the teacher's perceptions of their infrastructure serve as the ultimate foundation for their resource selection and use. This finding builds on those of Barab and Luehmann (2003), who found that teachers' perceptions of innovations like a new set of resources play an important role in determining whether and how teachers engage with those innovations. As Allen & Heredia (2021) suggest, giving teachers a platform for surfacing and discussing sources of incoherence can help teachers navigate incoherence, shaping their selection and use of resources.

These findings illustrate the significance of studying not only how science teachers undertake documentational genesis, but also how interactions between teachers and their infrastructure -- specifically, IGIs -- shapes this work. Furthermore, both the IGIs themselves and the interactions among them can enable or limit teachers' agency for documentational

genesis. Given the vast number of potential IGIs with which science teachers interact and the ever-evolving nature of those IGIs, deepening our understanding of how IGIs influence teachers' documentational genesis can provide valuable insight into how the design of IGIs might promote coherence, supporting the teaching of science rather than frustrating it.

Support For Crafting Coherence With Resources

In addition to findings about the role of incoherence in limiting teacher agency that can prove challenging to identify, this study illustrates the need for balancing structure and agency in the design of resources themselves. All three beginning teachers expressed several different tensions surrounding their use of resources such as pacing, coverage, sequencing, vocabulary, and balancing inquiry-oriented teaching strategies with content coverage. Mrs. Hughes, for example, expressed feeling overwhelmed by the structure of the collection -- a feeling that might have been alleviated with additional markers within the resources as to their intended use. This finding supports the idea that too little guidance on the use of resources can lead to frustration and feelings of overwhelmedness, particularly among beginning teachers (Davis & Krajcik, 2005).

Conversely, one could argue that the lesson plan format of the GCSCC may have provided too much structure, reducing the ability for teachers to adapt the lessons to their context. Each lesson provided a specific script of teacher moves and student activities, reflecting a desire among the lesson developers to create a comprehensive resource that provided as much guidance for teachers as possible. Of the five teachers who reported using GCSCC resources during the interviews, only one teacher used lesson plans as they were written. Three teachers used only one or two resources from the GCSCC, and even then only a piece of a larger lesson. Several of the experienced teachers expressed a desire for the resources to be more

adaptable in nature, allowing them to better align with their existing resources. The experienced teachers in this study had well-established class routines and lesson formats that they were unwilling to discard for the sake of trying an entire GCSCC lesson. Making the GCSCC resources more adaptable may have helped these teachers pull individual components of lessons, thereby reducing the amount of content they needed to search through in order to find the pieces that they might use.

A balance, then, should be struck in the design of resources by providing teachers with sufficient guidance to reduce the work required to interpret a resource while still allowing for adaptation to local context. Such a balance meets the needs of beginning teachers who may need additional support and experienced teachers who often desire greater adaptability. The findings that beginning and experienced teachers perceive and mobilize resources differently aligns with past work on resource use (Remillard, 2011; Visnovska et. al, 2011). This is not to say that beginning teachers do not seek adaptability or experienced teachers do not seek educative support. Rather, the findings from this study highlight the value of designing the resources to meet both sets of needs. While designers have worked toward creating such resources for decades with varying degrees of success, the large-scale development and implementation of such resources remains a challenge (Barab & Luehmann, 2003). For science teachers in particular whose work often depends on access to scientific equipment, designers of instructional resources must weigh whether teachers likely have access to the necessary scientific materials and equipment to use an instructional resource.

Documentational Genesis as a Form of Professional Knowledge

The differences in documentation using the GCSCC between the experienced and beginning teachers in this study illustrate how documentation represents a form of professional

knowledge. In this light, part of becoming a professional teacher means learning how to search for, interpret, evaluate, and adapt resources from a vast resource system (Pepin et al., 2017) that include both infrastructure resources and personal resources -- the role of teacher as critical curator (Sawyer et al., 2020). Radford (2011) characterized teachers' professional knowledge as "knowing with tools", marking resources as an inextricable part of teachers' work. More broadly, Brown (2011) refers to teachers' "ability to perceive and mobilize existing resources in order to craft instructional contexts" (p. 24) as *pedagogical design capacity* -- a skill that he describes as central to the professional work of teachers.

The experienced teachers in this study demonstrated a greater level of comfort with navigating their resource systems than their beginning colleagues; when the infrastructure changed with the rollout of new IGIs, experienced teachers used strategies like appealing to past resources, searching for resources from sources they trusted, and honing those searches by looking for specific markers in the resources that served as a basis for evaluation. The role of documentation experience in shaping this work aligns with DAD's proposition that teachers gain professional knowledge through documentation by way of instrumentation (Remillard, 2005; Trouche, 2004). By contrast, the beginning teachers who had less documentation experience expressed a feeling of overwhelmedness when navigating their resource systems. For some teachers like Mrs. Hughes, this overwhelmedness inhibited their use of both the GCSCC and the resources provided by other, more experienced teachers. The work of searching for, interpreting, evaluating, adapting, and preparing resources takes precious time, even more for teachers with less documentation experience.

Despite the value and importance of learning how to engage in documentation using large resource systems, teachers rarely if ever receive intentional support with this work (Taylor,

2013). While teachers may receive support on the use of a specific resource through professional development, teachers often receive comparatively little support for learning how to search for, interpret, evaluate, and adapt resources for coherence using their entire resource system. In the present study, GCS implemented the GCSCC with little teacher support for its use. While the district provided the teachers with an incentive to review the resources during the Summer of 2022, this incentive did not include systematic and ongoing professional support for the use of those resources. As a result, many of the teachers failed to see how the GCSCC might support their work and abandoned the resources. Conversely, when GCS launched a new set of science IGIs at the start of the 2023-24 school year, teachers received professional support through Frontiers with how those IGIs provided coherence across the state standards, the instructional materials (i.e. Defined Learning, CIBL), and the common formative assessments the district created. By making this alignment more explicit, teachers like Mrs. Meyer could more readily implement the resources in their instruction -- a sensation that she described as "the stars aligning". This example illustrates that additional IGIs like an instructional framework with accompanying teacher professional learning can support teachers with crafting coherence in their documentational genesis. However, this study also illustrates that the design and implementation of those IGIs must meet the different needs of both beginning and experienced teachers based on their expertise gained through instrumentation.

The question remains: how can schools and districts craft IGIs to support teachers' documentation across their resource systems while attending to the differential needs of beginning and experienced teachers? Answering this question provides a focus of future research. As an illustration of how this system could look, nearly all of the teachers interviewed in this study expressed a desire for options and alternative choices within the GCSCC. Rather

than a single, highly-structured lesson for each topic, teachers expressed a desire for a GCSCC in which each of the state standards contained multiple resources tested by other teachers in the district to ensure that the resources aligned with their infrastructure. This system could also include opportunities for teachers to share their experiences using a resource with other teachers in the district in order to provide beginning teachers with additional guidance and examples of how resources can be used in varying, science-specific ways. Such a system is consistent with studies on the value of teacher-driven curricular design (Balgopal, 2020; Severance et al., 2016). As the barriers to the development of the GCSCC in this study illustrated, professional development would be necessary for both the development of these resources and the use of the system to search for, interpret, evaluate, and adapt the resources, particularly for beginning teachers.

In this way, teachers can receive support for both what resources to use and how to use them while still maintaining the agency needed to select and adapt resources in ways that are appropriate for their specific context. While similar systems have been tested at large-scale levels (e.g. Rocha, 2018), such studies have often focused on national rather than localized systems which can miss the opportunity for these resources to align with state and district infrastructure. Further design work in this area may highlight ways which in the design of resource systems in partnership with the design of IGIs can promote the crafting of coherence through documentation (Penuel, 2019).

The Role of Instructional Vision in Coherence-Crafting With Resources

While exploring the ways in which teachers professionally craft coherence between resources and their infrastructure can shed light on how both resources and infrastructure can be designed to promote this coherence, care should be exercised when aligning these resources and

IGIs with an instructional vision. In this study, the instructional framework used in the development of the GCSCC represented a specific vision for how a lesson should flow within a classroom. This vision included a Launch, a student-driven Exploration, a class Discussion, and a Land that provided closure for the lesson. Similarly, teachers' interpretations of the demands of the state test led them to form conclusions about how their classroom instruction should look, with some teachers adopting more didactic and test-centered pedagogical approaches. The ways in which the teachers in this study interacted with these and other IGIs demonstrated that, as teachers interpreted their infrastructure, they made determinations about how their selection and use of resources should create coherence with the instructional framework embodied by these IGIs.

In some cases, these interpretations can result in perceived incoherence between a teacher's pedagogical beliefs and the instructional frameworks embodied in their infrastructure (Smith & Southerland, 2007). For example, Mrs. Meyer had received training in the use of the OpenSciEd model (https://www.openscied.org) prior to her employment with GCS. This training fostered in her a belief that science instruction should use phenomena as anchors for student-centered inquiry and modeling, yet she interpreted this vision as misaligning with her infrastructure. This incoherence led her to still use phenomena as a launching point for an instructional unit, but her class never revisited those phenomena throughout the unit, creating an inconsistency with the OpenSciEd model. The tension she experienced between her pedagogical beliefs and the instructional framework embodied in her infrastructure was further illustrated in the differences in implementation of the Mystery Bones lesson; despite co-designing the lesson with Mrs. Mason, Mrs. Meyer adapted the lesson on-the-fly to facilitate discussion among her students about an incorrect arrangement of the bones.

While this study did not explore the impact of teachers' documentational genesis on student learning, Mrs. Meyer expressed that, in past semesters, her high student test scores garnered praise from her administrators, illustrating the reinforcing role that instructional oversight played in encouraging her to align her instruction with the state test. In this way, Mrs. Meyer used resources to craft coherence with her infrastructure, but in a way that largely incorporated more didactic teaching practices. One could imagine that, had she instead chosen to favor her previous instructional philosophy that embraced more authentic scientific exploration among students, she may have received pushback from administrators if her students' test scores decreased, suggesting that she may be held more accountable to test results than students' engagement with authentic scientific practices. Similarly, Mr. Martinez and Mrs. Branson focused many of their decisions about which resources to use and how to use them in ways that specifically provided coherence with the state test.

These examples illustrate how instructional frameworks embedded in infrastructure can encourage teachers to align their documents with a vision for science instruction. However, the pedagogical vision underlying the design of this infrastructure lead teachers away from reform-based science teaching practices. In cases where IGIs at GCS incentivized teachers to focus on students' performance on a standardized test, teachers selected and used resources in a way that created coherence with those expectations. In these cases, teachers' documentational genesis often resulted in instruction that reflected didactic teaching practices rather than student-centered inquiry. For example, Mrs. Branson relied on guided notes and worksheets for her biology class – both of which emphasized the transmission of information rather than student engagement in disciplinary science practices. Conversely, she gave students in her Marine Science class – an untested subject – more agency in their learning by enabling them to select topics of interest for

study. Likewise, Mrs. Cook selected and used resources in ways that created coherence with her pedagogical belief that science instruction should emphasize student reasoning rather than rote memorization, in some part enabled by the fact that her class did not have a state test.

As these examples demonstrate, crafting coherence among resources and IGIs may not necessarily result in reform-based and equitable instructional practices (Settlage & Meadows, 2002). Teachers in this study exercised agency in their documentational genesis, yet in some cases, the design of the IGIs that influenced this work resulted in the selection and use of resources that reflected more didactic pedagogical configurations. One could conceive that with a set of IGIs that instead embodied reform-based science teaching practices, teachers would similarly align their documents with a more reform-based pedagogical vision. While the new science IGIs at GCS reflected an intentional effort to facilitate science instruction that aligns with a new instructional framework, more time will be needed to determine how this new infrastructure influences teachers' documentational genesis and student learning in the long term, if at all.

Infrastructure, therefore, reflects a set of structures that necessarily constrains teachers' agency, guiding their selection and use of resources toward a specific instructional vision. Indeed, leaving teachers with total agency and no structural support can lead teachers to an *anything goes* approach to education, which can deepen ineffective and inequitable teaching practices (Buxton et al., 2015). Simultaneously, teachers require some degree of agency to translate the instructional framework embodied by the infrastructure into their context (Squire et al., 2003). This tension reflects the dialectic nature of structure and agency; the interactions between teachers and resources are neither top-down nor bottom-up, but rather reflect a back-

and-forth relationship as teachers interact with, reproduce, and transform resources (Martin & Carter, 2015; Rivera Maulucci et al., 2015).

The careful design of infrastructure and resources around a reform-based pedagogical vision may also support teachers' learning and professional growth. For example, when a state decides to adopt a new set of reform-based science standards such as The Next Generation Science Standards, the state has implemented an IGI that has explicit assumptions about how students learn science (NRC, 2012). Teachers whose existing documents align with a different set of assumptions will require support to redesign their documents to provide coherence with this model. As this study illustrates, teachers with more experience may have more robust documents and may require more support in the documentational genesis required to create coherence between their documents and the new instructional framework (Allen, 2023). Additionally, this study illustrates that teachers may not take up those practices if they provide too much perceived incoherence with the rest of their IGIs. Therefore, if a school, district, or state wishes to encourage the use of equitable, culturally-sustaining (Paris, 2012) pedagogical practices among science teachers, each of the IGIs in those teachers' infrastructure must be examined to ensure that they promote alignment with the new instructional framework.

As Penuel and colleagues (2009) argue, however, such alignment is not necessarily enough to push teachers to adopt new practices. Teachers also need access to instructional resources that align with these practices as well as support for adapting resources in ways that align with this instructional framework. In other words, teachers require support in exercising their agency through documentational genesis in a way that both meets the idiosyncratic needs of their contexts and creates coherence with the desired instructional framework. As Buxton and colleagues (2015) found, facilitating teachers' engagement with these instructional frameworks

and resources through professional learning opportunities focused on the translation of instructional resources and frameworks into context can result in greater enactment of the desired instructional framework.

The design of IGIs and support for teachers' agency in documentational genesis must therefore facilitate the crafting of coherence toward more reform-based science teaching or risk facilitating teachers' selection and adaptation of resources that can deepen ineffective and inequitable teaching practices. In this way, infrastructure and accountability can help teachers implement more reform-based teaching practices through science teachers' exercised agency for the selection and use of resources that create coherence with a reform-based instructional framework embodied in the infrastructure. Teachers need some structure to facilitate the use of equitable and effective teaching practices while maintaining sufficient agency to craft documents that embody this pedagogical vision and meet their contextual needs. The question remains: how can different kinds of IGIs be designed to embody these reform-based instructional frameworks, especially when the IGIs with which teachers interact are designed by different institutions at the local, district, and state levels? This question can serve as a direction of future research.

Limitations of the Study

As I discussed in Chapter 3, one of the most significant limitations to this study was that I could not verify teachers' claims about their implementations of resources during interviews through classroom observations due to conflicts with my work schedule. While I collected teacher artifacts where I could to provide sources of triangulation (Tracy & Hinrichs, 2017), the majority of my interpretation of the data from Phase 2 relied primarily on the testimonials provided by teachers during interviews. While this procedural barrier may limit the validity of the findings, each of the teachers I interviewed expressed similar perceptions and beliefs about

the GCSCC. With few exceptions, each of the claims I made in the analysis was shared by two or more teachers, providing an additional source of triangulation and increasing the validity of the findings (Clandinin, 2013; Merriam & Tisdell, 2016). Additionally, I found substantial agreement between each teacher's Spring and Fall interviews, suggesting that teachers' perceptions remained largely stable during this time. My status as a district insider also gave me access to a suite of district-level documents including emails and the newly-developed science IGIs. Furthermore, as I discussed earlier in this chapter, this study emphasized the role that teachers' perceptions of IGIs played on their documentational genesis, not necessarily the IGIs themselves. Two different individuals working in the same system may perceive the IGIs in different ways, yet one teachers' perception of the IGIs would likely have little bearing on the influence of another teachers' perceptions on their work. In this way, I sought to mitigate the impact of limited data availability by seeking alternative means of triangulation and structuring my analysis of the data in a way that accounted for these limitations.

Other limitations also presented themselves during the study. As I discussed in Chapter 4, my use of page views as a metric for teacher engagement with the GCSCC presents some challenges for interpreting the quantitative findings. Page views were the main data source available to me through Canvas, yet such a metric for measuring engagement may enhance apparent teacher engagement with collections that contain more pages. Indeed, my analysis of the Phase 1 data revealed differences in teachers' use of the GCSCC collections across grade levels and content areas, yet these differences aligned with the number of resources found in each collection. Interview data highlighted some ways in which disciplinary and grade level differences could provide mechanisms that caused these differences, yet a set of collections that each contained a complete set of resources would have provided more reliable data.

I also conducted no inferential statistical testing using the Canvas metadata; the presence of the previous confounding variable and the likely unique nature of the development and implementation of the GCSCC meant that the results of such testing would not likely translate well outside of this context. I had all of the login data from teachers to that point, so comparisons of the access patterns across the collections included the total set of data rather than a sampling. As such, these findings were specific to the time and place of this study, which focused on highlighting mechanisms by which IGIs can enable and constrain teachers' agency for documentational genesis. While I revisited the GCSCC throughout the analysis phase of the study to validate specific conjectures, I no longer systematically collected the full metadata the way I did in Phase 1 after I began inviting teachers to participate in interviews for the study. Further research into the long-term impact of the GCSCC may find that the GCSCC plays a new role in supporting teachers in the district once the teachers gain experience with the new science IGIs.

In addition to the previous limitations, I was unable to secure interviews with teachers in each subject area, such as EES. When selecting schools to include in Phase 2 of the study, I sought to focus the scope of the participant invitations to what I predicted would be a manageable number of communities to compare in rich depth. However, no EES teachers volunteered to participate in the study, and the only interview with a 6th grade science teacher I could secure was with a math teacher who taught 6th grade science for a semester to cover for a vacancy. Interviewing an EES and another 6th grade science teacher may have revealed further insights into differences in IGIs between tested and untested subjects, as both 6th grade science and EES were untested subjects. To account for this, I relied on the interviews with Mrs. Cook; while she did not teach EES during the time that I interviewed her, she had taught the course in

the past and taught Chemistry -- an untested subject -- at the time of the study. I generalized the depiction of the relative agency that teachers of untested subjects have in GCS schools provided by Mrs. Cook, Mrs. Branson, and Mrs. Hughes, yet other teachers may have perceived this dynamic differently.

The 6th grade science collection also contained the most resources of the four collections. Another interview with a 6th grade science teacher may have shed further light on the role that the number of resources in a collection played on teachers' use of the resources contained in the collection. Future research could incorporate interviews with teachers from more schools to gain more perspectives and fill in these gaps.

Directions for Future Research

Throughout this study, I used the logic model presented in Figure 2 of Chapter 2 as a tool for studying teachers' documentational genesis. The use of this model provided a means by which to highlight specific processes in which teachers engaged during documentational genesis, enabling the comparison of these processes among teachers. This model further served as a foundation to explore the factors that influenced the decisions that teachers made during documentational genesis. While this study focused on IGIs, future research may use this model to elicit other factors that influence these decisions. The model may also shed light on specific tension points within these processes, providing a foundation for intervention. If, for example, a teacher struggles to find resources that meet the needs of their context, at what stage of the process does the problem arise? Is the teacher struggling during the search process? Does the teacher have difficulty interpreting the resources they find, like Mrs. Hughes in this study? Does the teacher have difficulty adapting resources to promote coherence with other IGIs? In this way, the logic model represents a tool for further exploration of these processes.

The use of the logic model in this study also highlighted the nature of documents as the foundation for instructional design, particularly comparing the work of beginning and experienced teachers. The findings from this study suggested that, even if a teacher has career experience, teaching a new subject requires the establishment of new documents. This finding highlights the problematic nature of traditional conceptualizations of the term *beginning teacher* as limited to years of experience teaching any subject. However, teachers who are new to a subject but have teaching experience may still draw from their past documentational experiences in other subjects while engaging in documentational genesis in their new subject. For example, a teacher who teaches Chemistry for the first time after teaching Biology for several years likely has a repertoire of habits and sources of resources that shape their documentational genesis. Further research is needed to explore how past experiences in different contexts influence present documentational genesis. Science education may particularly benefit from this work given the relatively large number of science teachers teaching out of field (Banilower et al., 2018).

In addition to the methodological directions for future research outlined above, further research on the interplay between documentational genesis and infrastructure as an embodiment of teachers exercising professional agency as they negotiate with the structures that enable and bound their work could provide schools and districts with a set of principles for designing infrastructure that better promotes coherence. While this and other related studies (e.g. Heredia, 2020) highlight the importance of coherence, little is known about how coherence can be actively promoted and created in the design of school and district infrastructure. Future research could also focus on other contexts, kinds of resources, and kinds of infrastructure, identifying other sources of incoherence and creating a more generalizable set of principles by which

schools and districts can make more informed decisions about resource acquisition and deployment as well as IGI development. This line of inquiry also bears implications for the design of resources themselves, specifically those that seek to both provide educative instructions for teachers' use of the resource while promoting adaptive flexibility.

This research is particularly imperative in a time when state policies seek to constrain teachers' agency for selecting resources (e.g. Patterson, 2023; Stanford & Najarro, 2023), fueling a delegitimization of teaching as a profession. The fact that teachers exercise professional knowledge of their content and context as they select and adapt resources adds to the mountain of evidence that teaching represents a discipline with its own body of knowledge (Shulman, 1986) -- a position that some politicians and political activists question. By further exploring the ways in which teachers actively select and adapt resources to align with their infrastructure, we can continue to highlight the professional nature of this work and inform policies that influence the resources to which teachers have access and the agency that teachers' possess to select and use resources. To quote Balgopal (2020):

> Giroux (1985) claimed that until teachers are viewed as intelligent, capable professionals, their successes will not be highlighted. He argued that when teachers are treated as clerks of policy and bureaucracy (implementing curricula that others have developed) and whose abilities as reflective practitioners are ignored, schools are less efficient and less capable of graduating students who are civically engaged.

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APPENDIX A: RECRUITMENT SCRIPT FOR GCSCC LEAD TEACHER

Hello [teacher name],

My name is David Schouweiler. I teach science at GCS and am currently working on my doctoral dissertation at UNCG. My dissertation research focuses on the curriculum collection of resources launched by the district this past summer. My research interest focuses on the ways in which this collection of resources has or has not been used by science teachers in the district with the purpose of understanding the factors that either enable or inhibit the usefulness of these resources.

To explore these factors at GCS, I am conducting a research study that involves exploring the design, development, and use of the curriculum collection's resources. This study is being conducted in two phases. In the first phase, I analyzed the metadata from the Canvas course in which the curriculum collection was housed. From this data, I explored patterns in the ways in which GCS science teachers accessed the resources. The second phase of the study focuses on exploring what resources teachers used in their classrooms (if any), how teachers modified (or did not modify) those resources, and what contextual factors supported or inhibited the use of the resources.

To explore these factors at GCS, I am conducting a research study that involves exploring the design, development, and use of the curriculum collection's resources. I would like to invite you to participate in this study due to your role as the lead teacher overseeing the curriculum collection. Your participation would involve an interview of up to 60 minutes with the purpose of discussing the design of the curriculum collection including the design process and key elements. If you choose to participate in this study, you will be compensated with a $20 Amazon gift card for your time. Your data will be kept confidential; I will use pseudonyms to refer to both you and your school, and information that you share will not be shared with the district if it could readily be tied back to you.

To be clear, this study is not meant to be evaluative in any way. Rather, the purpose of this study is to understand how our district and other school districts can better support science teachers' access to and use of resources for teaching science. Findings from this study will result not only in the completion of my doctoral dissertation work, but also in a set of recommendations to the district containing ways that the district can support teachers.

If you are interested in participating in this study, I would like to set up the first interview at your earliest convenience. Please feel free to reach out with any questions or concerns.

Best regards,

David Schouweiler

APPENDIX B: INTERVIEW PROTOCOL FOR GCSCC LEAD TEACHER

Thank him for his time, remind him that participation is voluntary, overview the purposes of the study

1. Background Information
    - What school do you teach at?
    - What subject(s) do you teach?
    - What degree(s) have you earned?
    - What route did you use to become a teacher (e.g. a traditional undergraduate program, lateral entry)?
    - How long have you been a teacher?
    - How long have you been at GCS?
    - How long have you taught science?
        - If different from years teaching: what did you teach prior to teaching science?
2. Development of the GCS Curriculum Collection (GCSCC)
    - What was the design phase of the Curriculum Collection like?
    - What was your role?
    - How did you work with the teacher designers?
    - Was there a specific scaffold or lesson template you shared with them, and if so, what were they?
    - (If applicable) What degree of control did you have in selecting this framework or design principles?
    - When you were giving feedback on the drafts of these lesson resources, how did you evaluate them? What criteria did you use?
3. Intended use by teachers
    - How do you see teachers using the resources your team created?
    - What were some of your favorite resources? Why?
4. GCSCC structure
    - How are the resources in the Canvas course organized?
    - (Follow-up questions will depend on this answer with the goal of determining how the GCSCC Canvas course is structured)
5. Is there anything else you would like to share that you think might help this study?

Thank him again, ask if follow-up questions are welcome and, if so, preferred mode of contact

APPENDIX C: RECRUITMENT SCRIPT FOR DISTRICT LEADERS

Hello [teacher name],

My name is David Schouweiler. I teach science at GCS and am currently working on my doctoral dissertation at UNCG. My dissertation research focuses on the curriculum collection of resources launched by the district this past summer. My research interest focuses on the ways in which this collection of resources has or has not been used by science teachers in the district with the purpose of understanding the factors that either enable or inhibit the usefulness of these resources.

To explore these factors at GCS, I am conducting a research study that involves exploring the design, development, and use of the curriculum collection's resources. This study is being conducted in two phases. In the first phase, I analyzed the metadata from the Canvas course in which the curriculum collection was housed. From this data, I explored patterns in the ways in which GCS science teachers accessed the resources. The second phase of the study focuses on exploring what resources teachers used in their classrooms (if any), how teachers modified (or did not modify) those resources, and what contextual factors supported or inhibited the use of the resources.

As a building level administrator or support staff involved in the teaching of science in your building, I am inviting you to participate in the second phase of this study. As a participant in the study, you would be asked to participate in an audio-recorded interview of up to 60 minutes with the purpose of constructing a more complete picture of the context in which RSS science teachers work. This interview will include questions about things like material resources, schedules, accountability measures, professional development opportunities, and other factors that affect teachers' work and professional growth. If you choose to participate in this study, you will be compensated with a $20 Amazon gift card for your time. Your data will be kept confidential; I will use pseudonyms to refer to both you and your school, and information that you share with me will not be shared with the district if it could readily be tied back to you.

To be clear, this study is not meant to be evaluative in any way. Rather, the purpose of this study is to understand how our district and other school districts can better support science teachers' access to and use of resources for teaching science. Findings from this study will result not only in the completion of my doctoral dissertation work, but also in a set of recommendations to the district containing ways that the district can support teachers.

If you are interested in participating in this study, I would like to set up the first interview at your earliest convenience. Please feel free to reach out with any questions or concerns.

Best regards,

David Schouweiler

APPENDIX D: INTERVIEW PROTOCOL FOR DISTRICT LEADERS

Thank interviewee for their time, remind them that participation is voluntary, remind them of the purposes of the study

1. Background
    a. What school do you work with / at?
    b. What is your role at this school?
    c. How long have you served in this role? At this school?
    d. How long have you worked in this district?
2. Infrastructure
    a. The purpose of this study is to better understand how infrastructure (e.g. policies, accountability measures, resources, etc) influence the ways that teachers use resources in their teaching. I am going to ask you some questions about these kinds of infrastructure to get a better understanding of the context in which science teachers at your school operate. What does the typical day of a science teacher look like at your school?
    b. Are there any specific curriculum resources that teachers at the school are expected to use? If so…
        i. What are those resources?
        ii. How are these expectations communicated to teachers?
        iii. How are teachers held accountable for using these resources?
    c. Are there any specific pedagogical expectations for science teachers at your school like specific teaching strategies or assessment strategies? If so…
        i. What are some examples of those expectations?
        ii. How are these expectations communicated to teachers?
        iii. How are teachers held accountable for using these strategies?
    d. What degree of autonomy would you say science teachers at your school have over choosing the resources they use?
    e. Do science teachers have common planning time, a PLC, or some other time specifically for collaborating with each other? If so…
        i. What does that look like?
        ii. Who is in charge of structuring that time? How is that time typically structured?
    f. What kinds of PD do science teachers at your school engage in? How often does this happen?
    g. What kinds of lab supplies do science teachers have access to?
        i. Is there a procedure for teachers to request supplies? If so, what does that entail?
    h. What does a typical science room at your school look like? What kinds of safety equipment, tables, etc are there?
    i. Has your science department been fully staffed for most of the year? Have teachers had to take on extra responsibilities this year like coverage of classes due to things like staffing shortages?

j. Is there anything else at your school that may shape the way that science teachers plan and implement instruction?

Thank leaders again, invite them to share follow up thoughts if they think of them via email

APPENDIX E: RECRUITMENT SCRIPT FOR TEACHERS

Hello [teacher name],

My name is David Schouweiler. I teach science at GCS and am currently working on my doctoral dissertation at UNCG. My dissertation research focuses on the curriculum collection of resources launched by the district this past summer. My research interest focuses on the ways in which this collection of resources has or has not been used by science teachers in the district with the purpose of understanding the factors that either enable or inhibit the usefulness of these resources.

To explore these factors at GCS, I am conducting a research study that involves exploring the design, development, and use of the curriculum collection's resources. This study is being conducted in two phases. In the first phase, I analyzed the metadata from the Canvas course in which the curriculum collection was housed. From this data, I explored patterns in the ways in which GCS science teachers accessed the resources. The second phase of the study focuses on exploring what resources teachers used in their classrooms (if any), how teachers modified (or did not modify) those resources, and what contextual factors supported or inhibited the use of the resources.

As a science teacher in the district who has accessed these resources, I am inviting you to participate in the second phase of this study. As a participant in the study, you would be asked to participate in two audio-recorded interviews of up to 60 minutes. These interviews will include questions about your teaching experience, the resources you used from the curriculum collection (if any), and factors relevant to your work as a science teacher such as physical resources provided by your school and teaching schedules. Additionally, you will be asked to keep a log of which resources from the curriculum collection you use during the time between interviews as well as a description of how you use those resources in your teaching. This log should take no more than five minutes to complete each time you use a curriculum collection resource.

Participation in this research project is voluntary and should amount to no more than 5 hours total of your time. Your data will be kept confidential; I will use pseudonyms to refer to both you and your school, and information that you share with me will not be shared with the district if it could readily be tied back to you. Should you decide to participate in this research, you will be compensated with a $20 Amazon gift card for each interview you participate in.

To be clear, this study is not meant to be evaluative in any way. Rather, the purpose of this study is to understand how our district and other school districts can better support science teachers' access to and use of resources for teaching science. Findings from this study will result not only in the completion of my doctoral dissertation work, but also in a set of recommendations to the district containing ways that the district can support teachers.

If you are interested in participating in this study, I would like to set up the first interview at your earliest convenience. Please feel free to reach out with any questions or concerns.

Best regards,

David Schouweiler

APPENDIX F: TEACHER SPRING INTERVIEW PROTOCOL

Thank teachers for their time, remind them that participation is voluntary, overview the purposes of the study

1. Background Information
    - What school do you teach at?
    - What subject(s) do you teach?
    - What degree(s) have you earned?
    - What route did you use to become a teacher (e.g. a traditional undergraduate program, lateral entry)?
    - How long have you been a teacher?
    - How long have you been at GCS?
    - How long have you taught science?
        - If different from years teaching: what did you teach prior to teaching science?
    - What does a typical day of teaching look like in your classroom?
    - How do you typically go about planning a lesson or unit of instruction?
        - What kinds of resources do you typically use?
        - Where do you typically search for or access these resources?
2. Resource use
    - What are some resources (if any) that you used from the curriculum collection (CC)?
    - Did you mostly use entire lessons, or did you select pieces from lessons to incorporate into your existing lessons?
    - Were there any resources that you wanted to use, but had to adapt them to your context? If so, how did you change the resources to make them useful for you?
    - Did your work with the CC inspire you to change any of your existing lessons or resources? If so, how?
    - Are there any lessons or resources from the CC that you plan to use going forward? If so, which ones, and why?
3. Structure of the (CC)
    - When you accessed the CC, were you primarily looking for a specific resource or just browsing?
    - In general, how easy was the CC to use in order to find what you were looking for?
    - Was there any kind of resource or resource for a specific topic that wasn't in the CC that you wish was there? If so, what?
    - If you could change one part of the Canvas course to make it more useful to you, what would it be and why?
4. Infrastructure
    - Were there any resources that you wanted to use, but felt that you couldn't? If so, which one(s), and why couldn't you use it?
    - Were there any resources in the CC that required you to have access to specific materials and equipment? If so, what kind of resources?

    - How well do you feel that the CC resources align with your teaching philosophy?
    - How might the CC program be improved or expanded to be more useful to you?
5. Is there anything else you would like to share about your experience with the CC resources?

Thank teachers again, explain the documentation table part of the study, ask teachers whether they would like to participate and whether they would like to participate in a follow-up interview near the end of the semester

APPENDIX G: TEACHER FALL INTERVIEW PROTOCOL

Thank teachers for their time, remind them that participation is voluntary, remind them of the purposes of the study

1. CC use
    - Did you find yourself going back to the CC at all this semester? If so…
        - How often, and what prompted the search?
        - When you accessed the CC, were you primarily looking for a specific resource or just browsing?
        - In general, how easy was the CC to use in order to find what you were looking for?
    - Was there any kind of resource or resource for a specific topic that wasn't in the CC that you wish was there? If so, what?
    - If you could change one part of the Canvas course to make it more useful to you, what would it be and why?

If the teacher found themselves revisiting the CC since our last session, ask questions in section 2, else skip to 3.

2. Infrastructure
    - Were there any resources that you wanted to use, but felt that you couldn't? If so, which one(s), and why couldn't you use it?
    - Were there any resources in the CC that required you to have access to specific resources? If so, what kind of resources?
    - How well do you feel that the CC resources align with your teaching philosophy?
3. Is there anything else you would like to share about your experience with the CC resources?

Thank teachers again, invite them to share follow up thoughts if they think of them via email.

APPENDIX H: EXPANDED GCSCC DATA TABLE FROM PHASE 1

Table H9. Expanded GCSCC Data Table From Phase 1

	Fall 2021			Spring 2022			Summer 2022			Fall 2022			Totals			
	Pages	Users	Visits	Pages	Users	Visits	Pages	Users	Visits	Pages	Users	Visits	Pages	Users	Visits	Unique Users
Totals	3909	18	52	2816	14	48	3211	41	70	9133	43	139	19069	68	309	52
By Subject																
6th Grade	269	9	14	462	7	19	1093	16	27	7891	19	94	9715	28	154	28
8th Grade	2938	6	20	1973	4	17	925	11	17	571	9	20	6407	19	74	19
Bio	702	3	18	381	3	12	730	9	19	558	9	15	2371	13	64	13
EES	0	0	0	0	0	0	463	5	7	113	6	10	576	8	17	8
Middle Schools																
MS1	178	4	8	384	3	9	349	3	5	318	6	7	1229	7	29	6
MS2	110	1	3	22	1	2	193	1	4	1725	1	20	2050	2	29	2
MS3	2354	2	10	1728	2	18	125	5	6	460	7	19	4667	8	53	8
MS4	0	0	0	0	0	0	680	9	15	2275	8	22	2955	12	37	6
MS5	0	0	0	0	0	0	53	3	4	2421	5	21	2474	6	25	4
MS6.1	38	3	3	102	1	1	465	4	8	537	1	12	1142	5	24	4
MS6.2	51	1	3	23	1	2	83	2	2	772	4	18	929	6	25	5
MS Totals	2731	11	27	2259	8	32	1948	27	44	8508	32	119	15446	46	222	35
High Schools																
HS1	62	1	3	31	2	3	286	1	5	32	2	2	411	4	13	4

HS2	0	0	0	0	0	0	173	1	3	19	1	2	192	1	5	1
HS3	626	2	14	350	1	9	435	7	8	235	4	8	1646	9	39	6
HS5	35	1	2	0	0	0	0	0	0	18	1	2	53	1	4	1
HS6	0	0	0	0	0	0	161	2	5	100	2	5	261	3	10	2
HS Totals	723	4	19	381	3	12	1055	11	21	404	10	19	2563	18	71	14
Special Programs																
K-8 Virtual	455	3	6	176	3	4	197	2	4	0	0	0	828	4	14	3
Early College	0	0	0	0	0	0	11	1	1	221	1	1	232	1	2	1
Special Totals	455	3	6	176	3	4	208	3	5	221	1	1	1060	6	16	4