INVESTIGATING SCIENCE TEACHERS' INTERPRETATIONS OF MOTIVATING FEATURES OF INQUIRY-BASED SCIENCE CURRICULUM AND THEIR ENACTMENT DECISION MAKING

by

SHELLY ANNE WITHAM

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ABSTRACT OF THE DISSERTATION

Investigating Science Teachers' Interpretations of Motivating Features of Inquiry-based Science Curriculum and their Enactment Decision-making

By SHELLY ANNE WITHAM

Dissertation Director:

Dr. Clark A. Chinn

It is challenging to motivate and deeply engage students in inquiry-based science settings. Inquiry tasks are difficult, require the coordination of deep-level learning strategies, and extend over time. Despite these challenges, the curriculum supports found in inquiry-based curricula have the potential to provide optimal conditions for high quality motivational enactment in support of students' basic need for autonomy. The existing literature has not yet provided insights into how teachers draw on inquiry curriculum with autonomy-supportive features and translate it into high quality enactment. Thus, we need information about how teachers work with, optimize, supplement and modify inquiry materials to have a fuller understanding of how their enactment supports student autonomy in optimal ways within inquiry contexts. The purpose of this study was to (1) examine how teachers interpret and notice the autonomy supportive features provided within inquiry curricula, (2) investigate the particular modifications and revisions teachers make when considering enactment of these motivating features, and (3) explore the rationales and reasons behind these enactment decisions. Data was collected from interviews and classroom observations from four inquiry teachers to examine how they augment, diminish, or enact as intended autonomy-supportive curriculum features. Teachers planned to enact the curriculum as intended 78% of the time and planned modifications 22% of the time. Encouragingly, 56% of these planned modifications enhanced student autonomy. Reasons influencing teachers to adopt autonomy-supportive practices were driven not only by teaching pressures, but also by various supports. Implications for inquiry curriculum developers and for elaborating our understanding of autonomy-supportive practices within inquiry contexts will be discussed. Findings underscore the importance of accounting for motivation curricular features in combination with teachers' motivational beliefs as antecedents to their resulting motivational enactment.

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Chapter 1: Introduction

While there are motivating features for initiating student's motivation in inquiry settings, there are several challenges to sustaining motivation in ways that deeply engage students. Inquiry tasks are difficult, require the coordination of deep-level learning strategies, and extend over time. Inquiry requires students to invest more cognitive work than traditional classrooms, and these materials introduce a high degree of challenge and complexity (Blumenfeld, Kempler & Krajcik, 2006). In response, students may experience lowered competence, diminished interest and diminished intrinsic motivation, and may resist cognitive work (Doyle, 1983; Henningsen & Stein, 1997).

Despite these challenges, the curriculum features of these inquiry-based units have the potential to provide the necessary conditions for high quality motivational enactment. For example, the open nature of inquiry tasks affords opportunities for students to generate ideas, revise ideas after examining key evidence, plan how to go about solving tasks, and take responsibility for the refinement of ideas. The examination of motivational qualities of inquiry-based units is particularly timely, given the recent adoption of the *Next Generation Science Standards (NGSS)* that calls for more active exploration of science ideas, scientific inquiry, scientific practices, and engineering practices with less emphasis on rote mastery of an activity or procedure (National Research Council, 2013).

The current study focused on autonomy-supportive, relatedness, and competence-supportive qualities of inquiry-based units and the accompanying motivational practices as enacted by inquiry teachers. According to Self-Determination Theory (SDT), autonomy can be defined as the experience of one's behavior as self-endorsed and compatible with one's values, interests, and beliefs (Deci & Ryan, 1985a; Deci & Ryan, 1985b). When conditions are supportive of the individual's experience of autonomy, high quality forms of motivation and engagement for activities are fostered, as well as enhanced performance and persistence (Reeve & Jang, 2006; Reeve, Jang, Carrell, Jeon, & Barch 2004). We know that teacher practices and curriculum features can either facilitate or undermine autonomy needs, with consequences for intrinsic motivation and learning (Deci & Ryan, 1985a; Deci & Ryan, 1985b). Inquiry classrooms may be especially facilitative of autonomy given curricular tasks that promote students as originators of ideas; a key aspect of autonomy-supportive practice. In SDT, competence support refers to practices offering optimal challenge (Ryan & Grolnick, 1986), whereas relatedness refers to students' sense of relatedness refers to practices that create positive relationships with teachers and peers (Furrer & Skinner, 2003).

Autonomy-supportive practices provided by teachers refers to the amount of opportunity for initiation a teacher affords, so the student can connect his or her behavior to personal goals, interests, and values. In the SDT literature, autonomy support is: (1) the provision of meaningful rationales, (2) the use non-controlling language, (3) offering choices, (4) informational feedback, and (5) nurturing inner motivational resources (Su & Reeve, 2011). In recent studies, researchers extended the conceptualization of autonomy support beyond the above designations to include organizational, procedural, and cognitive autonomy support (Stefanou, Perencevich, DiCintio, & Turner, 2004). Organizational and procedural autonomy support involves teachers' practices for providing students with opportunities for decision making in the classroom. *Organizational autonomy support* refers to when teachers involve students in decision making related to classroom organization, such as which group should present first or the selection of group members. Teachers provide *procedural autonomy support* with decision-making opportunities related to task format, such as choice in displaying work or how to work with materials. *Cognitive autonomy support* focuses on teacher's practices, which provide students with agency related to content ideas, skills, thinking, and learning. Teacher practices afford cognitive autonomy through cognitive choice (e.g. strategy choice, scaffolding, informational feedback) by maintaining openness of the curriculum tasks, eliciting students' content ideas and accompanying justifications, and encouraging a range of explanations among students.

Competence-supportive practices provide students with intermediately challenging activities in which there is not boredom with easy tasks or reluctance to work on difficult ones. These practices provide students with the opportunity to attain challenging goals which conveys to students that they are becoming more competent (Schunk, Pintrich, & Meece, 2008). Teachers' motivational practices also play a significant role in fostering an environment in which students feel they belong and are cared for within classrooms by their teachers and peers through *relatedness*.

The complex tasks and autonomy-supportive features of inquiry curricula alone may not be sufficient for sustaining students' motivation and deep-level learning strategy use, given the heightened challenge and sustained effort investment required. In light of this challenge, teachers may need to accompany the curriculum features with varying high quality motivational practices satisfying students' needs for relatedness, competence, and autonomy. Here, teachers' instructional practices can play an important role in helping to sustain the high levels of motivation and cognitive engagement needed as students work to synthesize and apply ideas (Stefanou et al, 2004). The role of the teacher can involve highlighting the motivational features of curricular elements, optimizing their enactment, and supplementing these curricular features with additional motivational practices (Kempler, 2006).

Prior observation studies have provided information about how teachers' autonomy support have supplemented traditional curriculum, within a task context that is disconnected from students' own values and goals. In traditional contexts, teachers use primarily narrow forms of choice, on instructionally less relevant aspects of academic tasks, and with a limited range of autonomy supportive practices (Bozack, Vega, McCaslin, & Good, 2008; Turner, Warzon, & Christensen, 2011; Wiley, Good, & McCaslin, 2008). This research finds that autonomy support is narrow and rarely enacted in traditional classrooms (e.g., Bozack et al., 2008). Furthermore, motivation researchers who study motivational practices have a history of providing limited detail and descriptive information about the curricular context and instructional tasks (Blumenfeld, Soloway, Marx, Kajcik, Guzdial, & Palincsar, 1991; Blumenfeld, et al., 2006). As such, these studies are de-contextualized and limit our understandings of the full range of potential autonomy-supportive practices teachers can afford their students.

Motivational enactment is grounded and situated in curricular contexts with both resources combining to explain the afforded autonomy support (Rogat, Witham, & Chinn, 2014). That is, teacher practices and curriculum are intertwined when fostering autonomy support for students. Teachers afforded autonomy support within the context of these inquiry curricula materials (Rogat, et al., 2014). Our observational data identified frequent autonomy supportive practices relative to previous work in experimental and traditional settings. Further, not only do our findings suggest that teachers provided more frequent autonomy relevant practices, but those practices were sustained throughout the entirety of the inquiry units and represented a broad range of high quality practices. Observed practices included teachers connecting content to the unit's driving question (i.e., relevance), providing rubrics for students to self-evaluate their work based on student-generated criteria (i.e., cognitive autonomy), and eliciting and building on student-initiated ideas (i.e., responsive). Teachers also supported student opportunities to develop and revise ideas through the use of evidence. These practices provided meaningful and academically significant autonomy support extending beyond identified practices given the grounding of enactment in inquiry curricula with autonomy relevant features. Taken together, situating teacher practice in an inquiry curriculum with motivating features enables teachers to provide high quality autonomy support.

Despite this high quality and sustained enactment, we also observed frequent low cognitive autonomy support. One observed practice was teachers cutting short whole class and small group discussion that involved developing student ideas by employing leading or closed questions in ways that ultimately led to providing an answer (Rogat et al., 2014). In other observed cases, teachers used their lesson time to let the discussion go long, which allowed for student-initiated ideas, but left insufficient time for the teacher or students to raise the key point or synthesize the lesson. The teacher merely ends the dialogue. It may be that without having access to the key points, students may not gain the full benefits of the cognitive autonomy support.

Therefore, it is critical to study how teachers combine autonomy relevant practices and the curricular features, which ultimately augment what teachers do in inquiry classrooms. Ultimately, this raises interesting questions about how teachers grapple with enactment, the reasons behind enactment decisions and modifications they make. We do not yet have an understanding of why teachers afford a high level of autonomy support and why they afford low autonomy support. We need information about how teachers work with, optimize, supplement, and modify these inquiry materials to have a fuller understanding of how their enactment decisions within inquiry contexts.

To deepen our understanding requires detail about which motivational features teachers notice, teachers' interpretation of the motivational features of inquiry curriculum, teachers' enactment plans and accompanying changes made to curricular tasks, and their reasons behind those enactment decisions. Therefore, the focus of the current dissertation research was to analyze teachers' reported motivational planning, and to describe the interaction between curricular features and enactment decisions within an inquiry curricular context. Toward this end, this dissertation study examined teacher planning with a focus on how teachers augment, diminish or enact as intended the autonomy-supportive curriculum features.

Together with the interpretation of teachers' motivational practices, this study examined the reasons and justifications for teachers' interpretations and modifications to autonomy practices using SDT's research framework for identifying antecedents of autonomy-supportive teaching. The extant literature organizes these antecedents around three main categories organized around pressures from above, within and below: (1) the social context in which they teach (Taylor, Ntoumanis, & Smith, 2009) and administrative supports versus pressures (Pelletier & Sharp 2009), (2) the beliefs that teachers hold (Roth & Weinstock, 2013) and their own personality disposition (Van den

Berghe et al., 2013), and (3) the characteristics of the students they teach (Pelletier, Séguin-Lévesque, & Legault, 2002).

This extant literature has focused on the impact of teacher autonomy-supportive versus controlling behavior on student motivation (e.g. Reeve, 2009; Reeve, Bolt, & Cai, 1999; Reeve & Jang, 2006). The current study seeks to build from this research by elaborating our understanding of antecedents of motivation practices by investigating teachers' reasons for enactment decisions and modifications within a curricular context that has motivating features and for which previous research has identified as facilitating more frequent and higher-quality autonomy-supportive practices (Rogat, et al., 2014).

In sum, the purpose of this dissertation study was to (1) examine how teachers interpret and notice the autonomy supportive features provided within inquiry curricula, (2) investigate the particular modifications and revisions teachers make when considering enactment of these motivating features, and (3) explore the rationales and reasons behind these enactment decisions.

Theoretical and Practical Implications

With the recent adoption of the *NGSS* (NRC, 2013), teachers are at the forefront of implementing new and challenging science curricula. Given findings for how teachers respond to the motivational features of an inquiry curriculum, curriculum developers and designers could (1) develop better curricular materials that support autonomy and (2) develop better professional development targeted at autonomy-supportive teaching. Ultimately, teachers need to combine a range of strategies for motivating learners during complex tasks. These strategies should be enacted both early and across the unit, addressing a variety of students' motivational beliefs (Rogat et al., 2014). Further, focusing on the role of teacher beliefs and reasons behind teachers' enactment decisions of autonomy-supportive and controlling practices will elaborate our current understandings of teachers' motivational beliefs (Reeve, 2009; Reeve, 2013), with a more contextualized examination of proposed lesson modifications. Further, by examining not only teaching pressures, but also how teachers resolved pressures and teaching supports, we will gain a better understanding of the best professional development for inquiry teachers.

Research Questions

1. How do teachers interpret and notice the autonomy supportive features provided within inquiry curricula?
2. What are the specific modifications and revisions teachers make when considering enactment of autonomy-supportive motivating features?
3. What are the rationales and reasons underlying teachers' enactment decisions?

Chapter 2: Review of Literature

Reform-oriented contexts, such as inquiry curriculum units include tasks in which students learn complex scientific ideas by engaging in scientific practices. These tasks include working with models, constructing scientific explanations, engaging in argumentation and debate, gathering and analyzing data gathered either from students' own investigations or captured within complex datasets, and presenting ideas to peers. Reform-oriented science instruction shifts the focus to student control through the engagement of hands-on learning (National Research Council, 1996) in contrast to more teacher guided traditional science instruction. Minner, Levy, and Century's (2009) review of 138 "inquiry-based science instruction" studies indicated that having students actively think about and participate in the investigation process increases their science conceptual learning. Thus, reform-oriented science instruction places students in inquiry contexts that expand opportunities for student ownership of ideas.

With the recent adoption of The NGSS, there was again a call for students to be engaged with science instruction within inquiry contexts (NRC, 2013). The NGSS's vision of science proficiency is housed within four strands that expect students to develop explanations, generate and evaluate evidence, and participate in the discourse and processes of science (National Research Council, 2007). This focus on students' active cognitive involvement in their own learning have replaced earlier standards that focused primarily on students' engagement in the processes and activities of science (NRC, 1996).

In these reform documents, there was a shift from a focus on procedures and hands-on experimentation toward a focus on the cognitive processes involved in the disciplinary practice of science (Furtak & Kunter, 2012). Inquiry units had curricular participation structures (i.e. jigsaw groups) that forefront students as initiators of ideas moving away from simple recall of ideas, comprehension of readings, and understanding of science terminology. Further, inquiry instructional units built upon students' prior knowledge and experiences in the real world through hands-on experiences, exploration of science ideas, scientific inquiry, scientific practices, and engineering practices with less emphasis on rote mastery of an activity or procedure (NRC, 2013). Therefore, examining motivational practices is timely due to the NGSS' calls for science reform in ways that deeply engage learners. However, it is challenging to motivate and deeply engage students in inquiry settings. Inquiry tasks are difficult, require the coordination of deep-level learning strategies, and extend over time (Blumenfeld, et al., 1991). Despite these challenges, the curriculum supports found in inquiry-based curricula have the potential to provide optimal conditions for high quality motivational enactment.

Motivational Features of Inquiry

Reform-oriented contexts, such as inquiry curriculum, have incorporated autonomy-enhancing features (Blumenfeld et al, 2006). Further, the NGSS (NRC, 2013) have articulated the importance of engaging in inquiry while learning content, and inquiry curricula have integrated motivating features as one tactic to deeply engaging students and integrate several curriculum features that have the potential for facilitating autonomy support. Inquiry curricula have *contextualization* by organizing unit content around a driving question (Krajcik & Blumenfeld, 2006) or embedding the study of content ideas within relevant problems. This enhanced relevance by connecting content to students' interests or lives and provided an authentic problem context that serves to organize the key content ideas (Chinn & Malhotra, 2002; Rivet & Krajcik, 2008). Second, inquiry curricula contained *open tasks* such as: model generation, scientific explanation, scientific inquiry investigations, data analysis, and a driving question. These tasks have afforded autonomy given their open nature, with openness having more than a single right answer (Cohen, 1994) as well as opportunities for self-direction, choices, and decision making (Henningsen & Stein, 1997; Reeve & Jang, 2006; Ryan & Deci, 2000). Further, these open tasks were grounded in student-initiated ideas and involved high cognitive demand, requiring students to engage in explanation, justification, and synthesis of their working ideas in ways that facilitate cognitive autonomy (Stein, Grover & Henningsen, 1996).

Third, inquiry curricula have incorporated *disciplinary practices* of science, such as developing and revising models based on evidence, and the use of justification to substantiate claims (Chinn & Buckland, 2011; Duncan, Freidenreich, Chinn, & Bausch, 2011) holding students accountable for meeting science norms, rather than simply to the teacher's right answer (Gresalfi, Martin, Hand, & Greeno, 2009). Fourth, inquiry curricula have afforded opportunities for *collaboration* in small groups during which the students within the group, rather than the teacher, are responsible for decision making and directing the group activity (Rogat, Linnenbrink-Garcia & DiDonato, 2013).

Inquiry environments have also been found to be effective for learning. Chinn, Duncan, Dianovsky, and Rinehart (2013) reviewed literature showing that students who study science in inquiry environments learn more than students in traditional instruction (see also Hmelo-Silver, Duncan, & Chinn, 2007). Research also has indicated that these environments required guidance and scaffolding in order to be effective (Chinn & Clark, 2013; Chinn et al., 2013) as these same materials introduce a high degree of challenge and complexity (Blumenfeld et al., 2006). A challenge here is that, in response to the heightened challenge of inquiry, students have experienced lowered competence, diminished interest and intrinsic motivation, and have resisted cognitive work (Henningsen & Stein, 1997). Inquiry required more cognitive work than what occurs in traditional classrooms students are used to.

Students' Basic Needs: Autonomy, Competence and Relatedness

Self-Determination Theory (SDT) provided a framework for studying motivation. SDT differentiated between types of motivation (intrinsic v. extrinsic) based on the different goals that provoke action (Ryan & Deci, 2000). SDT articulated a framework that guides researchers seeking to understand practices and social context (i.e. classrooms) that enhance or diminish need satisfaction and the full functioning that follows from it (Reeve et al, 2004). Researchers have shown that classroom contexts can either facilitate or undermine these basic needs, with consequences for intrinsic motivation and learning (Deci & Ryan, 1985a; Deci & Ryan, 1985b). Students were often motivated by external factors such as rewards, grades, evaluations, or the opinions they fear others might have of them.

Yet, just as frequently, students were motivated from within, by personal interests, curiosity, or values (Ryan & Deci, 2000). Intrinsic motivation to engage in an activity has been found to have positive relations with academic achievement (e.g. Cordova & Lepper, 1996; Deci & Ryan, 1985b). Researchers have shown that intrinsic motivation is often related to student creativity and deep-level learning strategies facilitated in social contexts that support students' basic psychological needs for autonomy, competence, and relatedness (Ryan & Deci, 2000). Conditions supporting the individual's experience of autonomy, competence, and relatedness have fostered high quality forms of motivation and engagement for activities, including enhanced performance and persistence.

Defining autonomy, competence and relatedness. Broadly, *autonomy* has been defined as experiencing one's behavior as self-endorsed, volitional, and compatible with one's values, interests, and beliefs. Student autonomy referred to a student's ability to take on the responsibility for his or her own learning and to set appropriate learning goals.

As a construct, *competence* can be defined as students' feelings of academic efficacy, as either a collection of skills abilities that are attributed to individuals (i.e., perceived cognitive competency) (Ryan & Grolnick, 1986) or as a competent participation constructed within an activity system (Greeno, 2006; Gresalfi et al., 2009). The interaction between the affordances that a student must participate competently was dependent on a complex combination of the classroom setting, the teacher, and the curriculum, all of which can contribute to whether or not a student is deemed to be competent (Gresalfi at al., 2009). Both autonomy and competence are necessary conditions for maintaining students' intrinsic motivation (Deci, Koestner, & Ryan, 1999).

Students' sense of *relatedness* referred to positive relationships with teachers and peers (Furrer & Skinner, 2003). This component of self-determination theory interconnected the learning environment, interpersonal relationships, and community culture in a classroom. Researchers in SDT have suggested that satisfying the need for relatedness facilitated the process of internalization. Students tended to internalize and accept as their own the values and practices of those to whom they feel connected to and from contexts in which they experienced a sense of belonging. In the classroom, relatedness was associated with a student feeling that the teacher genuinely likes, respects, and values him or her (Ryan & Deci, 2000; Niemiec & Ryan, 2009).

Relationship between autonomy, competence, and relatedness. Past studies have found that relatedness and competence are likely interrelated with students' feeling of autonomy. Ryan and Powelson (1991) found that students with autonomy-supportive teachers reported greater perceived competence and rated teachers as "warmer" than controlling teachers. These authors (Ryan & Powelson, 1991) posited that students are likely to be highly motivated to learn when they experience autonomy support and feel a sense of belonging in school. Osterman's (2000) review of belonging also indicated that students with a sense of belonging tend to perceive themselves as more competent.

Achievement outcomes. Autonomy, relatedness and competence support had positive learning outcomes for students. SDT explained these beneficial learning outcomes as the result of self-determined motivation in students that occurs when teachers provide autonomy support (Reeve et al., 1999). Specifically, Grolnick and Ryan (1987) found conceptual (versus rote) learning may be optimized under conditions that facilitate active, autonomous involvement on the part of the learner. Grolnick and Ryan (1987) examined fifth graders in two directed-learning conditions, one noncontrolling and one controlling, and one nondirected-learning condition. The researchers found achievement outcomes in conceptual learning were facilitated by both the nondirected- and the noncontrolling-directed-learning sets relative to the controlling condition. The authors suggested that the integration of learning required active processing and organization that was more likely to occur under conditions conducive to a perceived internal locus of causality where there was more autonomy afforded (Grolnick & Ryan, 1987, 897). The fifth graders self-reports also indicated the children in the controlling condition felt more pressured and somewhat less interested than those in either the nondirected or noncontrolling-directed environments (Grolnick & Ryan, 1987). Similarly, in a study of preservice teachers, it was found that students of autonomy-supportive teachers benefitted academically (Reeve, et el., 1999). Further, in Reeve's (2009) work, a brief review of 44 published investigations between students' school functional and teachers' motivating styles found that students function more positively when teachers support their autonomy rather than control and pressure them toward a specific way of thinking, feeling, or behaving (Reeve, 2009, 163).

Further, studies have linked relatedness to positive academic outcomes and increased engagement (Deci & Ryan, 1991; Furrer & Skinner, 2003; Osterman, 2000). Correlations made from 641 student self-reports of relatedness lead Furrer and Skinner (2003) to the conclusion that children's sense of relatedness played a significant role in their academic motivation, engagement, and performance. Osterman's (2000) review of belonging documented a positive influence of school belonging on student's motivation and academic achievement. Discussion in the extant literature on relatedness has been largely interpersonal in nature (i.e., teachers, peers) but has largely omitted the influence of curricular contexts that may foster a student's sense of belongingness. However, researchers have shown that teachers' motivational practices play a significant role in fostering an environment in which students felt they belong and were cared for within classrooms by their teachers and peers (Osterman, 2000).

SDT and Inquiry

Given the recent calls of the NGSS, researchers have not yet begun to study the teachers who are at the "front lines" of putting these reforms into practice. The curriculum supports found in inquiry-based curricula have the potential to provide more optimal conditions for high quality motivational enactment in support of students' basic needs for autonomy, competence and relatedness. Science instruction aligned with NGSS standards should promote teacher practices that may serve to heighten student autonomy opportunities such as the generation of student ideas, open task structure, hands-on activities, and unit contextualization. In particular, tasks within inquiry environments provided opportunity for promoting students as originators of ideas and strategies as is central to autonomy-supportive practice. Students would be offered more meaningful choices, not with instructionally irrelevant aspects of the learning activity (Cordova & Lepper, 1996) or surface types of strategies such as choice of partner (Stefanou et al., 2004), but on tasks that allowed for explanation and hypotheses for their own ideas. Ultimately, inquiry science teachers may need to accompany the curriculum features with varying high quality motivational practices to initiate and sustain students' deep-level engagement.

Therefore, the current study focused on teachers' practices that support students' basic needs for autonomy, relatedness, and competence within inquiry contexts. Taken together, it is critical that research examine how teachers enact and modify curriculum in ways that foster student autonomy, students' competence, and a sense of relatedness; all of which are constructs that support students' academic success.

Early Work in Autonomy Support

Early work in autonomy support provided evidence that teachers *can* support student autonomy and *can* be trained to support student autonomy through professional development. Autonomy support revolves around finding ways to nurture, support, and increase students' inner endorsement of their classroom activity (Reeve & Jang, 2006; Reeve, Deci, & Ryan, 2004). Beyond enacting autonomy supportive practice, it is similarly important to diminish controlling behaviors such as the use of external rewards, controls, and pressures (Skinner & Belmont, 1993). Using the SDT framework, prior research have recognized that teachers facilitate intrinsic motivation using autonomy support and minimizing controlling practices. While early notions of autonomy focused on the provision of choice and the removal of extrinsic rewards and external controls, SDT conceptualizes autonomy more expansively. Autonomy support also encompassed the provision of choice along with the provision of rationale, relevance, positive feedback, and responding to students' ideas.

Teachers afforded autonomy when they provided latitude in decision making (Skinner & Belmont, 1993) and encouraged students to experience themselves as origins of their actions (deCharms, 1968). Rationale and relevance introduced lesson or task purpose and may foster student autonomy when aligned to students' personal interests, values, and goals (Assor, Kaplan, & Roth, 2002). Relevance was fostered by incorporating activities relevant to students' personal interests and goals, by explaining the relevance and rationale behind assigned tasks, and by being responsive and open to task modification given students' voiced goals and values (Assor et al., 2002; Reeve & Jang, 2006).

Autonomy support referred to putting students in a position of authority, taking the student's perspective, and providing pertinent information (Black & Deci, 2000). Teachers fostered autonomy by encouraging students' endorsement of classroom activity by conveying a rationale, purpose, and value for activity (Reeve et al., 2004); these practices supported autonomy because they showed students how school work can help them attain their own personal goals, pursue their own interests, and fulfill their own values (Assor et al., 2002; Reeve et al., 1999; Skinner & Belmont, 1993). The benefit of including rationale and relevance was supported by research indicating benefits for motivation and engagement, more so than perceptions of choice (Assor et al., 2002).

SDT research has found that autonomy-supportive teachers are more likely to listen to students, allow students to manipulate instructional materials, ask for student opinions, respond to student-generated dialogue, and take students' emotional perspectives (Reeve et al., 2004; Reeve & Jang, 2006). Other research has also characterized autonomy supportive practices as those that offer rationales for the value of learning (Reeve et al., 1999) and positive feedback regarding competence (Deci, Vallerand, Pelletier & Ryan, 1991). When teachers connected class assignments to students' own goals, interests, and values, it evoked students' feelings as though these activities were valuable in helping them accomplish what they themselves choose to accomplish (Reeve & Jang, 2006). Finally, teachers who provided positive feedback about students' mastery and progress supported autonomy (Deci, et al., 1991; Reeve & Jang, 2006), because such feedback provided information to students about how they can make progress toward their own freely chosen and valued goals. Positive feedback facilitated autonomy when students were recognized for making progress or demonstrate improved understanding (Reeve & Jang, 2006).

Limitations of early studies. Most of these early theoretical recommendations for how to become more autonomy supportive in a classroom came from studies using written surveys of students' self-reported perceptions and teacher's self-report surveys (e.g., Skinner & Belmont, 1993) as well as controlled laboratory studies (e.g., Deci, Eghrari, Patrick, & Leone, 1994). Laboratory studies raise questions of ecological validity, especially because these studies have often examined practices during tasks that may constrain the range of autonomy support. Some studies have deliberately examined autonomy-relevant practice during tasks with less obvious utility (Deci et al., 1994) or have examined autonomy during laboratory tasks deliberately designed to constrain the range of autonomy support (Cordova & Lepper, 1996). Reeve et al. (1999) classified preservice teachers as high or low in autonomy support based on self-reports and observed their practices when instructing a peer on problem solutions for a puzzle during a 10-min instructional exchange in a laboratory setting. An important advance in this study was evidence that teachers *could* support student autonomy. While this research may have resembled student experiences during traditional school activities, we questioned how to extend these conceptualizations of autonomy support, because the research context seemed to restrict the range of autonomy provided. Findings indicated that autonomy-supportive teachers spent more time listening, asking what students wanted, demonstrating responsiveness to student questions, and expressing a willingness to take students' perspectives. In addition, these teachers allowed more time for students to manipulate objects, resisted simply giving the answer, and used fewer controlling directive statements (Reeve et al., 1999).

Limitations of observational studies. There are conducted observational studies of autonomy support in classrooms, but mainly in classrooms using more traditional curricula. Reeve and colleagues (2004) observed high school teachers' use of autonomy supportive and inhibitive practices before and following training. Importantly, this study provided evidence that teachers *can* be trained to support student autonomy. However, observed enactments were reduced to ratings, and the descriptive nature of the data was not maintained.

Observational studies of autonomy supportive practices that have described how teachers' autonomy support is enacted within traditional curriculum limited the student experiences that were interesting, relevant, and afford meaningful choice (Assor et al., 2002). Teachers tended to offer choice on more superficial task components, such as selecting partners for group work, choosing the format of a final product (graph or table), or selecting colors to decorate a graph.

Although researchers acknowledged the potential of authentic activities, long-term projects, and inquiry-oriented reforms for enhancing autonomy, the difficulty of developing and enacting these units seemed to have led researchers to study more restricted learning environments that afforded only "minimal embellishments" for autonomy (Cordova & Lepper, 1996). We know from prior research that enactment tended to focus on the provision of narrow forms of choice (e.g., Bozack et al., 2008), which may only initiate students' feelings of control without fostering deep-level engagement (Stefanou, et al., 2004). Findings further have indicated that such classroom teachers provided a limited range of autonomy, focusing on the provision of academically irrelevant choices (Bozack et al., 2008; Stefanou et al., 2004). These studies concluded that teachers offer infrequent and limited supports for autonomy within traditional classrooms. But, these observational studies have provided information about how teachers autonomy support have supplemented traditional, non-inquiry-based curriculum, within a task context that is disconnected from students' own values and goals.

Taken together, research to date has yielded a conceptualization of autonomy support that focuses on a rather narrow range of teacher practices. This may be partially attributed to the fact that observational research exploring classroom enactment of autonomy is limited and this research has primarily been conducted in the context of laboratory studies and traditional classroom contexts. In traditional classrooms, one possible reason for this was that teachers may find it difficult to integrate supports for autonomy when enacting traditional curricula given tasks that are teacher-centered, lecture-style, passive learning contexts that require rote memorization and recall. It was critical to extend observation to contexts that enhance the likelihood of detecting significant autonomy support. In this way, it would be possible to enrich our understanding of the variety of ways in which teachers provide autonomy when the curriculum is designed not to constrain it but to expand it. This was especially critical because available research provides limited guidance for teachers in how to implement these practices in nontrivial ways.

Recent Developments in Autonomy Support

Elaborated framework for autonomy support. Current literature has extended the conceptualization of autonomy into educational contexts. Recent theoretical elaborations of autonomy support can ground investigation for how teachers provided more academically significant autonomy support within curriculum contexts encouraging a broader range of autonomy. Stefanou et al. (2004) explained that enacted autonomy support has essentially become synonymous with choice, with limited access to a full range in autonomy-supportive practices that connect classroom activities to students' goals, interests, and values. Thus, Stefanou and colleague's work (2004) argued for broadening the conceptualization of autonomy by including cognitive autonomy support within a taxonomy of three types of support. Organizational autonomy involved students in decision making related to environmental procedures concerning class management and classroom environment. Procedural autonomy included the provision of decision making related to procedures and task format including, but not limited to, choice of group members, due dates, seating, and classroom rules. Cognitive autonomy encouraged students' ownership related to ideas, strategies, thinking and learning. These different practices resulted in different student outcomes. The authors' (Stefanou et al., 2004) vignettes sought to understand the features of autonomy support as it is implemented in practice. Stefanou and colleagues (2004) found that organizational autonomy support may encourage a sense of comfort in the way a classroom functions, and procedural autonomy support may encourage initial academic engagement, but cognitive autonomy support may be the essential ingredient to maximize academic engagement and foster deep-level thinking.

Broadened framework to study autonomy supportive practices. Using this broadened framework, Bozack et al. (2008) investigated whether these autonomy-supportive practices could be identified in teachers' practice as part of a school reform effort focused on enhancing achievement in low income schools. Findings indicated that there were few provided opportunities for choice (also see Wiley et al., 2008). In addition, choice was typically offered only after completion rather than during an assigned task. While several lessons involved students manipulating objects, in 50% of these cases students used the same objects in a uniform manner, indicating limited procedural autonomy. Teachers responded to student questions (responsive) but often did not elaborate on student's voiced ideas. Teachers did not situate the content in a broader context to enhance relevance. Finally, students had several opportunities to talk, but these were primarily teacher–student exchanges within whole-class discussion; only 25% of instances involved students working in partners or groups.

Turner and colleagues (2011) used the procedural, organizational, and cognitive autonomy-support framework as part of a professional development initiative in support of teachers' motivational practices (Turner et al., 2011). Two of the three teachers selected for in-depth observation and interviews evidenced some beginning shifts in autonomy-supportive practice. For example, observed teachers asked more "why" questions in small group venues and held back doing the work for students in efforts to elicit explanation from students. These teachers enacted traditional curricula and therefore may have had fewer affordances for cognitive autonomy-supportive practice.

Broadened framework to study autonomy in inquiry. Inquiry environments may be more likely to afford autonomy support, and particularly to provide many opportunities for the academically significant form of cognitive autonomy, given the tasks of these curricula. Encouragingly, findings indicated a higher frequency of autonomy-supportive practice in comparison to published work in non-inquiry environments. Further, these inquiry environments afforded more opportunities for cognitive autonomy (i.e. student ownership of ideas) within inquiry curricula. In a previous study, Rogat and colleagues (2014) extended the extant theoretical frameworks and developed conceptualizations of autonomy support based on our observational data of inquiry-based science enactment. This study presented the curriculum affordances in ways that help to differentiate the role of curriculum features and teacher practice. Most significant was the higher frequency of cognitive autonomy support, because prior research found little evidence of this academically significant form in traditional classrooms (Rogat et al., 2014). This research broadened the conceptualization by examining teacher practices in an inquiry curriculum that afforded richer range of autonomy-supportive practices (Rogat et al., 2014). Beyond indicating that teachers enacted more autonomy-supportive practice, we found that the autonomy-supportive practice provided was multi-faceted and sustained over time. This contrasted with the existing literature in which the view of autonomy support was narrow and rarely enacted in traditional classroom practice.

It was essential that teachers have access to additional resources offered through curricula materials and tasks (Rogat et al., 2014). By situating the teacher practice in an inquiry curriculum with motivating features, our study confirmed that autonomy-supportive practices *existed* inquiry classrooms and that these practices were providing high quality, academically significant autonomy support. We know that teachers *did enact* high quality autonomy support. This suggested that there were motivating features in inquiry curricula and that the curriculum tasks are high quality (Rogat et al., 2014). However, since this past research relied heavily on observations of solely the teacher's *actual* enactment, information was limited concerning teachers' own views and interpretations of motivational practice. The missing component critical to further our understanding is insight into teacher planning modifications and how curricula with motivating features translates into high quality autonomy support despite enactment challenges and tensions.

Challenges and tensions with providing autonomy support. Given the high degree of challenge presented by inquiry materials and specific to autonomy, it is critical to understand teacher enactment of these curricula. While an inquiry context has motivating features, it also comes with enactment challenges. In past research, teachers misconstrued inquiry-based practices as student-centered with minimal guidance (Kirshner, Sweller, & Clark, 2006). Teachers had difficulty conceptualizing or integrating autonomy support in their inquiry instruction (Rogat et al. 2014; Turner et al., 2011), which may be influenced by their own interpretations of autonomy and inquiry. Autonomy raises its own tensions, challenges, and ambiguities, particularly in an inquiry setting. Turner and colleagues (2011) found that teachers faced difficulty mapping professional development exemplars of cognitive autonomy support to their own instruction given how different the modeled instruction seemed from their own. Tensions in enacting autonomy support to cut time or let go too long may have been influenced by interpretations of autonomy and inquiry itself. Rogat and colleagues (2014) evaluated teacher practices in inquiry science classrooms and found though cognitive autonomy supportive practices were among the most frequent, it was often coupled with evidence of low cognitive autonomy support. This work (Rogat et al., 2014) revealed tensions and enactment challenges that aligned with earlier research suggesting teachers face dilemmas regarding time and content coverage with granting student autonomy (Marx, et al., 1994). Studying the teachers' interpretations of inquiry materials further helped us as motivation researchers to understand how tensions and challenges in providing autonomy are resolved.

An Integrated Understanding: Students' Basic Needs, Teacher Practices and the Curriculum

Given the profound influence curriculum may have played in affording students autonomy support, a key expansion of this work would involve gaining insight in to how teachers read curriculum, interpret curriculum features, and modify and enact the intended curriculum. Guided by prior research, we previously examined teachers enacting inquiry-based science curriculum with supportive features and found frequent, sustained, and high quality autonomy-supportive practices (Rogat et al., 2014). For example, teachers connected content to the unit's driving question (i.e., providing relevance), provided rubrics for students to self-evaluate their work based on student-generated criteria (i.e., cognitive autonomy), and elicited and built on student-initiated ideas (i.e., teacher listening). Teachers also supported student opportunities to improve and revise their ideas developed within explanatory models, using evidence. These practices provided meaningful and academically significant autonomy support.

Teachers' autonomy supportive enactment within an inquiry curricular context (Rogat, et al., 2014), yielded promising results indicating that teachers do have a richly diverse provision of academically significant autonomy supportive practices. Most importantly, teachers enacted both frequent and varied autonomy supportive practices over a broad range of autonomy-supportive practice, especially cognitive autonomy support, which may be the essential ingredient to maximize motivation and engagement in the classroom (Rogat, et al., 2014; Stefanou et al., 2004).

Limited studies of curricular context. Motivation researchers who study motivational practices had a history of providing limited detail and descriptive information about the curricular context and instructional tasks (Blumenfeld, et al., 1991; Blumenfeld, et al., 2006). This prior work neglected the fact that learning processes themselves are deeply embedded in context and concepts to be learned (Furtak & Kunter, 2012), ultimately limiting our understandings of the contextualized nature of autonomy-supportive practices. Current research needs to go beyond treating teachers' motivational practice as supplemental to curriculum, to provide richer detail and descriptive information about the curricular context and instructional tasks (Blumenfeld, 1992). Also, the extant literature has studied teachers supplementing traditional curriculum within a context that is completely disconnected from students' own values and goals.

Furthermore, past work has primarily considered teachers' motivational enactment as supplemental to curriculum, providing minimal description of the role of the curriculum while teachers foster motivation. Few observational studies provided in-depth descriptions of enacted curricula. This means that teacher enactment has been studied separate from curriculum, not together with supportive curriculum materials. One potential reason for this separation is that research has been conducted in traditional classroom settings where teachers direct activity and are in control, allowing limited opportunity for students to be initiators of ideas. In a traditional context, teachers used constrained choice on instructionally less relevant aspects of academic tasks and enacted a limited range of autonomy supportive practices (Bozack et al., 2008; Turner et al., 2011; Wiley et al., 2008). Bozack and colleagues (2008) examined field notes from third, fourth, and fifth grade classrooms and found low frequency of autonomy support in the form of student choice. Similarly, Wiley and colleagues (2008) documented few opportunities for student choice in their observational study.

The need for studies in inquiry contexts. Theoretical conceptualizations of autonomy support have been advanced, but not in contexts that increase the likelihood of detecting significant autonomy support. For instance, there is little research showing that cognitive autonomy support can be found in classrooms taught by students' regular teachers. Moreover, only short descriptions of the enacted curricula are provided in previous work. Further, extant research has relied on student-reported perceptions and laboratory studies with uninteresting and inauthentic tasks or games that may ultimately constrain our conceptualization of autonomy-supportive practice.

What is missing is an accounting of the curricular tasks that teachers might be influenced by and their beliefs of the effectiveness of tasks as written in the curriculum. Since teacher practices within inquiry-based curricular contexts have potential to provide more optimal conditions for student motivation (Blumenfeld et al., 2006), motivation research would benefit from this analytic lens to gain information about how teachers work with, optimize, supplement, and modify inquiry materials. Therefore, it was important to draw on studying the role of the teacher and the curriculum together in ways that have not been done before within motivation research. Further, there was a need to examine how teachers think about the motivational potential of the curriculum and how this gets translated into their enactment decisions. A motivating curriculum in itself may not be sufficient to provide autonomy, it may require teachers to enact practices beyond the intended curriculum features or modify features.

It was important to study teachers' interpretations of the motivating features of curricular materials in inquiry and how those understandings influence their enactment decision making. Since enactment of inquiry often raised tensions and challenges specific to autonomy supports, our understanding regarding how teachers reflected on and resolved these tensions can be advanced by studying teachers' situated "problem solving" and their reported influences on their enactment decisions within the specific context of inquiry curriculum. Thus, by studying teachers' autonomy-relevant interpretations and modifications of inquiry curriculum lessons, alongside their stated reasons for these, we gain access to the reasons behind teachers' enactment decisions of autonomy-supportive and controlling practices within inquiry classrooms.

Given the curricular context with its autonomy enhancing qualities, this study considered teacher enactment as part of a larger activity system, which also included interactions among the curriculum materials and student contributions (Greeno, 2006; Gresalfi et al., 2009). Gresalfi and colleagues (2009) conducted a study that investigated sixth, seventh, and eighth grade mathematics students' construction of competence in the classroom. The researchers concluded that the structure of the curriculum tasks affords different opportunities for students to engage with content in different ways (Gresalfi et al., 2009, 67). Though Gresalfi and colleagues (2009) acknowledged the curriculum as part of the activity system of classrooms, they did not expand on how teachers make enactment decisions that may afforded students experiences that shape agency. An important component missing here was the teacher's interpretation and enactment of the curriculum.

It was important to understand how teachers coordinate their perceptions of the curricular motivating features with beliefs in ways that elevate autonomy supportive practice affording students need for autonomy, relatedness, and competence support. Therefore, it was important to study inquiry settings whose curriculum and tasks have features likely to support students' need for autonomy, relatedness, and competence in combination with teacher practices to fully understand teachers' motivational practices.

Antecedents of Autonomy-relevant Practice: Influences on Teacher Behavior

Given the benefits of autonomy-relevant teacher practices and the evidence of high quality, academically significant autonomy support coupled with tensions and challenges observed in inquiry classrooms (Rogat et al., 2014; Turner et al., 2011), it was critical to understand *how* teachers work with inquiry curriculum. With that said, research needed to investigate how teachers are thinking about and interpreting the autonomy relevant features of inquiry materials. Along with this, we recognized that teachers have reasons for their enactment decisions. For the current study, it was essential to understand what influences teacher behavior specific to autonomy-relevant practices. To conceptualize teachers' influences on enactment decisions and modifications as teachers interpret inquiry materials, the current study drew from the antecedents framework in the SDT literature.

Defining antecedents of teacher behavior. In the current literature, the study of the antecedents influencing teachers' behavior of enacting autonomy-related practices was based on both past research and recent developments in the measurement of motivation derived from SDT (e.g., Pelletier et al., 2002). Most of the literature focused on SDT's idea that a teacher has an orientation toward control versus autonomy (e.g., Reeve, et al., 2013). The literature often drew on the mini-theories within SDT such as SDT's model of behavioral regulation (e.g., Roth & Weinstock, 2013) or SDT's mini theory of Basic Psychological Needs Theory (e.g., Van den Berghe et al., 2013). The larger question that researchers tended to ask in these studies was why teachers adopt autonomy-supportive versus controlling motivational teaching styles. To answer this, studies explored the factors that may enhance or diminish students' autonomy. The results of these studies have been compiled into a set of factors that influence teacher behavior. The extant literature recognized three main influences on instructional practices; teachers' perceptions of various pressures from (1) above (e.g., social context; administration), (2) within (e.g., their own beliefs), and (3) below (e.g., students' characteristics), that influence their instructional practice.

Defining pressures. Early work in antecedents studied *pressures from above,* focusing on teachers' behaviors when pressured with performance standards (Deci, Spiegel, Ryan, Koestner, & Kauffman., 1982; Flink, Boggiano, & Barrett., 1990). Teachers were placed in pressured conditions to test if they would then use controlling strategies. These early studies found that teachers did respond to pressures to have students perform well in more controlling ways. Later studies expanded the influences by conceptualizing pressures at work (Pelletier et al., 2002) citing pressures to comply with colleagues and to comply with the curriculum in addition to complying with performances standards as important influences on teachers' controlling behavior. More recent studies identified other *pressures from above* including teachers' own performance evaluations, and time constraints (Taylor et al., 2009). As these more recent studies turned toward qualitative interviews of teachers, other *factors from above* began to show up in the literature. Some teachers found positive ways to deal with these pressures (Taylor et al., 2009; Hornstra, van der Veen, Peetsma, & Volman, 2015). For instance, teachers' own accounts explained these *pressures* as *positive factors* to monitor student progress in response to performance standards and feeling supported by their schools to teach according to their beliefs (Hornstra et al., 2015).

Early work studying *pressures from below* focused on teachers' perceptions of unmotivated students (Skinner & Belmont, 1996; Pelletier & Vallerand, 1996; Pelletier et al., 2002; Sarrazin, Tessier, Pelletier, Trouilloud, & Chanal 2006). These studies found teachers exhibited more controlling strategies, even when self-described as "autonomy supportive" as determined by teachers' own self-reports (Pelletier et al., 1996). More recent studies identified other *pressures from below* including students' general motivation in school, perceived student ability, student age, and student gender. This work, based largely in physical education classes, found teachers used more controlling strategies in response to these various pressures. Research on one *factor from below*, students' general motivation in school, found that teachers discussed a need for *relatedness* as critical to helping students (Hornstra et al., 2015).

Early work in *pressures from within* examined teachers' self-determined motivation toward work finding that more self-determined teachers provided more autonomy support (e.g., Pelletier et al., 2002). Later, the concept of *pressures from within* drew from work that recognized adults tend to have a range of general orientations (i.e. autonomy-supportive to controlling) toward others (Deci, Schwartz, Sheinman, &

Ryan,1981) and show a distinctive autonomy-supportive style (Reeve et al., 1999). *Pressures from within* were defined as influences that arise from teachers' own beliefs, values, and personality dispositions (Reeve, 2009, 164). Teachers' controlled orientation involved controls such as threats, offered rewards, and demanding expectations. Whereas, teachers' autonomous orientation involved a sense of freedom and tendency to act based on personal values or interests. More recent work studied teachers' autonomous motivation toward teaching as a *pressure from within* exploring factors that may enhance or undermine a teachers' tendency to nurture students' autonomy (Roth, Assor, Kanat-Maymon, & Kaplan, 2007; Roth & Weinstock, 2013).

Research on factors from above. Research on factors from above has examined the perceived influence of the social and school context on teacher practices. Previous research has found emphasis on students' grades, compliance with the curriculum, and teachers' own performance evaluations as the most significant pressures on teachers' motivational practices.

Past research in this area has found that impressing on teachers that they are responsible for their students' performance, relative to a group for whom there were no performance standards, resulted in more controlling teaching behaviors (Deci, et al., 1982). However, this study explored conditions artificially created by the experimenters. Flink and colleagues (1990) extended this early research by conducting a field experiment with 4^{th}-grade teachers and students. These researchers had similar findings. Teachers who were externally pressured to produce good student performance were more controlling and less effective in their teaching than teachers who were asked to help their students (Flink et al., 1990).

Taylor and colleagues (2009) used semi-structured interviews to investigate how teaching context influenced teachers' motivational strategies towards students. Results showed that teachers' perceived emphasis on student assessment and the time constraints associated with physical education lessons often compelled them to use teaching strategies which conflicted with their beliefs about how to motivate students (Taylor et al., 2009). Additionally, teachers' own performance evaluations and pressures to conform to other teachers' methods influenced the teachers' motivational strategies (Taylor et al., 2009). In this same study, perceived cultural norms and norms of teaching were associated with the teacher-student relationship and impacted teachers' motivational strategies. These cultural norms were reported by different teachers as either in line, or in conflict with their teaching beliefs (e.g., asking students what they want to do vs. teachers as authority) (Taylor et al., 2009).

Other studies investigated teachers' perceptions of pressure from above to comply with curriculum or performance standards communicated by parents and colleagues (Pelletier, et al., 2002) and perceived expectations from supervisors to use rewards (Harackiewicz & Larson, 1986). Related to the current study, during the enactment of inquiry curricula, it is anticipated that teachers' social and school context will play a role in influencing their motivational teaching behaviors.

Research on factors from below. Research on factors from below account for teachers' perceptions of student characteristics. For example, a student's lack of motivation, attitude toward school, and behavior have been cited as important influences on teacher behavior. Skinner and Belmont (1993) found a strong relationship between teachers' behavior and students' engagement, showing that teachers respond to disengagement with more controlling and coercive behaviors. This was similarly true in a lab setting; teachers' perceptions of students' lack of motivation, negative attitude toward school, or engagement in disruptive behaviors were related to lower quality motivation to teach and more controlling behaviors (Pelletier & Vallerand, 1996; Pelletier, et al., 2002). However, when teachers were convinced students were intrinsically motivated, they were found to use more autonomy-supportive practices (Pelletier & Vallerand, 1996; Pelletier et al., 2002).

One explanation for teachers' responses to *pressures from below* has been teaching behavior mediated by teachers' own motivation. Students who lack motivation may be perceived as aversive. It was found that teachers interacted less frequently with students that they expected to be more motivated, and teachers were much more controlling with students that they believed to be not motivated (Sarrazin, et al., 2006).

Hence, these results supported the idea that individuals' preconceived beliefs and expectations about student motivation and engagement have a significant influence on behaviors (Pelletier & Vallerand, 1996). Teacher expectations of student motivation for *observed* autonomy support or control explained a self-fulfilling prophecy as teachers modified their interactions with motivated or amotivated students. A teacher's beliefs about a student's motivational orientation set in motion interpersonal behaviors toward the student, which in turn, may eventually cause the student's behavior to confirm the teacher's initial beliefs (Skinner & Belmont, 1993; Pelletier & Vallerand, 1996; Pelletier et al., 2002; Sarrazin et al., 2006).

While studying the implementation of challenging instruction, Fulmer and Turner (2014) investigated how teachers *could resolve pressures* from students by increasing student autonomy. This evidence of *resolved* pressures (Fulmer & Turner, 2014), was infrequent (reported in only two teachers) but important. One math teacher reported that her response to students' lack of effort during group work was to make students responsible for all group members' learning. One social studies teacher responded to a lack of interest in the subject matter by allowing students the choice of how to display their answers when being assessed on the material. Though infrequent, these responses provided some evidence as to how teachers could respond to student pressures in positive and autonomy-supportive ways, rather than through exclusively controlling means.

Research on factors from within. Research on factors from within have focused on teachers' personal characteristics (i.e. their beliefs, values and personality dispositions). Teachers' motivational orientations for teaching, or autonomy orientation, has been measured as a causality orientation to act out one's own interest and value one's own actions (Roth & Weinstock, 2013) vs. controlled orientation (Pelletier, et al., 2002).

Roth and Weinstock (2013) explored the factors that may enhance or undermine teachers' tendency to nurture students' autonomy. The authors found a link between teachers' epistemological beliefs and students' autonomous motivation (Roth & Weinstock, 2013). Van den Berghe and colleagues (2013) extended this work to observe interactions with students during physical education classes rather than relying exclusively on self-reports by teachers. This study showed that autonomy orientation was unrelated to need-supportive teaching behavior, but control-oriented teachers provided less structure and engaged in more controlling teaching behaviors (Van den Berge et al., 2013). Other research found that if teachers felt incompetent, teachers became less intrinsically motivated and less self-determined toward their work, consequently impacting their behavior (Sarrazin et al., 2006). Related to the current study, it is expected that, during the enactment of inquiry curricula, teachers' personal epistemologies, beliefs about student motivation, and beliefs about inquiry may play a role in influencing their teaching behaviors.

Taken together, previous research (Rogat et al., 2014) identified tensions in classrooms between teachers' autonomy-supportive practices and their controlling or autonomy-inhibitive practices. Often, teachers motivated students with extrinsic rewards and grades as they navigated enactment challenges. These tensions and enactment challenges aligned with earlier research suggesting teachers face dilemmas regarding time and content coverage. Moreover, reliance on controlling practices stemmed from a variety of pressures from above, within and below.

Curricula informed by national reform efforts in science have motivating features and educative materials. These materials are part of situated context that affords motivational practices, including more frequent and higher quality autonomy support (Blumenfeld, et al., 2006; Furtak & Kunter, 2012; Rogat, et al., 2014). Therefore, inquiry-based science classrooms are an important context for investigating autonomy-supportive practices. The focus of the current dissertation research is deepening our understanding of teachers' enactment within inquiry contexts by striving to understand their motivational interpretations, enactment decisions, and modifications of these curriculum materials, as well as unpacking the explanatory antecedents that are facilitative of their autonomy-supportive practices. Accordingly, this dissertation research seeks to explore teachers experienced, and negotiation of, pressures from above, within, and below that yield autonomy-supportive practices.

Current Study

The purpose of this dissertation is to (1) examine how teachers interpret and notice the autonomy supportive features provided within inquiry curricula, (2) investigate the particular modifications and revisions teachers make when considering enactment of these motivating features, and (3) explore the rationales and reasons behind these enactment decisions. Four inquiry teachers with experience ranging from 2-11 years teaching 7th-10th grade science participated in four interviews and one classroom observation. All four science teachers had participated in professional development on inquiry science methods in the past.

Table 1

Proposed Interaction between Teacher and Curriculum

<table>
<tr>
<td rowspan="3">Classroom Context: Inquiry-based Classrooms

Participants: Experienced Inquiry Science Teachers</td>
<td rowspan="2">Teachers’ Own Motivational Practices</td>
<td rowspan="3">Influenced by</td>
<td>Factors from Below (i.e. students)</td>
<td rowspan="3">Combine as teachers’ planned curricular enactment (i.e. as intended & modifications) in ways that diminish or augment autonomy-relevant features</td>
</tr>
<tr>
<td>Factors from Within (i.e. teacher beliefs)</td>
</tr>
<tr>
<td>Inquiry-based Curriculums’ Motivational Features</td>
<td>Factors from Above (i.e. administration, national standards)</td>
</tr>
</table>

First, the study examines autonomy-related teacher practices and the autonomy-relevant curriculum features noticed by the four inquiry teachers. The combination of curriculum supports and instructional supports found in inquiry-based curricula should provide optimal conditions for high quality enactment in support of students' basic needs for autonomy, relatedness, and competence. There is some evidence that when provided with the supports for autonomy offered via curricula materials and tasks, that teachers do afford autonomy support at greater frequency and with higher quality (Rogat et al., 2014). Four experienced inquiry teachers were interviewed and observed. The study examines their autonomy-related practices (1) through an examination of teachers' own motivational practices in their everyday classroom and (2) while reviewing an inquiry-based curriculum lesson (IQWST) as they envisioned how they would plan to enact this lesson into their classroom. The selected IQWST lesson contains a range of autonomy-supportive task features (see Appendix F) including decision making opportunities, the provision of meaningful rationales, relevant content, and opportunities for students to have control over the development of content ideas. Autonomy-related practices were recorded as either augmenting or diminishing autonomy-relevant features.

Second, the study focuses on the planned modifications to the existing inquiry curriculum materials. As the four inquiry teachers discuss their enactment, autonomy-relevant modifications were classified as either augmenting or diminishing autonomy-relevant features.

Finally, the study explores the rationales and reasons behind the teachers' enactment decisions. Exploration of enactment decisions are open to identifying not only pressures, but also how teachers resolve pressures and describe supports for their autonomy-supportive behaviors. This recasting of antecedents seeks to expand our understanding of what influences teachers to augment or diminish opportunities for student autonomy support.

The current study builds on research that has not yet provided sufficient insight into how teachers enact and modify autonomy-supportive curriculum to translate it into high quality enactment. By studying the interaction between teachers' own motivational practices paired with an inquiry-based curriculum, explained by antecedents for these teacher practices, the larger goal of this dissertation is to enhance our understanding of how science teachers interpret motivating features of inquiry-based science curriculum via their enactment decision-making.

Chapter 3: Methodology

Overview of Methodology

This study examined qualitative interview data and classroom observation field notes focused on science teachers' interpretations of autonomy-relevant features of inquiry-based science curriculum and their enactment decision making. Further, this study examined the influences and reasons behind teachers' enactment decisions during inquiry instruction. This study employed qualitative methods to examine data relevant to the following research questions:

1. How do teachers interpret and notice the autonomy supportive features provided within inquiry curricula?
2. What are the specific modifications and revisions teachers make when considering enactment of autonomy-supportive motivating features?
3. What are the rationales and reasons underlying teachers' enactment decisions?

Measurement Development

Pilot interviews. To ensure the developed set of interview questions provided data to answer the research questions, a pilot study was conducted. Between August 25 and December 15, 2014, four teachers with teaching experience ranging from three years to twenty-nine years were interviewed. The four teachers were chosen through a network of science teachers known to the researcher. These piloted interview questions aimed to examine teacher planning with a focus on how teachers enacted autonomy-relevant curriculum features. All four teachers consented to audiotaping. Pseudonyms are used throughout to give anonymity to each teacher.

Pilot study participants. The four teachers varied in their teaching experience, science content areas, and curricular resources.

Eileen was a ninth-grade earth and space science teacher and had been teaching for four years. Her class period began each day with a “do now” and then continued with PowerPoint slides delivering the content for the class period. Eileen integrated think-pair-share exercises into each class period and engaged students in laboratory exercises both in her classroom and in the designated lab room down the hall.

Natalie was a middle school science teacher who taught sixth, seventh, and eighth grade. She had been teaching for three years. She was part of a middle school program in which classroom activities and required academics are integrated into Project Based Learning.

Nicole was a fifth grade teacher and had been teaching science inquiry for 29 years. She did not teach from a textbook and described several inquiry experiences that her students engaged in from day to day. Her knowledge and expertise in her content area and inquiry instruction were evident throughout the entire conversation.

Sandy was a middle school science teacher and taught sixth grade in an accelerated program. She had been teaching inquiry for 8 years. Sandy spoke enthusiastically about her students engaging in science activities.

Pilot study results. The pilot study informed several modifications to the developed set of interview questions. It became clear that these experienced teachers did not always depend on textbooks when planning curriculum. Interview questions aimed at textbook use were removed and replaced by more open-ended questions about the materials they drew from when planning (i.e. "What resources do you use as you plan your lessons?"). Another modification was to allow teachers the opportunity to tell a story of their classroom experiences. Interview questions were added that elicited a narrative about a particular lesson or had teachers recall a teaching situation, which provided insights into their daily practice (i.e. "Can you describe to me what happened and why?," "Can you describe to me a really good example in your class of an activity where students were engaged in scientific inquiry?"). In the second interview, the interview prompts were modified to elicit "teacher talk" in specific parts of a lesson (i.e. "What would you say to begin this brainstorm discussion?," "What would you say to the students to get them engaged and keep them involved in the discussion?," "What would you say to students at the close of the discussion?"). These modifications provided detailed accounts of the teachers' enactment practices.

A second critical finding from the pilot study was that study participants needed to be purposefully selected to access extensive knowledge and teaching experience with inquiry materials. By including both traditional teachers and inquiry teachers in the pilot, an important contrast was discovered in the depth of their answers. Whereas, both Eileen and Natalie integrated some inquiry activities into more traditional classrooms, neither were self-described inquiry teachers. Their answers were often brief and did not always offer detail about their classroom instruction. In contrast, Nicole and Sandy both described themselves as inquiry teachers.

Nicole and Sandy described more tasks modifications, had more in-depth descriptions of how they would plan a lesson, and provided more reasons behind enactment decisions. They also provided more detailed insight into key influences during their planning (i.e. accountability on statewide assessments, district-wide pacing calendars). Both Nicole and Sandy, due to their extensive experiences with inquiry, provided in-depth portraits of the challenges and successes within inquiry science instruction. Their answers provided classroom examples of successful lessons and reflections on how their inquiry instruction had been modified through the years. Moving forward, it seemed critical that teachers have worked with inquiry materials, for several years, in order to access the teachers' rich experiences relevant to the research questions.

Finally, there was no formal classroom observation during the pilot study. This additional measure would have confirmed the teachers' self-reported accounts of their autonomy-relevant practices. Consequently, a classroom observation was added to the final dissertation study.

Measures

Teacher interviews. The final set of interview questions aimed to elicit teacher narratives focused on how these teachers augmented, diminished, or enacted as intended autonomy-supportive curriculum features. The purpose of the first interview was to probe their conceptualization of inquiry and how they motivate students more broadly in their everyday science instruction (see Appendix A). The purpose of the second interview was to investigate what motivating features teachers notice in an inquiry curriculum and their interpretations of those motivating features (see Appendix B). Throughout the second interview, there were prompts for teachers' reasons and justifications for enactment decisions and modifications. The purpose of the third (see Appendix C) and fourth (see Appendix D) interviews were to capture teachers' reflections on their self-chosen inquiry lesson before and after enactment. Four interviews were conducted with each inquiry teacher. Descriptions of each interview sessions follow.

Interview one. The first interview gathered information about the teachers' teaching experience, teaching materials, and instructional practices related to scientific inquiry practices, and student motivation (i.e. "How many years of experience do you have with teaching inquiry?," "What is your role during this inquiry lesson?," How are students involved during this type of activity?," " How do your students respond to this type of activity?"). Teachers were asked to provide specific examples of lessons that engaged students in scientific inquiry practices and examples of lessons when students were motivated to learn (i.e. " Could you describe for me a lesson when you felt that you students were really motivated? Can you describe what happened and why?"). Throughout the interview, teachers were prompted to provide descriptions of their classroom experiences and to provide narratives of their science lessons.

Interview two. The second interview focused on teachers' motivational interpretations of a common pre-selected inquiry lesson. In advance of the second interview, teachers read through an inquiry lesson chosen from the *Investigating and Questioning our World through Science and Technology* (IQWST) science curriculum materials on Heredity and Natural Selection published by Sangari Active Science Corporation. This IQWST unit was unfamiliar to all teacher participants. This was done purposely so that the data on teachers' initial curriculum analysis would not be influenced by prior enactment challenges and successes. IQWST materials were rooted in principles of project-based scientific inquiry and focused on science's "big ideas," which were revisited across the middle school years to provide a coherent learning experience. In addition, IQWST integrated scientific practices, such as modeling and explanation, as well as learning performances that fuse content and these practices (Kracjik, McNeill, &

Reiser, 2008). IQWST materials contextualized and made relevant unit content in a driving question. As a whole, the Heredity and Natural Selection IQWST unit introduced students to the concepts of heredity, variation within and between species, and natural selection centered on the unit's driving question: Why do organisms look the way they do?

The four inquiry teachers were given a lesson that introduces students to variation within a peppered moth population (see Appendix E). This lesson includes activities designed to engage students through the use of evidence interpreted from authentic data sets provided by the curriculum. The introductory lesson has students participate in an activity that demonstrates how height can be an advantage in obtaining food. The activity uses candy placed at a high place in the classroom to demonstrate that some students are tall enough to reach the candy, while other students are not. This lesson links to the previous lessons' content on biological adaptations. After the brief candy activity, students work in groups with their peers to examine a real case where a variation in a trait proved to be advantageous: the peppered moth. This part of the lesson had students answer questions focused on eliciting students' hypotheses concerning the reasons for the moth population's decline. This was facilitated by the instructor guiding a student brainstorming session. In the next segment of the lesson, students looked at several sets of evidence and data in order to gather information to figure out what caused the change in the peppered moth population. This part of the lesson has students (1) participate in group work examining the evidences and (2) form jigsaw groups to share and examine all of the evidences in its totality. During the concluding lesson, students construct an evidence-based explanation to account for the change in frequencies of the two types of moths. This part of the lesson ends with the entire class coming together to form a final class consensus evidence-based explanation.

This IQWST lesson was chosen because it contained several autonomy supportive features including decision making opportunities, the provision of meaningful rationales, relevant content, and opportunities for students to have control over the development of content ideas, skills, and their own learning (see Appendix F). Moreover, these motivationally-supportive curriculum features were present throughout the entire IQWST lesson. The introductory lesson aimed at evoking student curiosity continued into a section that drew on students' ideas about a genetic variation in peppered moths that proved to be advantageous. The curriculum lesson then had students form jigsaw groups aimed at constructing evidence-based explanations for the moth population changes. This section was rich in cognitive autonomy opportunities as students took on the responsibility of developing and sharing student-generated ideas after interpreting authentic data sets. The concluding section of the IQWST lesson brought the class together to come to a consensus about the advantageous trait variation in the peppered moths.

Consequently, the second interview prompted teachers to focus on specific segments of the IQWST inquiry lesson while describing potential enactment of the IQWST materials (i.e. "What would you say to students as they get ready to do come together as a class to put together a consensus explanation? What directions would you provide to get this started?"). Other prompts asked teachers to elaborate on curriculum modifications that could influence student motivation (i.e. " Can you describe other modifications you would make related to student motivation?"). Moreover, the second interview examined the teachers' interpretations of the autonomy-relevant motivational features of the IQWST inquiry lesson (i.e. " What parts of this lessons would student find motivating?") and the reasons that supported any enactment or modification decisions (i.e. " What are the reasons for your modifications?").

Interviews three and four. Prior to the classroom observation, a pre-observation interview was conducted questioning teachers about the intended lesson and their instructional planning specific to the lesson. Teachers were asked to elaborate on any features, practices, or tasks designed to motivate students. Further, teachers were asked about any anticipated challenges with student motivation during the lesson and if any modifications were made to the lesson while planning to ensure that students stay motivated. Following the classroom observation, a post-observation interview questioned teachers about their reflections on the lesson as well as modifications they made to the lesson in response to students' motivation. When possible, teachers were encouraged to recall specific tasks or instances in the enacted lesson.

Classroom observations. Field notes were handwritten in each of the four inquiry teachers' classrooms. The field notes focused on autonomy-relevant motivational practices during the inquiry lesson. The purpose of the field notes was to capture the teachers' instruction during one classroom period and to verify that motivational practices teachers discussed were congruent with their actual enactment.

Data Collection

Participants. The final selection of the dissertation teacher participants were chosen from a pool of teachers that had experience developing inquiry science materials and enacting inquiry curricula. Five teachers were contacted in early May 2015, and four teachers agreed to be in the study. The four participants were science teachers from two school districts; both enrolling primarily European American students from an upper-middle-class district with high performance on state standardized tests. These teachers had between 2-11 years experience teaching 7th-10th grade science classrooms. All four science teachers had participated in professional development on inquiry science teaching methods in the past. Pseudonyms are used throughout to give anonymity to each teacher. The teachers were paid $100 upon completion of the post-observation interview. The following provides a brief description of each teachers' teaching experience, science content areas, and curricular resources.

Ben had been teaching 7th grade general science for seven years. He taught life science, earth science, and physical science in a spiral curriculum. He mainly focused on life science. When asked how many years he had taught inquiry, Ben said that all seven of his years had been spent teaching inquiry science. He attributed this to his university education; he was taught how to teach science as teaching through inquiry instruction. As a result, Ben created and wrote all of his inquiry science lessons. Textbooks were only drawn on as resources if needed.

Claire had been teaching for eleven years and said that she had been teaching inquiry for 7-8 years. She taught 7th grade general science. Claire described her classroom teaching as a spiral curriculum which consisted of life science, earth science, and physical science. She credited her university program for shaping her science teaching. While attending her university program, Claire was involved in writing inquiry-based science curriculum and wrote all of the inquiry science lessons for her own science classroom. She had a set of Pearson textbooks; however they were used as reference material only if needed. Textbooks were not driving classroom instruction.

Diane taught 7th grade and had taught for five years; teaching inquiry for three of those years. Her first year teaching, she taught 6th grade science. For the past four years, she had taught 7th grade general science; a combination of life science, physical science and earth science. Diane had experience developing evidence-based science lessons and used a Pearson Interactive textbook, which she was involved in creating and customizing for her school district.

Darcy had been teaching for four years; two of those years teaching ecology as a university teaching assistant. Darcy's first year teaching was in 9th grade Physical Science and Honors Biology. Now, in her second year, she taught 10th grade Academic Biology, which was the school's middle-level Biology course. The upper-level course was Honors Biology and the lower-level course was Physical Science. She described her students as a mixture of motivated and non-motivated science learners. Darcy used the Miller-Levine Biology textbook in her science classroom.

Interviews. Data was collected over a five-week period between May 12- June 10, 2015. The teachers participated in three preliminary interviews in advance of one classroom observation and one post-observation interview. The four interviews were conducted on the phone or in person by the researcher and audiotaped for transcribing purposes. The first and second interviews were conducted between May 12, 2015- May 29, 2015 and each interview lasted approximately 40 minutes. At the conclusion of the second interview, a date was set for a pre-observation interview, a classroom observation, and post-observation interview with each teacher. The third and fourth interviews were conducted between June 4, 2015- June 10, 2015 on the same day as the classroom observation. The pre-observation interview occurred in person at their school prior to my observation. The post-observation final interview was conducted immediately after the classroom observation for three of the teachers. Due to scheduling conflicts, the fourth teacher's post-observation interview was conducted on the phone later the same day.

Classroom observations. Observations were conducted in person between June 4, 2015- June 10, 2015. Only the researcher was present for the classroom observation and wrote field notes as the method of data collection. Classroom observations were not audiotaped or videotaped. Observations and the corresponding field notes focused on autonomy-relevant teacher practices during the inquiry lesson, with only minimal student data collected; the exception was capturing student-teacher interactions.

The four inquiry teachers each chose one class period that was convenient for their schedule and enacted an inquiry-based lesson during that period. Ben enacted a lesson on electricity. Here, students were evaluating their own student-created models of how a light bulb lights in a circuit. Claire also enacted an inquiry lesson on electricity. Similarly, her students were evaluating their own student-created models of a light bulb in a circuit. Diane enacted an inquiry-based lesson on evolution. During class, students were examining five pieces of evidence used by scientists to prove the theory of evolution. Darcy enacted an inquiry-based pig dissection lab. Student groups started exploring the pigs' organs by cutting open the mouth and abdominal cavity. Copies of the observed lesson plan and student handouts were collected from each teacher.

Consent. Consent forms were emailed to the participating teachers in advance of the interviews. The full dissertation study was explained to the teacher by the researcher and all teachers' questions were answered. A dated and signed copy was obtained from all four participants. In addition, at the start of each interview, the teacher's oral consent to participate and to be audiotaped was confirmed.

Internal and external validity. In regards to internal validity, open-ended interview questions had been developed to ensure that the questions access teachers' motivational enactment and practice more broadly, rather than a predetermined response focused solely on autonomy-relevant practices sought by the researcher. Experimenter bias was averted by having the graduate advisor read, analyze and confirm conclusions from the interview data. Finally, qualitative data analysis focused on examining and describing the interrelationships among motivational constructs, but causal claims were not made. Specific to external validity, the teacher interviews were accounting for enactment in a very specific educational context: science classrooms that enact inquiry curricula. Accordingly, analyses and conclusions were specific to this particular context and care was taken in extrapolating these patterns to classrooms more generally.

Qualitative Analysis

All interviews were transcribed by an undergraduate assistant and checked for accuracy. In advance of coding, the entirety of the interviews and classroom field notes were read along with the coding protocol to ensure that a focus on motivational constructs, specifically autonomy, relatedness, and competence support, were sustained during the process of coding. The unit of analysis for coding was based on the responses given. This meant that the data were not coded necessarily sentence by sentence or paragraph by paragraph, but coded for meaning. As a result, the coded instances ranged in length. Moreover, in some instances, multiple coding dimensions may have been used for any one segment. The qualitative examination of each interview transcription involved several passes through the data. Interrater reliability across all coded measures was 89% agreement with all disagreements discussed and resolved.

Coding autonomy. The final coding protocol was informed by previous research examining autonomy-relevant practices within inquiry-based contexts (Appendix G) (Rogat, et al., 2014). A description of each coding dimension(see Appendix H) follows.

Organizational and procedural autonomy support. This code designated teachers' practices for providing students with opportunities for decision making in the classroom (Stefanou, et al., 2004). Organizational autonomy support was designated when teachers involved students in decision making related to classroom organization, such as selection of group members and the direction of decision making within a group. Teachers provided procedural autonomy support with decision making opportunities related to task format, such as how to work with materials. Teachers could inhibit organizational and procedural autonomy when withdrawing opportunities for decision making around procedures and materials.

Rationale and relevance. This coding dimension was identified when teachers drew connections between content, tasks, and skills with student's goals, values, and interests. This conceptualization was grounded in the theoretical ideas established in past work (Assor et al., 2002; Reeve & Jang, 2006). Teachers conveyed rationale by discussing a lesson's purpose and utility of lesson content and/or skills. Teachers communicate relevance by connecting to a larger question through unit contextualization and the use of authentic data. Low rationale and relevance were designated when teachers discounted the value or purpose of the material.

Responsiveness. Instances of responsiveness included teachers' descriptions of active listening and responding to students (Bozack, et al., 2008; Reeve & Jang, 2006). Responsiveness was coded when teachers described how they would elaborate on student ideas and use them to make key content points. Peer responsiveness was coded when teachers talked about encouraging students to listen to each other and respond to one another's ideas. Instances were coded as nonresponsive when a teacher expressed being dismissive of student contributions.

Feedback. Positive feedback was coded as facilitating autonomy when teachers recognized progress and student understanding (Reeve & Jang, 2006). Instances of feedback were specific to student-initiated ideas. Negative feedback occurred when teachers provided criticism or critical feedback on students' contributions.

Cognitive autonomy support. This code identified teacher's practices which provided students with agency related to content ideas, skills, thinking, and learning (Stefanou, et al., 2004). Teacher practices afford cognitive autonomy by maintaining openness of the curriculum tasks, eliciting students' content ideas and accompanying justifications, and encouraging a range of explanations among students. In contrast, teachers could inhibit cognitive autonomy by closing a curriculum task, limiting opportunities for student explanation and meaning construction, and lowering the cognitive demand of a task or using low-level questions focused on rehearsal and recall. Teachers lowered cognitive autonomy by retaining teacher responsibility or heavily leading the discussion without building from students' contributions or by simply stating the answer.

Relatedness and competence. Though the study's intended focus was on autonomy, the coding process was not constrained by only autonomy relevant practices. The coding process remained open to self-determination theory's broader support of student's basic needs for autonomy, competence and relatedness, by incorporating codes for teachers' practices supportive of competence and relatedness. These codes identified teacher practices that set a positive and productive classroom climate including celebrating accomplishments (e.g. teacher explicitly acknowledges a contribution to the lesson or class discussion), classroom management (e.g. sustains on-task behavior, consistent routines such as "do now" or "ticket to leave"; feeling comfortable in a physical environment), and respect (e.g. academic or personal caring; teacher displays respect for student ideas). Both relatedness and competence proved to be key motivational constructs reported by the teachers and were included in the results.

Coding teachers' autonomy-supportive practices. The autonomy codes were assigned to instances of autonomy-relevant enactment practices. Enactment practices captured when a teacher described their enactment in the classroom. For example, the enactment practices code was used when teachers described self-created curriculum (i.e. development of driving question, use of initial models). Here, inquiry teachers provided insight into their practice, not just descriptions of how they used curricular materials.

Coding teachers' IQWST analysis of autonomy-supportive features. The autonomy codes were assigned to instances of autonomy-relevant enactment practices, noticing autonomy-relevant IQWST curriculum features, and teacher modifications. Noticing autonomy-relevant IQWST curriculum features meant that teachers discussed specific features and segments of the IQWST curriculum. At times these were prompted by the interview questions itself. Other times, they were discussed by the teachers independent of the interview prompts. Here, teachers acknowledged a component of the IQWST lesson and then responded or reacted to it. Curriculum noticing was designated when teachers *agreed* with the intended curriculum. Based on previous research (Rogat et al., 2014), it was assumed that teachers would present a high frequency of autonomy-supportive practices, across multiple coding categories, and throughout the lesson in a variety of curriculum tasks.

The modification code was used to capture when teachers elaborated on their enactment practices in ways that went beyond the detail of the IQWST curriculum. A modification meant that teachers extended and expanded their talk beyond making note of a practice within the curriculum or a curriculum task. Here, teachers were thinking of other ways of doing the activity, task, and/or discussion. They discussed how they would change the curriculum suggested practices. This code was used during all instances in which inquiry teachers *disagreed* with the intended curriculum, even if no modified practice was elaborated.

Coding teachers' reasons for enactment decisions. After the autonomy-relevant enactment practices, IQWST curriculum noticing, and IQWST curriculum modifications were identified, the dissertation interview transcript documents were coded for reasons. This round of coding required reading the codes within the context of the whole document. This meant that reasons given by inquiry teachers for the autonomy-relevant enactment practices, curriculum noticing, and voiced modifications were identified within larger segments of text; it was not simply a line-by-line process. Often the reasons were given before the practice or modification was described.

This coding protocol was informed by the literature on antecedents of autonomy support which were organized around three categories (Pelletier et al. 2002; Pelletier & Sharp 2009; Roth & Weinstock 2013; Van den Berghe et al. 2013). *Pressures from below* included teachers' perceptions of student characteristics of being bored, off-task, lack of motivation, and having a negative attitude toward school or the domain. *Pressures from within* included teacher beliefs and teacher characteristics. *Pressures from above* included accountability, student assessments, administration, and time constraints. The extant literature often described these antecedents as negative pressures that influence teachers to employ more controlling and less autonomy-supportive practices.

Analysis of the data. The goal of the analysis was not teacher comparison, but a rich conceptualization of teachers' autonomy-relevant practices across all measures (see Appendix J for exemplars). Along with autonomy relevant practices, the analysis provided an understanding of the types of modifications they make to the curriculum tasks, and autonomy-relevant modifications to their classroom instruction. In the qualitative analysis, the range of pressures reported by teachers as reasons behind their autonomy-relevant enactment decisions and modifications was examined.

The qualitative examination of each interview involved several passes through the data and was exploratory. Field notes from classroom observations were used to confirm each teacher's enactment coincided with self-reported teacher practices. The resulting data allowed for the development of a detailed characterization of how teachers read a curriculum, how they created opportunities for student autonomy as they were planning lessons, what types of in-the-moment modifications they made as a lesson was being enacted, and how they reflected on their practice relevant to student motivation. Further, the data yielded both pressures and supports that underlie autonomy-supportive teacher practices, curriculum noticing, and modifications. Overall, the analysis provided rich examples of how the teachers provided autonomy support or inhibited autonomy with an inquiry context.

Finally, to augment the qualitative data analysis, frequency counts of each autonomy-relevant code and reason were tabulated. Since the instances were coded for meaning, they ranged in length from a single phrase to several paragraphs of text. Therefore, the count simply reflected the presence of each code discussed in each lesson segment. Frequency counts were also performed for the reasons each teacher gave for their enactment decision-making. Here, data was organized by teacher.

All of the participants' data was treated in accordance to the ethical guidelines of the American Psychological Association (APA) and Rutgers, The State University of New Jersey Institutional Review Board (IRB).

Chapter 4: Results

The following results are organized into five main sections. The first section will provide a rich portrait of how the teachers provided autonomy-relevant support through their own described motivational practices during Interview One. The second section will provide a summary of the teachers' IQWST analysis focused on the autonomy-relevant features from Interview Two. The third section will report on observed autonomy-relevant practices made during the Classroom Observations to verify congruence with teachers' described enactment practices. The fourth section will provide a cumulative summary of autonomy relevant motivational practices across these three evaluations. The final section will provide a summary of reasons for teachers' motivational practices.

Teachers' Own Autonomy-Supportive Practices

During Interview One, the four inquiry teachers discussed their own motivational classroom practices. In this first round of investigating the teachers' motivational practices, the teachers provided insightful reflections and rich accounts of their enactment practices in an inquiry classroom. Overall, these four inquiry teachers shared a common conceptualization in inquiry. The most salient commonality among teachers' motivational practices was designing lessons that elicited and challenged student thinking (i.e. cognitive autonomy). The teachers felt their roles as coach (Claire, Darcy, Diane) and "captain of a boat" (Ben) were crucial as students retained more responsibility for their own learning. Looking across all of the autonomy-relevant dimensions (see Table 2, the four inquiry teachers described a myriad of high quality autonomy-supportive practices. Notably in Interview One, two teachers (Claire, Darcy) also discussed their struggles with the challenge of still maintaining structure over student-developed lesson content (i.e. low cognitive autonomy) in the classroom. Throughout the study, this will be a consistent challenge for the inquiry teachers: high quality cognitive autonomy instances were often coupled with instances of low cognitive autonomy.

Table 2.

Frequency of Teachers' Own Autonomy-Relevant Practices

	Procedural Autonomy	Relevance	Responsiveness	Feedback	Cognitive Autonomy	Competence	TOTALS
Enhanced Student Autonomy	3 (7%)	8 (19%)	7 (16%)	2 (5%)	19 (44%)	4 (9%)	43
Diminished Student Autonomy	0	0	0	0	8	0	8
Totals	3	8	7	2	27	4	51

In the sections that follow, I report on the detailed accounts of autonomy-supportive classroom practices provided by the four inquiry teachers. The results are organized around motivational practices aligned with coding categories: procedural autonomy, relevance, responsiveness, feedback, cognitive autonomy, and competence. In each main section, the exemplars will highlight autonomy-supportive enactment practices teachers used in their own classrooms.

Procedural autonomy. Teachers provided procedural autonomy support with decision-making opportunities related to task format, such as how to work with materials. A common practice among all of the inquiry teachers was having student work in groups and two teachers (Darcy, Claire) believed it was essential to allow students to work with materials throughout the lessons. For example, Darcy explained how important it was to have classroom activities that allowed students to be actively involved saying, "I think it does make a big difference for a lot of these kids, especially if they can really get their hands on something that they have put their hand into, something that they've done and now there's a result because of that little- that they're doing something." (Darcy, I1, Lines 160-163). Here, Darcy felt this kept students invested in the lesson.

Claire described a unit she has created, "We did a reaction time unit, and I let them pick any variable they thought affected reaction time, and they got the test it. They designed an experiment... and they got to decide what they wanted to do." (Claire, I1, Lines 264-268). It may be that these open-ended student-designed labs are important in supporting students' procedural autonomy because it allowed students the opportunity to make task decisions.

Key points. Overall, these two teachers (Darcy, Claire) facilitated procedural autonomy by enacting classroom practices that allowed for student decision-making while handling lab materials and designing their own labs, which may serve to increase student autonomy as they are afforded the opportunity to be actively involved.

Relevance. Teachers conveyed relevance by evoking curiosity and connecting student interest to a larger unit question while using meaningful and real-world examples.

Evoking curiosity. One way that teachers provided relevance in their lessons was by evoking curiosity. For instance, Darcy described one lesson where students had to test several unknown liquids versus a couple known ones. Then from that, they had to make their scale of the pH-based balances unknown liquids. Darcy explained the students' enthusiasm, "And at the end, they got to find out what each liquid was. And they were very excited if they found out that they were right because they were also looking at the color of it. They were doing their wafting, the smelling. It [wafting] gets them excited." (Darcy, I1, Lines 338-341)

Similarly, Claire described a lesson in her heat unit that asks: What happens when you put a coat on a snowman? Claire believed that this seemingly simple question was perfect to get her students interested "because they're naturally inquisitive. And so if you tap into the right thing, once you get started, the unit really runs itself. You don't have to worry so much about forcing kids to do things because they want to know." (Claire, I1, Lines 242-245). She further explained, "The whole concept is that kids just want to know things, and so if you pick the right question, they become engaged in the content." (Claire, I1, Lines 259-261).

Though both Darcy and Claire believed that tapping into and holding student interest helped students stay engaged in the lesson, this would only enhance relevance for students if aligned with their own values and goals.

Meaningful examples. Beyond simply evoking their curiosity in the beginning of an inquiry lesson, some teachers (Ben, Claire) enhanced the provision of student relevance with meaningful, real-world examples. Ben described a physical science unit he created which focused on speed, acceleration, and velocity. The unit question was: Do you think there is a speeding problem in front of our school? Ben used this real-world example to engage his students centering the lesson on a meaningful and authentic problem. He elaborated:

> T: And once we start to get into the unit, it's their school- it's in front of their school. It's [speeding] happening with their parents a lot of times.

We'll collect data and they'll actually catch one of the parents speeding and it becomes a personal endeavor, a very connected lesson to them." (Ben, I1, Lines 347-350)

Further, Ben proudly shared that this unit was so relevant and interesting to students that they wrote letters to the town office and the superintendent explaining their data collected throughout this physical science unit. Here, Ben clearly conveyed how important it was to have a meaningful and relevant unit question.

In another example, Claire felt that relevant and meaningful examples provided a foundation for her inquiry lessons. She explained:

T: So when we talk about condensation, there's a million different examples of what happens. I'm like, "Hey, you guys took a shower this morning, I hope. What happens on the mirror?" Or, "What was on your car window this morning?" It just comes out and they're like, "Oh. Oh." And then they start coming up with their own things, so I think it's about picking things that they are interested in, which are all around them and then kind of building the relationships in those lessons and assessments." (Claire, I1, Lines 291-298)

Here, Claire believed that inquiry lessons, which included examples that students could relate to, afforded her the opportunity to go deeper into the science content.

Key points. Teachers who incorporate relevance may facilitate autonomy by addressing students' values, interests, and goals. Overall, the described classroom practices highlighted not only the significance of evoking students' curiosity, but more importantly emphasized the importance of sustaining student interest centered on authentic, meaningful problems.

Responsiveness. Three inquiry teachers described responsiveness in their classrooms in two key ways: active listening by the teacher (Ben) and peer responsiveness (Diane, Darcy).

Active listening. The teachers detailed how they actively listened to student ideas and used them to make adjustments toward the lesson goals. This was a particularly important component of Ben's classroom and was the teacher that spoke most explicitly about how important it was to actively listen to your students. Here, Ben explained:

> T: You have to give up control in the classroom, in the sense that like you have to be listening a lot to the kids, and the kids have to drive units and have to tell you when they're frustrated. You can't just plow through it. If they hit a point where they're frustrated, and you say, "Okay, well I'm just going to give you the answer or this is just how it is." Everything is null and void then. It defeats the purpose." (Ben, I1, Lines 245-250)

Later in the interview, Ben reiterated his point:

> T: just providing them with enough support and enough encouragement and just things that keeps them moving, keep them moving, keep them into it. Change things up when it needs to be. I always have to be listening to them with the bigger thing in mind, with the bigger idea or picture in mind. (Ben, I1, Lines 280-283)

In another example of active listening, Ben acknowledged his attention to his students' ideas and believed that responding to them was critical to student understanding. He explained:

> T: the biggest thing that I realized when I was starting to learn how to become a teacher, was ... this ... idea that students have misconceptions... It's something that ... you can't ignore .... Whether you want to ignore it or not, you have no choice. Students are coming into your classroom with ideas and you have to honor them and discuss them. (Ben, I1, Lines 110-114)

In these excerpts, Ben believed that his role was to constantly respond to the students' needs and understandings, which may enhance students' feelings of autonomy because it is their students' ideas that are used to make key lesson points.

Peer responsiveness. When teachers discussed responsiveness, they highlighted the importance of encouraging students to listen to each other and respond to one another's ideas. As Diane explained, "All of the students are engaged during this [student-centered lesson] because I'm not really asking the questions or leading the discussion. <u>They're</u> asking each other, 'What do you think? How does this relate?,' And <u>they're</u> like leading the discussion." (Diane, I1, Lines 116-119). Darcy provided another instance of peer responsiveness. She explained:

> T: I keep telling them is they've got to think about the questions - if there's a question or readings that what I keep saying is, "You gotta read. You gotta think about. You gotta talk to you partners. If you get stuck on something, you have to talk to each other. Try and figure it out." And I

> suppose that's the role of the students in my mind. Their role is to- not to try and get the right answer, but in the process of getting the right answer they need to work together to figure it out. (Darcy, I1, Lines 221-227)

Here, both Diane and Darcy demonstrated the importance of students listening to each other and supporting each other as they tackle challenging inquiry lessons.

Key points. Overall, these three teachers (Ben, Diane, Darcy) described classroom practices that afforded responsiveness by responding to students' ideas during discussion, honoring students' questions and explanations, and encouraging peer responsiveness. These teacher practices are important to student autonomy because students are the initiators of ideas and viewed as having valuable contributions to the lesson discussion.

Feedback. Positive feedback can be particularly salient for students when teachers acknowledge progress and student understanding. One teacher (Claire) explained how she provides whole class feedback during her units saying, "Sometimes I'll bring the group together when I feel like a lot of students are struggling with the same thing." (Claire, I1, Lines 172-174). Here, Claire had the opportunity to support the whole class and recognize her students' progress and evolving ideas.

Key point. While only one teacher (Claire) provided an explicit description of how she provided positive feedback in the classroom during Interview One, it was important to highlight that student autonomy can be supported when teachers acknowledge progress and student understanding.

Cognitive autonomy. Teacher practices afforded cognitive autonomy by maintaining openness of the curriculum tasks, providing structured lessons, and eliciting students' ideas. These practices served to encourage students' ownership over curriculum materials.

Maintaining open tasks. When the open-ended nature of inquiry tasks were maintained, teachers let students struggle through the inquiry materials, maintaining the challenge and decision making without taking back the control. Ben explained:

> T: The idea of giving up control sounds chaotic almost. It sounds ... almost like you let the kids run the show and they kind of come up with everything. And that’s not really the way...you’re the facilitator in the sense that you have to keep the big picture in mind. And your job is to really kind of like the captain of the boat in the sense that you have all these minds working towards a common goal and your job is to make sure that they get the right type of evidence in the right manner, so that they can really engage in those discussions... you don’t want to give them the answer; you don’t want to tell them how this is supposed to work. What you really want to do is you want to put them in a situation where they feel ownership and they feel like ... this is something that [they] really want to think about." (Ben, I1, Lines 264-274)

Here, Ben felt that it was beneficial to give students the opportunity to be in control during inquiry lessons. However, as Diane, Claire, and Ben explained in these next excerpts, it was also a challenge to balance this giving up of control and student frustration. The teachers felt the need to restrain themselves from inserting themselves into the conversation too much. Diane explained, "the hardest part is not giving away the answer when they’re struggling, because the purpose of it is for them to struggle through it. And it’s very hard when they’re struggling through it, not just giving them the answer." (Diane, I1, Lines 82-84). Similarly, Claire explained, "it’s hard to just let the kids just talk to each other. Or even when I sometimes listen into group work, I have to remind myself to just like listen for a little while and direct as needed, but not insert myself just for the sake of inserting myself." (Claire, I1, Lines 176-179). Finally, Ben explained why he holds back and lets his students struggle explaining:

> T: you can tell that their brains are churning and they’re going over it in their heads and it’s frustrating because it’s a lot of components that have to work together to create that mechanism. But that shows me that the frustration is a sign that they’re engaged, that they want to get to it. That need to know is there. (Ben, I1, Lines 217-221)

Clearly, Claire, Ben, and Diane expressed the difficulty of giving up control and allowing students the freedom to struggle with the cognitive work of inquiry.

Responding to high level of challenge. Darcy and Claire discussed examples of how they provide students opportunities to engage in inquiry tasks by maintaining structure in their lessons. Here, these teachers would break down tasks for students as they engaged in the cognitive work of inquiry science. Darcy explained that the goal of a teacher in an inquiry lesson is, "To identify the students’ needs, and some of the students may not be ready for that full inquiry step right at that moment, so you may have to scaffold it for them." (Darcy, I1, Lines 204-209) in order to motivate their engagement.

Claire described structuring the lessons so that her students are able to participate in the inquiry process as a lesson begins, which she believed was a benefit to all students to get them engaged. She explained:

> T: So one of the things that the special education teacher and I have worked on, over the course of the year, is scaffolding, modeling in general, but especially early models. ... I find that's where students struggle the most - when they feel like they have no idea and they don't even know where to start. (Claire, I1, Lines 153-164)

Both Darcy and Claire believed that it was important to identify students' needs and ensure the inquiry tasks were made more manageable through a more structured learning experience.

Eliciting students' ideas. Ben elicited students' ideas during his daily lessons. Ben believed that his classroom was "an environment and situation where the students are not just engaged in the lesson, not just engaged in the hands-on activities, but we call it minds-on learning" (Ben, I1, Lines 61-63). Ben then used those ideas as key points in further discussions.

Low cognitive autonomy. Though it was infrequent, there was evidence of low cognitive autonomy. Two teachers (Claire, Darcy) expressed challenges with inquiry materials related to maintaining teacher structure and the challenge of withholding answers while they struggled with challenging inquiry curricula.

Maintaining structure. In the following excerpts, Claire discussed the challenge of maintaining structure. Claire grapples with the freedom to allow tasks to be open and exploratory with the need to give students the accurate answer, saying "I've found that as long as you make it okay to not know the right answer at most of the time, then they become comfortable with it. And then clearly at some point, there is a right answer and you should know it." (Claire, I1, Lines 115-116). In another example, she described how at certain points in her inquiry units, she would pause and do notes on the science concepts to reinforce what they are learning. She described her cell unit:

> T: So, for example, in our how does lead get into the cell unit, the students learn that some things can squeeze into the cell, and we pause and I do notes on diffusion and they get like official diffusion notes to have in their binder about diffusion because you have to remember that even though we're teaching inquiry, there is content that we need to cover and assess, and the students need to prepare for assessments and they need those terms and they need the notes kind of spelled out in clear way. (Claire, I1, Lines 307-316)

For Claire, this was a common tension. She valued inquiry but also struggled to cover specific science content. Here, it may limit cognitive autonomy because the teacher still retains the right answer or the official notes on what is important.

Telling students answers. For one teacher (Darcy) there were some science topics that she believed needed to be presented to students accurately and this meant removing inquiry practices altogether. Global warming was one such topic. While discussing a unit on global warming, Darcy explained:

> T: Some lessons where I really want them to get a very precise explanation; I find that I want to take control back for that. I will want to say that very precise explanation. I think there's a little bit of a concern where we have time-limited inquiry, which is essentially what I have coming up. I worry about the students coming away with the wrong idea,

so I’d rather have a clear sense, like a clear- facts that I’m presenting and then just leaving it at that." (Darcy, I1, Lines 245-247; 249-252)

Clearly, Darcy believed in the inquiry process in most situations, but here she felt compelled to tell the scientifically accurate answer.

Key points. Overall, Claire, Ben, Diane, and Darcy described classroom practices that provided students with cognitive autonomy through eliciting student ideas, scaffolding, and open tasks, but this was not without its challenges. In response to student frustration, teachers grappled with maintaining structure and the need to provide answers in their science classrooms while trying to facilitate student autonomy.

Competence-supportive practices. Two teachers (Claire and Diane) discussed how they would help students feel more competent with the inquiry materials. Both Claire and Diane felt that all students needed to feel competent when sharing their ideas while constructing an understanding, learning new scientific terminology, and grappling with new science concepts.

Optimal challenge. Claire offered her students challenging, yet attainable problems and often used practices that allowed students to work together in pairs, small groups, and as a class while tackling challenging inquiry curriculum. Claire believed that opportunities for students to work together was motivating to students in an inquiry classroom, saying "We also have them do partner work sometimes, so that they’re not on their own. But I find that’s where students struggle the most when they feel like they have no idea and they don’t even know where to start and they’re nervous that answer’s wrong and they just kind of freeze up. (Claire, I1, Lines 161-162). Here, Claire believes that working together students would find support from their peers and persist with the challenge of inquiry because students felt they had a partner to rely on. Claire further explained how motivating the right level of challenge could be, "After the initial challenge of figuring it out and getting over the risk factor, the kids are more motivated" (Claire, I1, Lines 239-240). Claire continued, "The way I think about it is a lot of times is I use inquiry to make their brains sticky, so that the terms and the things like that easily stick. So once they kind of put the time and the effort into trying to figure it out, ... it becomes less about the word and more about concept" (Claire, I1, Lines 307-319). Here, Claire acknowledged that once students recognized that they were competent with this challenging curriculum, the students' level of confidence with the material and scientific terminology would increase.

Diane described how important it was that all students felt challenged, confident and eager to share ideas with the class saying, "they're excited to be able to show each other what they're doing, because they feel confident in their roles." (Diane, I1, Lines 138-139). Proudly, Diane shared that her special education students also displayed confidence and were integral parts of the class discussions. For example, Diane described an instance when the class was looking at evidences and creating models. She took pride in sharing:

> T: I teach two sections of in-class support. The first time that my in-class support teacher and I did this as a lesson, I was like there's no way they're going to get it. But one of the most exciting things for us - the one time that somebody put their model on the board and one of the special education kids said, "Well really, according to evidence number two, you needed to include this." The fact that they're saying that without even

being prompted is exactly what you're looking for. (Diane, I1, Lines 143-148)

Importantly, Diane found that inquiry reaches all of her students and is a rewarding experience for her special education population.

Key points. Overall, Claire and Diane described classroom practices that provided students with opportunity to feel challenged and competent. It was important that students felt supported when working with challenging inquiry materials.

Summary of teachers' own autonomy-supportive practices. To summarize, during the first round of investigating the four inquiry teachers' motivational practices, the teachers provided insightful and detailed accounts of their enactment practices in an inquiry classroom. Looking across all of the autonomy-relevant dimensions, the four inquiry teachers described instances of high quality autonomy-supportive practices related to procedural autonomy, relevance, responsiveness, feedback, cognitive autonomy, and competence support. A notable challenge for two teachers (Claire, Darcy) was striking a balance between giving up teacher control while still maintaining structure (i.e. low cognitive autonomy) in the classroom as evidenced by high quality cognitive autonomy instances often coupled with instances of low cognitive autonomy.

Teachers' IQWST Analysis of Autonomy-Supportive Practices

During Interview Two, the four inquiry teachers examined the curriculum features of the IQWST unit on Heredity and Natural Selection in detail. In this second round of investigating the teachers' motivational practices, the teachers provided rich narratives of their hypothetical enactment of the IQWST lessons. Throughout the analysis of the IQWST lessons, the teachers provided detailed accounts of various curriculum features they noticed. The teachers presented a high frequency of autonomy-supportive practices, across multiple categories.

Interestingly, the four inquiry teachers not only noticed the curriculum features as intended, but also proposed several modifications to the IQWST materials. It was particularly important to gain an understanding of the specific modifications and revisions teachers made when analyzing this inquiry-based curriculum with autonomy-supportive motivating features already present – given that teachers may respond by either further facilitating or inhibiting these motivating features. These four inquiry teachers, they found several places in the IQWST curriculum where they could augment autonomy support for their students. They suggested curricular modifications that enhanced student opportunities for autonomy support that exceeded the intended curriculum.

As evidenced in Table 3, there were frequent coded instances of autonomy supportive practices noticed by all teachers with cognitive autonomy support (46%) by far the most prevalent intended practice. Interestingly, enhanced cognitive autonomy support (56%) was also the most frequent proposed autonomy support affected by the curriculum modification.

Table 3.

Frequency of Autonomy-Relevant Practices in IQWST

	Organizational and Procedural Autonomy	Rationale and Relevance	Responsiveness	Feedback	Cognitive Autonomy	Relatedness and Competence	TOTALS

Curriculum Noticing & Enactment Practices	7 (8%)	18 (20%)	9 (10%)	3 (3%)	42 (46%)	12 (13%)	91
Modifications	0 (0%)	3 (12%)	0 (0%)	0 (0%)	14 (56%)	8 (32%)	25
Totals	7	21	9	3	56	20	116

Given my primary focus on autonomy-supportive practices identified and described by the four inquiry teachers, in the sections that follow, I richly characterize in more detail these autonomy-supportive practices. The results are organized around six motivational practices aligned with coding categories: organizational and procedural autonomy, rationale and relevance, responsiveness, feedback, cognitive autonomy, and relatedness and competence. Within each main section, the exemplars will highlight the autonomy-supportive curriculum features that teachers noticed, proposed enactment of the IQWST curriculum, and suggested curriculum modifications (see Appendix F).

Organizational and procedural autonomy. The IQWST curriculum afforded organizational and procedural autonomy through the provision of decision-making opportunities within student groups about task decisions. As expected, some teachers (Darcy, Diane, Claire) noticed and discussed these affordances during the introductory candy activity and the jigsaw. The teachers recognized autonomy-supportive practices that involved giving students control over choice of group members and task completion. Other autonomy-supportive practices allowed student decision making centered on how to engage with lesson evidence, such as participation in the candy activity and the creation of summary charts during the jigsaw. Autonomy-inhibitive practices limited student decisions and maintained teacher control over decision-making.

Curriculum noticing and enactment practices. The teachers noticed task decisions that afford organizational autonomy. Organizational autonomy was afforded in

IQWST lessons when students were allowed to direct the decision-making within the group. For example, Darcy explained her approach to group work, "when they do regular group work, I try and leave it a little more up to them in terms of how they work together in their groups." (Darcy, I2, Lines 762-763). Darcy felt that her students should be allowed to form their own groups and take on the responsibility of completing the assignment.

The teachers also noticed task decisions that afford procedural autonomy. Procedural autonomy affordances in the IQWST lesson involved task decisions such as how to read, interpret, and integrate evidence into their explanations. Darcy felt that the provision to participate in the introductory candy activity and handle the materials might encourage the students to actively participate. In another example, Diane thought that as opposed to simply telling students about advantages of height as a teacher demonstration or lecture notes, "this [candy activity] is one of things that involves them getting out of their seats, involves a challenge, so it’s something that- they would just be interested in figuring out " (Diane, I2, Lines 655-658). This may increase students’ willingness to engage in the lesson tasks when they are a participant in the candy activity. When the teachers discussed the jigsaw activity, they all noticed and liked the use of an evidence chart in the student pages, which allowed students to pull all of the evidences together into one graphic organizer. This may allow students freedom to have control over their own interpretations of the evidences.

In some instances, teachers expressed the need to limit the students' decision-making, rather than affording autonomy by making decisions about group process. Notably, these instances often corresponded with the teacher's need to structure and closely monitor group work. In this example, Claire explained, "I might even assign jobs. This person is the recorder; this person the graph person- is making sure that all of the students have the graphs in front of them. Whatever. But I just find that adding structure and direction to these kind of activities keeps the students focused." (Claire, I2, Lines 760-766). Here, Claire discussed how she might have directed the group work as students transitioned into their jigsaw groups. In the past, Claire has seen students not become experts, which then put the group at a disadvantage with missing evidence. Claire acknowledged that for a successful jigsaw all students needed to be motivated to do their part. Therefore, this classroom management strategy of assigning jobs within the group may help facilitate the student focus.

Key points. In terms of organizational and procedural autonomy support, Darcy, Diane, and Claire noticed several key features in the IQWST curriculum. Most importantly, they detailed opportunities to take on the responsibility of forming and managing their own groups. This may allow students freedom to have control over their own interpretations, thus increasing the feeling of autonomy. Student opportunities to be involved in task decisions with evidence may serve to increase student autonomy because they may be more willing to engage in the lesson tasks when they are actively involved. Though infrequent, inhibitive practices removed decision-making opportunities, thus potentially decreasing student autonomy.

Rationale and relevance. Teachers who incorporate relevance may facilitate autonomy by addressing students' values, interests, and goals. The IQWST curriculum afforded relevance through opportunities to contextualize the lesson content by connecting to the unit's driving question and investigate authentic data sets during the brainstorm activity and during the jigsaw activity. The four inquiry teachers (Claire, Ben, Diane, Darcy) recognized both the rationale and relevance features afforded by the IQWST curriculum. Further, the teachers elaborated on practices beyond the intended curriculum, suggesting modifications that further enhanced the lessons' rationale and relevance by maintaining a continued focus on the main content points and connecting the content to professional scientific practices. One inhibitive practice limited relevance by modifying a group activity into a brief demonstration by only a few students.

Curriculum noticing and enactment practices. Unit contextualization was noticed by all four teachers in both the introductory activity and through the use of a driving question. Connecting to the larger unit of heredity and natural selection, the IQWST curriculum's introductory candy activity was noticed by all four teachers (Claire, Ben, Diane, Darcy) as an effective way to introduce the lesson and provide connections to the larger lesson question, "How does Variation Matter?" For instance, Claire acknowledged the introductory activity saying, "I feel like they would be engaged and be motivated to get up and to pretend and do this activity. I think that the point would be made" (Claire, I2, Lines 565-568).

The four teachers (Claire, Ben, Diane, Darcy) all agreed that the introductory candy activity was an effective instructional move to elicit unit contextualization. Ben elaborated on the importance of relevance in the following exemplar:

> T: I think anytime that we have an opportunity to link what we're getting into or new information; if you can link it to something that they've spent time investigating, they've spent time learning about and trying to

understand it, it just makes that connection deeper. (Ben, I2, Lines 644-647).

Ben believed that when you exploit the opportunity to have students make a connection between the lesson and prior knowledge, it is more meaningful than having them memorize science content.

Some teachers (Ben, Claire) recognized the motivational benefits of communicating the relevance of the driving question. Ben believed making explicit the connection between the evidence and "the bigger question that we're trying to find out," (Ben, I2, Lines 884-889) would heighten the students' investment into the lesson. Similarly, Claire talks about the importance of finding the right driving question:

> T: I think the key is tapping into the fact that kids are inquisitive. They do want to know about the world around them. They find it interesting and I think that the key is coming up with the right question, particularly the right driving question for a unit to get them to really want to know. I mean all of the other forms of motivation are short-lived and they don't get at the same kind of depth of learning as intrinsic motivation would. You can give them candy and that's cute and they might be excited about that activity, but that doesn't really motivate them to learn and it doesn't really allow the learning to stick, which is ultimately the goal, in my opinion. (Claire, I2, Lines 912-920)

Here, Claire and Ben emphasized how critical it may be to contextualize and ground discussion in the larger unit question.

The IQWST curriculum's use of authentic data and evidence sets was a curriculum feature providing relevance that Claire and Ben noticed and were excited about. The teachers saw value in giving students the opportunity to interpret authentic data and evidence sets while studying real case studies compiled by the scientific community. Claire saw motivational value in the lesson's use of authentic data explaining:

> T: I really think the real life example is giving them the opportunity to answer the question with the evidence is the most motivating in itself, so I think engaging the students and trying to figure out what's happening with the peppered moth and why the peppered moth and why it's happening? I think if you hook them in the right way, that should motivate them throughout and I think, the candy activity is kind of interesting but I don't think that's where the true motivation lies. (Claire, I2, Lines 901-906)

Claire further explained how authentic data is a part of most of her classroom lessons throughout the year, which may explain her noticing of the data in the IQWST curriculum: "I liked that the evidence was really well-developed and I feel like it's better developed than the evidence that I typically use in terms of like the background information and the different kinds of charts and tables" (Claire, I2, Lines 432-435). Claire talked about how difficult it sometimes is to access authentic data that students can understand and use in the classroom, "A lot the times I find when I design materials, I find data and then I kind of end up tweaking more than I would like to so that the students can understand it" (Claire, I2, Lines 444-446).

Ben recognized authentic data as a relevant and important component for the lesson segments to follow saying, "We're going to look at some experiments, some studies, and some data that they collected and we're going to see if we can figure out what they did, and talk about it, and interpret it, and look at their data." That would set the stage for the next day." (Ben, I2, Lines 837-840). Having a curriculum that provides good, useable data sets was important and may enhance relevance for students since it provides connections to real organisms, which may address students' personal values and interests.

Finally, the teachers noticed that the IQWST curriculum affords rationale through the introduction of lesson purpose and lesson coherence. Diane recognized the introductory candy activity as a great way to convey lesson coherence. She explains, "It would be nice to do that [candy activity] because then you could constantly reference back to that. 'Remember that time you couldn't reach the candy?'" (Diane, I2, Lines 518-520). Diane explained how she might convey rationale during the lesson saying, "Okay, now that we've finished this [later lesson], how does that relate to that candy bowl at the very beginning?" (Diane, I2, Lines 648-649). Diane emphasized rationale by noting the importance of making explicit the connection between the introductory candy activity and the key content point.

Similar to Diane, Ben felt there should be an explicit connection made to the candy activity. Here, Ben explained that "The key would be making sure they have the link between them picking up candy and understanding that it has to do with differences in their height and genetics and how that's going to link into another species, another investigation, another problem" (Ben, I2, Lines 629-632). In another example, Ben explained how he would envision enacting the introductory candy activity, which added rationale to the IQWST unit, "For starters, the unit ... is something that I know is going to get them invested into the next lesson but also ties into previous lessons." (Ben, I2, Lines 596-598).

As exhibited by these exemplars, Ben would provide rationale through communicating coherence among unit lessons and lesson purpose. Students may feel that the tasks are useful and connected to their learning goals.

Modifications. One modification by teachers was maintaining relevance. Claire suggested a modification to maintain emphasis on the content point of the activity, which enhances the lesson segment's relevance (demonstrating advantage and disadvantage of a particular variation, height) saying:

> T: I like the *intent* of this activity. I don't really like the candy thing. I felt like if I were imagining this in my classroom, the lesson would completely become about candy and not so much about the learning. The other thing- I felt like it could have been more authentic. So it's not realistic that if someone can't reach candy, that they would die off. So I would, I would actually do an activity similar to this and I would change it to maybe even having the students pretending like they're giraffes. You could put certain leaves at different heights. To me, it would make it a little less distracting by not including the candy and also it's more of a direct analogy. (Claire, I2, Lines 536-569)

By ensuring that students understood the intended content connection, this modification may further enhance the relevance of the introductory activity with the substitution of the leaves to better simulate the real, authentic need organisms have for food to survive. This modification may be particularly important for lesson contextualization given that the next lesson segment shifts to looking at authentic data regarding the moth species.

Teachers modified the curriculum tasks by connecting to the work of scientists. Another suggested enhancement to the IQWST curriculum was to tie the use of authentic data and evidence sets to the work of the scientific community. The IQWST curriculum afforded relevance by evoking curiosity centered on an authentic problem set of evidences based on studies of the peppered moth population in the scientific community. Students may view this as motivating because it may increase their interest in the topic affecting their willingness to invest more effort and be more engaged. For example, Claire believed that the introductory candy activity did just this; grabs student interest and evokes curiosity, "The kids get really into it, and I think it drives home the point." (Claire, I2, Lines 568-569).

Moreover, Claire sets the stages for future lesson tasks by highlighting that this is what practicing scientists do as in this example, "Usually I end with asking them, ‘Okay, you’re scientists you have a bunch of ideas. What do scientists do next?’ Just to reiterate the point that when scientists have questions and they have ideas and they know the answers the next step is to look at the evidence" (Claire, I2, Lines 684-681). By tying to the work of the scientific community, students may view the relevance of their tasks as going beyond simply a classroom task and relating it to a scientific profession.

In some instances, modifications were suggested that could limit relevance. Darcy suggested modifying the activity by having only a few students do the activity, as more of a demonstration for the class, to avoid losing students if the activity went on too long. Darcy explains, "I don't want to spend a lot of time on getting everybody up to the class and in different groups and having them all try it out. I think after the second kid, they'd go, "(Teacher's name) we got it. We get it. Short people can't reach candy."" (Darcy, I2, Lines 533-535). This teacher's modification has the potential to diminish relevance of the activity for those students who do not have the chance to participate. In addition, if the activity is shortened too much and limited instructional time is afforded to making the connection back to previous content ideas, students may see the introductory activity as simply a demonstration and not an integral part of the larger lesson to follow.

Key points. The four inquiry teachers discussed relevance and rationale throughout the IQWST lesson. Most importantly, teachers would have reconnected with the driving question, which may be beneficial in fostering relevance of unit content and facilitating student autonomy by addressing students' values, interests, and goals. Together with unit contextualization, the connections teachers make to the work of scientists may provide students with opportunity to align with their own interests and goals by relating classroom tasks and the careers of professional scientists. Further, the IQWST curriculum provided data sets that the teachers got excited about. These authentic data sets may align with student interest about the real organisms. The provision of rationale within the lessons and larger unit may support students' feelings that the lesson task are meaningful and connected to their own learning goals thus providing autonomy support. Finally, the instance of limiting relevance by shortening or restricting participation in the introductory candy activity had the potential to be detrimental to student autonomy, however the consequence of this minor modification is not known.

Responsiveness. The IQWST curriculum afforded responsiveness with opportunity to draw on students' ideas to generate a list during a brainstorm discussion and the use of these student ideas while constructing a class consensus explanation. Most teachers (Claire, Ben, Diane) discussed curriculum opportunities that elicited both active teacher listening and peer listening.

Curriculum noticing and enactment practices. First, Diane and Ben noticed IQWST curriculum practices that highlighted opportunities for teachers to not only actively listen to their students and but also to reintegrate student ideas to make key lesson points. In this exemplar, Diane is discussing how she would conclude the lesson and pull the whole class together for a final discussion:

> T: We're going to make a final class model, and we want to make sure that we include all the best things in your models. Look over your model and think about what are the most important components of it that cannot be missing? Because sometimes when we do these models, everybody can do it differently, so what is the main important thing that you think definitely needs to be included in it? (Diane, I2, Lines 877-884)

Here, the IQWST curriculum calls for consensus and Diane explained that by priming her students to think about the best thing in each model, the students were better prepared to share out their ideas with the class. Diane described a similar instructional move in which her active listening is accompanied by questions such as, "Why would you do it this way? Is there evidence that made you do it this way? Is there something that you could be missing?" (Diane, I2, Lines 720-722).

Ben explained how he would listen to his students and how important it would be that he guided his students with content understanding:

> T: I'll listen to different students and I'll try and extend their understanding and try and lead them to something that deals with pollution or something that deals with predators, just enough that it gets it into their heads and they start to think about it, but I want them to come up with it. (Ben, I2, Lines 765-769).

Both Diane and Ben would create opportunities to restate student ideas using the students' own words to add content points throughout the lesson. It is critical to return to students' models, ideas, questions, and brainstorming ideas.

Second, the teachers noticed curriculum features that encouraged peer responsiveness. The nature of the IQWST unit question opens up opportunity for agreement and disagreement. For example, Claire and Diane demonstrated peer responsiveness when they discussed how to set up the group work and class discussions presented in the lesson. Peer responsiveness during group work while interpreting the graphs and evidence was set up here by Claire. She would encourage students to listen to each other's explanations and respond to each other. In the following interview excerpt, Claire explained how she would initiate this during collaborative group work throughout the jigsaw:

> T: I remind them like, "Everyone is helping out. You're there to help each other understand. In this case, every single person needs to walk away

> with an understanding of the content, so you need to help each other do that." And sometimes what I'll even do is when they come up and ask me a question that really I know that they can answer within the context of their group, I'll just redirect them back to their group. Like, "Did you ask your group about that? Did you guys talk about it? I don't mind helping you, but you need to try to figure it out as a group or whatever first." And sometimes that comes back to a collaborative task. (Claire, I2, Lines 731-738)

In another example, Diane would encourage peer listening during class discussions making her norms explicit. She explains, "Sometimes, I'll say, "No, you had your hand up. You were supposed to be listening to what he was saying. So let's hear what he had to say, and then you can respond." (Diane, I2, Lines 965-967)

Both Claire and Diane would make explicit calls for students to listen and to respond to their peers.

Key points. It is important that teachers are responsive to their students and the teachers recognized opportunity for responsiveness throughout the IQWST unit. Active listening may provide autonomy support because it demonstrates that the students were heard and are a valuable part of initiating the key points. Instances where students engage with their peers may foster autonomy support because of its focus on them being the initiators of discussion, not solely the teacher.

Feedback. Positive feedback curriculum opportunities noticed by the teachers included recognition of progress and understanding of curricular materials. The four inquiry teachers provided instances of elaborate feedback that focused on student-initiated ideas.

Curriculum noticing and enactment practices. Teachers noticed opportunities for positive feedback. Diane and Darcy set up checkpoints and expectations as the whole class worked through the lesson content.

Diane explained, "There would need to be some type of check-in at some point, where I'm going around checking in with the groups before they break out into their jigsaws (Diane, I2, Lines 463-465). Similarly, in the following excerpt, Darcy explained:

T: So usually, I'm walking around the room, and when they say that they're done. I'll look at what they have written. And I'm like, "This is great. Can you think of something else? Try and get as many- even if you think you have one good hypothesis, try and think of some other explanations." (Darcy, I2, Lines 636-639)

Here, both Diane and Darcy were setting up the opportunity to provide positive feedback to students during key parts of the lesson where it is was important to check in on student progress. Additionally, checkpoints may support cognitive autonomy because they would facilitate the jigsaw activity by dividing the challenging tasks into smaller, more manageable tasks.

Ben would provide positive feedback to groups related to collaboration as they begin to form their understanding of the evidences, "Each of you plays a role. It doesn't matter what piece of evidence you're bringing in. You all have equal weight. You're all equally important." (Ben, I2, Lines 1075-1076). Ben's feedback would provide students encouragement as they grapple with evidence.

Key points. Feedback in a situation that recognized student progress may foster autonomy by focusing on student-contributed ideas. The teachers recognized that the provision of positive feedback centered on student ideas that emphasized student progress was essential to autonomy-supportive practice.

Cognitive Autonomy. The IQWST curriculum afforded cognitive autonomy with emphasized centrality, evolution, and revision of students' ideas as part of the unit. The four inquiry teachers (Claire, Ben, Diane, Darcy) discussed the provision of opportunities for eliciting student thinking through scaffolding and allowing students to retain responsibility for the lesson content. During the IQWST lessons, students would engage in the interpretation of data in jigsaw groups, share ideas with classmates, and formulate a final consensus evidence-based explanation based on developed explanations and ideas. One suggested modification was to add a debate. During inhibitive practices, teachers maintained structure of the lesson by synthesizing student ideas.

Curriculum noticing and enactment practices. Teachers noticed curriculum tasks that used elicited student ideas as a basis for the lesson. Teachers recognized the importance of eliciting students' ideas at the very beginning of the IQWST unit as the peppered moth is first introduced during class discussion. Teachers' questions would ensure that student ideas' were central to class discussion. In the following example, Ben would elicit ideas at the very beginning of the lesson when the peppered moth is first introduced by accessing the students' prior knowledge about what they already know about the peppered moth. Ben would use this opportunity to conduct a brainstorming discussion by instructing students to:

T: make sure that we're getting all our ideas out on the table and make sure that we're getting everything that we can in terms of the patterns that you can see. Let's have a class-wide discussion-let's create a class model of what we know about the black peppered moth, the peppered moth. What has happened to it over the past century? What are themes? What do you guys see?" (Ben, I2, Lines 708-711; 717-720)

Ben felt that this initial brainstorming of ideas would pull out students' misconceptions about moths. Further, Ben would continue to probe his students' understandings about the moths. He explained:

T: get [out] all of our ideas and even a lot of misconceptions about where moths actually live and what do they feed on and their coloring. Is it- do you think it's genetic? Do you think that they just acquired it from the environment? Just get a whole bunch of things out there. Just get all those questions out there and flowing. (Ben, I2, Lines 725-729)

Ben expressed the importance of allowing students the opportunity to be the initiators of a discussion in "a situation where students are comfortable bringing up ideas, sharing ideas and at the helm of the discussion" (Ben, I2, Lines 748-750). Similarly, Darcy would elicit student ideas with the following directions:

T: I want you to think about what could be going on with these peppered moths. I want you to talk to your groups, talk to your pairs and write down everything you can think of. Start writing them down because when once you write down one thing, it might trigger something else in your partner's mind, so I want you to keep working at it. (Darcy, I2, Lines 628-632).

Here, Darcy recognized that all student ideas were important and worthwhile to the brainstorming discussion. However, during these types of initial student discussions, there was a voiced concern or tension about not giving the answer away as explained here by Claire:

> T: The hardest part for me during this kind of lesson is trying not to give anything away. I want the experience to be authentic, and so I want the students to have their own ideas and bring them all to the table and have them all start on an equal playing field. (Claire, I2, Lines 642-643; 646-648)

Diane was also concerned about not giving the answer away and voiced concern about the suggested IQWST prompts as she explained, "I definitely wouldn't have had them discuss these sense-making questions before they did that. Because of these sense-making questions were kind of leading" (Diane, I2, Lines 675-677).

Here, Diane would elicit students' ideas, which may convey the message that their ideas are the starting point for the lesson discussion. These discussed practices showcased the importance of student thinking with questions that invite students to generate a range of ideas about the peppered moth.

Second, teachers noticed task support during the jigsaw. In addition to practices that elicited preliminary student ideas, teachers (Diane, Claire) noticed and described enactment practices that supported student ideas throughout the entire lesson. As discussed above, the teachers (Diane, Claire) would provide feedback to students as they engaged in the jigsaw activity by adding checkpoints and monitoring student understanding of evidence. This was also coded as cognitive autonomy support as teachers help students grapple with the cognitive work of interpreting sets of evidences.

Diane described how she would assist students with the cognitive work of interpreting sets of evidence by creating "stopping points". In the following example, Diane discussed adding these checkpoints to the IQWST lessons to monitor the curriculum tasks during the jigsaw:

> T: It could be that when they're in their groups they answer it in that part in the packet, and then the whole group would have a discussion and then after they had the check-in with the discussion, write it in. That's a way that you can make sure you're not sending them away with the wrong info. So you make sure it's correct by the time they make it through the evidence section before they go out and share. (Diane, I2, Lines 503-508)

Diane also would add a checkpoint where she could monitor student progress without disrupting the student discussions. While students are in their jigsaw groups, she explained, "One thing I think I would've done in here that would've helped me to identify that [misunderstanding of the evidence] was, I think I would've added some sort of quick comprehension question at the end of each of these data sets, so that they could answer it alone." (Diane, I2, Lines 775-778).

In these instances, Diane's checkpoints may support cognitive autonomy because they would facilitate the jigsaw activity by dividing the challenging task of reading evidence and becoming an expert into smaller, more manageable tasks.

Diane and Claire acknowledged that the jigsaw method in the IQWST lesson would encourage students to hold each other accountable. As such, they would make student responsibility to their peers explicit when initiating student discussions. For instance, Claire believed that "the jigsaw model forces students to be accountable, so when they have to report back to another group about the study that they did, that accountability helps motivate students who may not be as naturally motivated by the content." (Claire, I2, Lines 461-464). Claire's point here is the vital need for students to understand that their peers are relying on them for accurate information concerning the data sets. Being held accountable to peers might provide cognitive autonomy support because it allows students to view their contributions as originating from their own cognitive work and not from the teacher.

Though other teachers agreed that the jigsaw activity allows students to view themselves as accountable to their peers, some teachers (Diane) expressed concern with the enactment of such an activity. Diane explained:

> T: I think definitely it requires a lot of finesse by the teacher. It allows you to kind of have that space to go to students who need that extra push, who you know might struggle. But definitely making sure that each representative knows that they're talking about so that they're representing the idea correctly, and to make sure that each individual is going to feel confident enough to share what they learned. And also, that everybody is going to trust them. (Diane, I2, Lines 559-564)

Along with Claire, Diane emphasized how important it would be to guide students in how to think about reading and understanding the presented evidence, which may be autonomy-supportive.

It is interesting to note that these teachers also seem to be resisting the NGSS principle of interpretation of evidence, requiring students to show comprehension of evidence and only when students are accurate can they then draw the correct conclusion for the model. It is not clear if these practices are fully supportive of student autonomy or if they also have some inhibitive influence on student autonomy.

Modification. In one very interesting curriculum modification, Ben suggested ending Lesson 9.3 with a debate. Here, students would be given the opportunity to debate, share ideas, listen to each other, and build arguments. A debate would provide opportunity for students to engage with the data and retain responsibility for their own understanding of evidence. In the following interview excerpt, Ben outlined how he might enact this:

> T: I think having a debate would be even more powerful than just doing it like- as opposed to just saying, "Okay, it looks like we agree on this."... What we're going to do is we're going to have a debate about it, or we're going to have something called 'argument island' where we're going to actually split you up. If you agree with one explanation, you actually physically get up and we're going to put you on this island. And your job is to convince other people to come to your island and to listen to your explanation. The way that you get them to come over is you have to support it with evidence. You have to be convincing and at any point during the discussion, you can move from one island to the next. (Ben, I2, Lines 1123-1138)

Ben's modified practice may be supportive of cognitive autonomy because the students are responsible for the content of the debate as long it sustains cognitive autonomy without losing track of the key point of a lesson.

In some instances, teachers suggested modifications that diminished cognitive autonomy. Though cognitive autonomy support was the most prevalent of all coded instances, instances of low cognitive autonomy were found. When teachers maintained structure, this may have served to diminish opportunities for students' cognitive autonomy. One such instance involved Claire's description of how she would maintain responsibility for synthesizing student models into a more manageable number of initial models. Claire described how she would enact an initial discussion by first brainstorming and then follow up the next day with an organized set of ideas that she collapsed into representative models:

> T: I have students work on initial models, whether individually or in groups, I'll collect them at the end of the period, but then I come back the next day with like three representative models of what they had. It allows me to synthesize their ideas and kind of pull out commonalities then come back with a reorganized model. (Claire, I2, Lines 691-700)

In this described practice, Claire seemed confident that this added structure allowed the students to really focus on the task of investigating the peppered moth and not be overwhelmed by too many different models or hypotheses. However, when the teacher synthesizes multiple student ideas, this may be perceived by students as not acknowledging every student's contribution. In addition, it is the teacher who is ultimately responsible for developing the consensus, which removes ownership from the students. While this practice is intended to synthesize ideas into a smaller set of initial ideas for students to work with, it may inhibit cognitive autonomy if the teacher is viewed as responsible for the answers where specific student ideas may have been omitted.

Key points. Taken together, there are two main points about cognitive autonomy practices and modifications. First, teachers' motivational practices that access student thinking and understanding though student discussion, group activity, and debate may facilitate cognitive autonomy because they evoke students' thinking and contributions. Second, scaffolds, group activity, and debates may convey to students that tasks are a shared responsibility and that the teacher was not the final decision maker in how evidence was read, interpreted, and used in the class-based explanation. Though infrequent, teachers may try to synthesize student ideas too much. While this may serve to organize students' thinking, the inclusion of too much direction may revoke some cognitive autonomy allocated to the students within the curriculum activity. This is why the instance of low cognitive autonomy could have the potential to undermine student autonomy because students may feel as if the work and ideas are not their own.

Relatedness and competence-supportive practices. Teachers discussed two main points concerning competence support in the IQWST curriculum. First, the teachers discussed strategies that broke the task into smaller components by inserting opportunity to take notes and to analyze the graphs. Teachers felt that this would sustain their motivation because it would increase their level of confidence with these challenging larger sets of evidence. Second, teachers discussed the level of challenge in these data sets. They saw them as doable by students with minor modifications.

The IQWST curriculum afforded relatedness through opportunities for students to work together to study the peppered moth by formulating hypotheses, discussing evidence, sharing ideas, and constructing class consensus. Students may find the IQWST curriculum motivating since the intended enactment incorporates strategies such as an interesting introductory activity and the jigsaw groups.

Curriculum noticing and enactment practices. Teachers noticed curriculum tasks that provided competence support. Claire and Diane both discussed how they would help students feel more competent with the IQWST materials by breaking down the tasks during the jigsaw. They both described the enactment of the jigsaw activity in parts; first reading their assigned evidence, then writing down their interpretations of the data before moving on to the next group. They both expressed wanting their students to feel confident as they become the experts. Claire suggested note-taking before moving on in jigsaw activity, "I think it's motivating for students in general to have something to fill out, but I think that also provides a level of confidence so that when go to their next group they'll- they can be the experts" (Claire, I2, Lines 804-806). Diane suggested a similar approach, "I may even sit down with them before they went over and have them write down what each one of them plans on saying, so that they feel confident and we both know they're saying the right thing" (Diane, 832-834). The goal here for both Claire and Diane was to have their students feel confident with the evidences.

Claire discussed how she would help groups who are misunderstanding the evidence. When student do not feel competent, she explained:

> T: I would have two different strategies. So if they know that they don't understand it, I would kind of lead them through, starting over modeling

> the thinking skills. And I'd say, "Okay, what do you notice about the x-axis? What do you notice on the y-axis? What number is going up? What number is going down? What does that mean? What could be happening?" Things like that. If the students don't understand it, but they think they understand it. I just end up kind of probing their thinking a little bit, so I'm like, "Okay, well you right here you said this is happening. Why do you think that's happening? Show me on the graph where you see that." And usually they end up realizing, "Oh, it's not what we thought." So there's different strategies based on the level of misunderstanding and their level of confidence about it. (Claire, I2, Lines 784-794)

This prompting by Claire may allow students to feel competent with the material as she breaks the task down into parts. The potential of misunderstanding the evidence and the level of challenge with the IQWST data sets was acknowledged by the teachers. They often talked about the challenging scientific terms and graphs. Here, Claire commented:

> T: something that I thought could enhance student motivation is the fact that it [the IQWST lesson] was really - I felt like students could follow it. I think something that sometimes decreases motivation, particularly with some inquiry activities, is that for some students it gets too hard. They look at a graph or table, they don't get it right away, then they quit. So I think that this [IQWST lesson] was the right amount of challenging and motivating, but not so challenging that most students would quit. (Claire, I2, Lines 504-509).

Here, Claire is acknowledging the importance of optimal challenge in curriculum materials.

Teachers noticed curriculum tasks that supported relatedness in places where the IQWST lessons provided opportunity for students to be paired with their peers. Each teacher recognized that group work would be critical for providing students with support as they would complete this challenging curriculum.

Claire explained that having students work together during the IQWST lessons would be motivating since "they're not on their own" (Claire, I2, Lines 161-162; 807-808). Claire added that, "students like to work in groups and things like the jigsaw model, so it allows students to work together" (Claire, I2, Lines 459-460). Here, Claire is emphasizing the importance of allowing students the freedom to work together since students may that they have help taking on the cognitive work required during inquiry.

Modification. Despite noticing several tasks that supported competence, teachers also suggested modifications that enhanced competence support in other tasks throughout the lesson. Both Claire and Darcy suggested one minor modification, which they both believed would help students' confidence level with the processing of scientific terminology without losing the meaning of the scientific data. They explained in the excerpts below:

> T: Some of the evidence was more challenging than others. I noted one in particular."... "Figure 3 on page 109 - the lichen coverage on trees and the proportion of *carbonaria*. I thought that was a little difficult to understand. The proportion of *carbonaria* wasn't clear to me. I knew what they were getting at because I understand the content already, to students who didn't

> I thought that would be confusing. I also thought that the use of the term *typica* and *carbonaria* was confusing. I felt like they could have just said dark and light, and it would have achieved the same thing. I just think it's extra processing for the students. It's kind of unnecessary." ... "Yeah, so I sometimes the scientific terms end up bogging down the content and the students spend so much time processing that information, they don't get to the heart of the information, so that's something I would simplify. I find when I'm looking for evidence I end up finding like more complicated tables and I end up like summarizing and simplifying from that. (Claire, I2, Lines 468- 493)

Darcy would explicitly say to her students "it [the data] is a little tricky. So don't feel bad about it if you miss it at first and then you correct it later" (Darcy, I2, Lines 497-502). She further explains that she would "do is like the *carbonaria* and the *typica*, I would probably put the light or the dark for some of my kids because I think they may have- they may start forgetting which ones were the dark type and which ones were the light type." (Darcy, I2, Lines 497-502). Both Claire and Darcy felt that simplifying the evidences by removing the scientific names of each moth would serve the goal of student mastery and understanding enhancing students' feeling of competence with the evidences.

Teachers modified some curriculum tasks that enhanced relatedness. While discussing the introductory candy activity, Ben was thinking of other ways to enact the introductory candy activity. Ben explained:

> T: You could have them do it in groups. You could have kids come up and explain their experience. It depends on the student population and depends

> on how- their dynamic too- how much like to question and get into it, but it's really about making sure that they've all got a spirit to try and that they can engage in the discussion. (Ben, I2, Lines 673-677).

Here, as Claire did, Ben also highlighted the desire of students to work together and engage in the activity with their peers.

Key points. The teachers saw competence as critical to students being able to handle the challenging IQWST materials. Students would need to feel supported while trying to decipher the complex scientific terminology and scientific graphs while constructing an understanding about what this evidence means to the overall curriculum question. Relatedness practices involved students working together throughout the IQWST unit. The inquiry teachers viewed these practices as important because their students could have their peers as support while engaging in the inquiry activities. This may serve to foster a sense of belongingness through shared experience.

Summary of teachers' IQWST analysis of autonomy-supportive practice. In summary, during Interview Two, the four inquiry teachers examined the curriculum features of the IQWST unit in detail. In this second round of investigating the teachers' motivational practices, the teachers provided rich narratives of their hypothetical enactment of the IQWST lessons, often highlighting similar autonomy-supportive enactment practices as in Interview One. Clearly, the four inquiry teachers were thinking about the IQWST curriculum in ways that went beyond the intended, written lessons. In addition to the high number of autonomy-supportive motivational practices, all four inquiry teachers also proposed several curricular modifications that would have augmented their own autonomy-supportive practices. This was particularly important as teachers responded by either facilitating or inhibiting autonomy-relevant curriculum features. Frequently, these coded instances were cognitive autonomy supportive practices (56%), which is significant given the benefits of cognitive autonomy support. However, it is notable that high quality practices were seen across all coding dimensions, not just in the cognitive autonomy category.

Teachers' Observed Practices

During the classroom observation, inquiry teachers enacted an inquiry lesson specific to their own classroom curriculum (Claire's electricity lesson, Ben's circuit lesson, Diane's evolution lesson, Darcy's pig dissection lab). In this third evaluation investigating the teachers' motivational practices, it was important to verify that how teachers discussed and described their motivational practices matched with their *actual* enactment practices. In general, observations and accompanying interviews indicated that their described motivational practices presented during Interviews One and Two were also evidenced within their enacted practices. This section will summarize the salient instances of autonomy-supportive practices identified during the classroom observation.

Procedural autonomy. Ben was the only teacher to discuss the importance of providing a brief procedural autonomy opportunity. After his circuit lesson, Ben reflected on wanting to pull out the physical circuit again as the students were discussing the models from the previous day. Ben felt that having student "actually touch things" (Ben, PostObs, Line 335) would be motivating and facilitate the model revisions better.

Key point. This motivational practice may support student autonomy because students are involved in handling lab materials.

Relevance. Ben, Diane, and Darcy provided brief opportunities for student relevance during their lessons by evoking curiosity around authentic problems and connecting to professional scientific practices. For some students, these practices have the potential to connect to their values and goals thus increasing student autonomy.

Evoking curiosity. Ben noted that one motivational challenge in his lesson on circuits was getting students invested in the evidence (Ben, PostObs, Line 276). He felt that he was always looking to make his lessons more interesting by connecting to students' lives or experiences. Similarly, Diane used student interest as a motivator during her lesson on evolution incorporating living and extinct forms of sharks and whales (Diane, field notes, 6/4/15). Diane felt that it was motivating to students to incorporate "organisms that [she] thought that they would definitely be interested in" (Diane, PostObs, Lines 33-34). She pointed out how interested the students were in sharks saying, "they all thought the sharks were really cool because they couldn't believe how big the Megalodon shark's teeth were" (Diane, PreObs, Lines 151-152).

Here, individual interest could be facilitated by situational interest (i.e. excitement about sharks) so some students who are very interested in sharks outside of school may view this as a supportive form of autonomy. However, relevance may be less salient for students if the connection between examples (i.e. sharks) and key content (i.e. using evidence to support the theory of evolution) are not clear, which may limit autonomy benefits. Moreover, autonomy support may not be supported if the students do not make the connection to their own interests and values.

Connecting to the work of scientists. Both Ben and Darcy discussed practices they felt genuinely mimicked professional scientific practice. For instance, Ben wanted his classroom to "feel like a scientific community where we talk about things" (Ben, PostObs, Lines 197-198) and Darcy felt that a pig dissection lab was motivating because it was a novel experience for students, one which they may never have again (Darcy, field notes, 6/8/15). Darcy further explained that since none of her students had dissected a pig before the lab would be motivating for them. She explained, "They've been talking about it all year. They are very excited about this." (Darcy, PostObs, Lines 148-149). Here, relevance may be autonomy-supportive if students felt that doing the work of scientists helped them connect the professional scientific practices to the key lesson points.

Key points. By evoking curiosity and connecting to professional scientific practices, these motivational practices support student autonomy by connecting to students' interests, values, and goals.

Feedback. Ben, Diane, Claire provided positive feedback and encouragement when students showed effort and persistence. For example, Ben used non-verbal cues as he circulated around the classroom (Ben, field notes, 6/10/15) such as head nodding to prompt students to continue working on the lesson. Ben discussed the motivational reasoning behind these non-verbal cues was his technique to say, "You don't have the right answer yet, but you're really close and I'm not going to tell you what is. That's not my job. My job isn't to tell you this is the right answer." (Ben, PostObs, Lines 147-149).

Diane used non-verbal cues during interactions with the groups (Diane, field notes, 6/4/15) such as smiles and claps often accompanied by praise. Diane praised students with statements such as "that's what I want to hear, you're being specific" to acknowledge that the students were incorporating all of the pieces of evidence. Diane felt that positive feedback statements such as "that was a really good idea," or "tell everybody else, share with them" (Diane, PostObs, Lines 94; 108-109) helped students stay motivated and engaged in the lesson.

Claire used praise in her classroom such as "I'm impressed. This is good." and "Good. I like the way you're thinking. That's a really interesting way of thinking." (Claire, field notes, 6/10/15). Claire felt that she used "meaningful praise" (Claire, PostObs, Lines 45-46) to motivate students to stay engaged in the lesson. For Claire, "meaningful praise" meant acknowledging students who were using evidence in their models or making connections to prior lessons.

Key points. By recognizing and praising student mastery, these practices support student autonomy, which goes beyond merely "good job", or "that's great" toward conveying high expectations for challenging inquiry work.

Responsiveness. Ben believed that it was critical to spend time listening to students throughout the lesson (Ben, field notes, 6/10/15). He described his role as, "what I'm going to be doing is listening. I'm going to be listening to their questions, listening to their perspective" (Ben, PreObs, Lines 117-118). This was confirmed during the classroom observation where he was responsive to student ideas (Ben, field notes, 6/10/15) and reintegrated those ideas back into the classroom discussion.

Key point. Being responsive to student ideas may support student autonomy because it demonstrates that the students were heard and are a valuable part of initiating the key points. Importantly, when Ben reintegrated student ideas back into the discussion, students were the initiators of ideas and may view themselves as having contributed to the lesson discussion.

Cognitive autonomy. Diane, Claire, Ben, and Darcy all evidenced the provision of cognitive autonomy during their lessons by eliciting student ideas and maintaining open tasks. Maintaining structure of the lesson leading students to a correct answer from the teacher were potentially inhibitive practices.

Eliciting student ideas. Diane used prompting to draw out student answers and encouraged students to elaborate such as “Can I ask you a question? What evidence do you have?" and "Think about this. You just said this. Is that really what you meant?" (Diane, field notes, 6/4/15). Diane felt that students needed to be the initiators of ideas and thought that "ownership [of ideas] is really important, and that’s why I don’t give the answer right away" (Diane, PostObs, Lines 189-190). Claire encouraged the initiation of student ideas saying, "I would love to hear from someone I haven't heard from yet today" and "S, you had a cool idea. I want you to share your idea" (Claire, field notes, 6/10/15).

Ben spent time prompting students with questions such as "What do you think?," and "what would you add or change in this model?" (Ben, field notes, 6/10/15) to ensure students were incorporating all the evidences into their models. Ben discussed his motivational reason for using student models as initiators of discussion. Ben believed that when students were "seeing it’s not something that I, the teacher, kind of put together for them and prescribed ... It’s something that one of them, maybe even themselves, generated the day before" (Ben, PostObs, Lines 53-57), the students could feel ownership over the lesson content. Here, both Darcy and Ben create opportunities where the focus of the lesson is students' shared ideas.

Maintaining open tasks. Ben felt that allowing students "to figure it out on their own or without any step by step or cookie cutter directions" (Ben, PreObs, Lines 96-97) was motivating. Here, Ben was referring to the previous day's lesson where student were given pieces of a circuit and told to make the light bulb light up. Ben believed the open-ended nature of the task was motivating because students see the work of figuring it out as their own, not just prescribed by a teacher. Students then created models to describe what was happening to make the circuit work. This may support student autonomy because the circuit lesson encouraged the creation of explanatory student models and allowed students to be independent problem solvers.

Maintaining structure. Coupled with high quality cognitive autonomy, similar challenges as evidenced in Interview One and Interview Two with maintaining structure, with the potential to diminish cognitive autonomy, was observed in Claire's classroom. Below Claire discussed an interesting tension with her circuit lesson saying:

> T: They were very motivated by the circuits. Things like that are always tricky because they sometimes get so into playing with the circuits that they forget about the important part. So what I did half way through the period yesterday was like, “You got the light bulb to light. Great job. Give me the circuit. Now the important part is why did the light bulb light.” (Claire, PreObs, Lines 131-135)

Here, Claire struggled with the motivational value of students figuring out the circuit by themselves versus the students knowing the correct mechanism that made the circuit work. Further, during the lesson enactment, Claire presented three models to the class saying. "I will tell you, one of these is right. So, that's what we are honing in on today." (Claire, field notes, 6/10/15) Clearly, there was a tension with wanting to tell the correct answer in this lesson. This may inhibit cognitive autonomy because the teacher retains ownership of the correct answer.

Key points. The four inquiry teachers (Claire, Ben, Diane, Darcy) afforded cognitive autonomy with motivational practices that allowed students to feel ownership over their ideas. However, some teachers (Claire) struggled with maintaining structure; a practice that may inhibitive student autonomy.

Relatedness and competence-supportive practices. When Ben and Darcy supplied competence support in their classrooms, they would tell students that they believed in their abilities to tackle challenging inquiry tasks. The teachers (Ben, Darcy) felt that this would sustain their motivation because it would increase their level of confidence with inquiry tasks.

Three teachers (Darcy, Ben, Diane) afforded relatedness through opportunities for students to feel their teachers cared about them and built trusting relationships. Students may find these practices motivating since it fosters a sense of belongingness in a comfortable classroom setting.

Competence. Ben and Darcy believed in supporting students' mastery during their challenging lessons. For instance, Ben expressed his expectations and supported students' confidence saying, “Hey, you should have confidence in your ability. You can do this. You’ve done it before. I believe in you, and I’m here to help you. We’re doing this together.” (Ben, PostObs, Lines 125-126). Ben felt this encouraged his students to engage in challenging inquiry tasks. Similarly, Darcy circulated around the classroom saying "perfect!," "there you go!," and "keep going!" while performing pig dissections when students were mastering the functions and structure of the pig anatomy. Darcy explained her motivational reasoning for this practice was to praise their specific actions since many students were shy about touching the pig. Darcy felt that reinforcing that they were doing a great job seemed to motivate the students to engage in inquiry tasks (Darcy, PostObs, Lines 86-87).

Relatedness. Darcy, Ben, and Diane fostered a sense of shared experience and belongingness during their classroom lessons. For Darcy, she saw the motivational benefits of having a good relationship with her students explaining that even her "failing" student was motivated in her classroom because he trusted and liked her as a teacher. In another example, Darcy took time to get to know her students and formed relationships with them, which was observed when she assigned group roles for the pig dissection. (Darcy, field notes, 6/8/15) Darcy explained to the students that roles were chosen based on their own preference and she explained she purposefully assigned one student (who clearly did not want to handle the pig) the role of recording information. The student responded to Darcy's assignment positively and was motivated to engage in the pig dissection even though she was very uncomfortable with the preserved pig on her lab table (Darcy, field notes, 6/8/15). Here, the caring that Darcy felt toward her students motivated her students to participate in the inquiry activities.

Ben inserted humor into the classroom at a point where students seemed to be "stuck" and having difficulty moving the discussion forward using himself as a "negative charge" moving around the room (Ben, field notes, 6/10/15). Here, Ben demonstrated the movement of electrons along the wires of a circuit and reenergized the discussion. Ben described his good rapport with his students, noting that this was key to getting students motivated to persist with difficult inquiry tasks. Ben believed that his own personality played a role in creating a "comfortable" classroom. (Ben, PostObs, Lines 197-198).

Diane spent time during class circulating around the classroom making explicit calls for all members in each group to participate in the small group discussions. She stressed the importance of each member contributing their ideas (Diane, PostObs, Lines 189-190). By knowing your students (Darcy), having a good rapport (Ben), and encouraging student participation in activities, particularly equal participation from all students (Diane) are likely to foster a sense of class belonging and relatedness.

Key points. The teachers (Darcy, Ben) saw competence as critical to students feeling supported and motivated to engage in inquiry tasks. It may be that verbal messages that support student confidence are particularly important during inquiry and motivate students to persist with the challenging tasks. Relatedness practices created classrooms in which teachers had good rapport with their students and had earned students' trust. These practices may serve to foster a sense of belongingness.

Summary of teachers' observed practices. During the Classroom Observation, the four inquiry teachers enacted an inquiry lesson aligned with their own curriculum (Claire's electricity lesson, Ben's circuit lesson, Diane's evolution lesson, Darcy's pig dissection lab). To summarize, during this third round of investigating the four inquiry teachers' motivational practices, the observations and accompanying interviews demonstrated several autonomy-supportive practices. Student autonomy was supported through the allowance of handling materials (i.e. procedural autonomy), by evoking curiosity (i.e. relevance), and connecting to scientific practices (i.e. relevance). Other practices were the provision of positive feedback and active listening by the teacher.

There was some evidence of competence supportive practices supporting student mastery and relatedness practices that demonstrated teacher caring. Cognitive autonomy supportive practices included eliciting student ideas, and maintaining open tasks. Inhibitive cognitive autonomy practices maintained structure by the teacher retaining ownership of the correct answer.

Summary of Results: Teachers' Motivational Practices

In summary, the previous sections have detailed autonomy-relevant exemplars of teachers' motivational practices across three different assessments (their own motivational practices, an analysis of a common IQWST unit, and during a classroom observation) and the reasons for those practices. The four inquiry teachers provided an extraordinarily rich portrait of autonomy-relevant practices. Since these four inquiry teachers had extensive experience in inquiry-based classrooms with inquiry-based curricula, they not only enacted autonomy-supportive practices in their classrooms, but they also noticed autonomy-relevant features as they read and analyzed the IQWST curriculum. Further, the four inquiry teachers discussed possible modifications to their practices that would enhance autonomy-supportive opportunities for their students.

A summary of their motivational practices across all three assessments in shown in Table 4. Notably, responsiveness, feedback, cognitive autonomy, and competence were the most common coded instances of autonomy supportive practices indicating a variety of high quality autonomy-supportive practices.

Table 4

Summary of Autonomy-Relevant Motivational Practices

	Interview One	Interview Two	Classroom Observation
Procedural Autonomy			
Handle materials	x	-	x
Design their own experiment	x	-	-
Choice of how to read, interpret and integrate evidence	-	x	-
(Low) limiting decisions	-	x	-
Organizational Autonomy			
Within group decision-making	-	x	-
Rationale			
Lesson purpose and coherence	-	x	-
Relevance			
Evoking curiosity	x	-	x
Using authentic data	-	x	-
Using meaningful real world examples	x	-	-
Unit contextualization	-	x	-
Connecting to the work of scientists/ scientific community	-	x	x
(Low) Limiting relevance	-	x	-
Responsiveness			
Active listening	x	x	x
Encouraging peer responsiveness	x	x	x
Feedback			
Whole class and group feedback	x	x	x
Cognitive Autonomy			
Eliciting student ideas	x	x	x
Maintaining open tasks	x	-	x
Debating student ideas	-	x	-
(Low) Maintaining structure	x	x	x
(Low) Telling students answers	x	-	-
Competence			
Supporting student's mastery with optimal challenge	x	x	x
Relatedness			
Fostering a sense of shared experience and belongingness	-	x	x

Overall, as evidenced by the three assessments of teachers' motivational practices there were multiple examples of autonomy supportive practices. When teachers augmented motivational practices to support students' autonomy support, competence and relatedness, they engaged in active listening (i.e. responsiveness), encouraged peer responsiveness, provided informational feedback (whole class and group), elicited student ideas (i.e. cognitive autonomy), maintained open tasks (i.e. cognitive autonomy) , and supported students' mastery with optimal challenge (i.e. competence). When teachers participated in inhibitive motivational practices related to support students' autonomy support, competence and relatedness, they were grappling with maintaining structure.

Reasons for Teachers' Enactment Decisions: Supports, Resolved Pressures, and Pressures

As a final goal, this study examined the influences responsible for teachers' motivational practices and enactment decisions during inquiry. These codes were grounded in established theoretical frameworks and prior research (see Appendix I). During the examination of how teachers' motivational practices were influenced by their perceptions of factors from above, within, and below, it became clear that there existed a new differentiation in our teacher sample between pressures resulting in control/diminished autonomy (i.e., pressures) versus pressures resulting in supports/autonomy relevant practice (i.e., positive factors or resolving pressures). Moreover, teachers also reported antecedents that were supportive of their autonomy-supportive practices (i.e., supports). Therefore, the codes were revised to reflect these new extensions to prior frameworks, to better showcase the resolution of pressures and teacher supports that influenced teacher practices represented in these data (see Appendix I). These results are particularly significant given the large number of autonomy-supportive motivational practices described by all four inquiry teachers.

The findings show that, within this dissertation study's inquiry-based curriculum context, the factors that influenced teachers were overwhelmingly positive which influenced teachers practice toward becoming more autonomy-supportive. In a subset of these instances, teachers were *resolving pressures* with enhanced autonomy-supportive enactment practices and modifications. In a second subset, teachers perceived *supports* from their profession (i.e., their administration) that encouraged more autonomy-supportive teaching. However, there were also some pressures influencing the teachers' motivational practices that resulted in practices that inhibited student autonomy. Table 5 summarizes the frequency of reasons given for their curriculum noticing, enactment practices, and modifications. Given that the resolved pressures promoted autonomy, we group these antecedents together with the perceived supports for autonomy-supportive practice.

Table 5

Frequency of Reasons by Teacher

Factors	Teachers	Resolved Pressures & Supports	Totals	Pressures	Totals
BELOW	Claire	28	120	5	9
	Ben	28		0	
	Diane	23		2	
	Darcy	41		2	
WITHIN	Claire	19	46	2	5
	Ben	10		1	
	Diane	4		1	
	Darcy	13		1	
ABOVE	Claire	4	11	1	9
	Ben	3		1	
	Diane	4		2	
	Darcy	0		5	

Overwhelmingly, the factors influencing these four inquiry teachers' motivational practices were supportive, positive influences allowing for the augmenting of autonomy support, competence, and relatedness evidenced in the three assessments (Interview One, Interview Two, Classroom Observation). The following exemplars detail the salient instances of supports, resolved pressures, and pressures that influenced these four inquiry teachers' motivational practices.

Factors from below. Teachers discussed factors from below as important reasons for enactment decisions in 129 out of 200 (65%) coded instances. One hundred twenty instances were coded as *positive factors* from below, with only nine reported *pressures* from below. Here, positive factors were instances in which teachers resolved pressures with enhanced student autonomy. Teachers viewed students' ability level [resolved pressure and pressure], students' response to challenge [resolved pressure and pressure], students' misconceptions [positive factor], students' interest [positive factor], and students' effort [pressure] as the most significant factors.

Students' ability level as resolved pressure and pressure. The teachers were influenced by their students' perceived ability and spent time thinking about to optimize learning for their particular student populations. Some teachers felt student ability was a positive factor (Claire, Ben, and Darcy) while other teachers saw students' ability was pressure (Diane and Darcy) in their enactment decision-making.

Claire was particularly concerned with the mix of high achievers and her special education students in the classroom. She explained:

> T: At both ends of the spectrum, students in the special ed population and my very high achievers have a very hard time with initial models from

> scratch. So if I said to them "How did the oceans form? Go." Without going over anything, they'd get nervous, they sometimes can't think of something (Claire, I1, Lines 153-157).

Interestingly, she believed that inquiry was a great response to this factor from below. She resolved this pressure from below by describing how she would adapt her inquiry toward more scaffolded tasks that break the unit up. Here she explained, "I think the thing about inquiry- like okay, maybe with my one special education class I can't do a full-blown inquiry unit. I don't think it's going to work, but I'm going to do three inquiry activities over the course of the unit instead (Claire, I1, Lines 371-373). Moreover, Claire believed that "in general, special education students are more motivated when they do inquiry than with traditional means" (Claire, I1, Lines 340-344). Claire went on to explain that her special education students did struggle to collect data and had some behavior issues, but continued to be a strong advocate toward inquiry for her students.

Similarly, when Ben was asked how he would initiate the jigsaw activity in the IQWST curriculum, he explained:

> T: I would probably look at my student population. I would probably assign them into their new- from their expert groups into their new jigsaw groups to make sure personalities fit, to make sure that the different learning styles and the different levels probably- I'd want to differentiate and make sure that it's going to be a solid group where they're going to be able to talk and get along and share and listen to each other. (Ben, I2, Lines 1053-1058)

Here, Ben resolved this pressure from below by differentiating student groups to foster the best discussions.

Diane required students to have check-in points throughout a lesson for her mix of very high achievers and lower ability students. She expressed caution about how to set-up a jigsaw activity, "I've found that a lot times you have to be really, really careful about making these groups then. Because then what if like a lower student had one of the studies and didn't understand it, they could totally be explaining it wrong." (Diane, I2, Lines 460-462). She spent time scaffolding lessons, monitoring group work, and holding peers accountable within groups.

Interestingly, Diane was the only teacher to mention not only her perception of students' ability, but also other students' perceptions about their classmates:

> T: Whether we like it or not, no matter how hard we try to avoid it, a lot of the times the students sometimes know who are the smarter kids in the class and who's not. So when it's not the smarter kids in the class, they might be nervous that they're getting the wrong information from that person. (Diane, I2, Lines 564-568)

Diane further explained that she felt pressure to group certain students together since her student population had a mixture of high honors students and special education students. She struggled with the challenge of ensuring all of her students had good, in-depth discussions.

Clearly, student ability level was a pressure for the teachers. Even though the teachers (Claire, Ben, Diane) resolved this pressure by responding to their students' ability with autonomy-supportive practices, they struggled with maintaining the participation of their lower ability students. They grappled with how to keep their lower ability students engaged and involved with challenging inquiry.

Students' response to challenge as positive factor and pressure. Frustration was a common student response to inquiry activities. Ben, Claire, and Diane felt that students often got frustrated when they encountered challenging features within the inquiry curriculum.

Ben considered frustration a sign that students were really thinking, "you can tell that their brains are churning and they're going over it in their heads and it's frustrating [for students] because it's a lot of components that have to work together (Ben, I1, Lines 217-221). Thus, frustration was a positive factor for Ben. Ben thought this level of frustration was "an indication that they're really thinking and that they've hit the point where they realize things aren't fitting, they are not making sense, or they need more evidence in order to answer the question" (Ben, I1, Lines 202-205). This suggested that students were engaged and invested in answering the driving question.

Though Claire thought that the IQWST curriculum was the right level of challenge, she acknowledged that this was not always the case, explaining, "I think something that sometimes decreases motivation, particularly with some inquiry activities, is that for some students it gets too hard. They look at a graph or table, they don't get it right away, then they quit." (Claire, I2, Lines 505-508). Claire resolved the pressure of challenge by anticipating her students' response to certain graphs. Claire responded with more autonomy-supportive practices that could help ease that frustration. Specifically, she discussed eliminating unnecessary scientific terminology like the Latin names for the peppered moths.

Interestingly, Diane described student challenge as both a positive factor and a pressure. She responded positively to student challenge by coaching and encouraging them, however she felt pressured to reassure students with the right answer. In the following example, Diane described how she dealt with student frustration telling her students, “Just take a chance. I don’t expect you to know the answer. You’re just learning it. You haven’t gotten any evidence. You haven’t figured it out yet. Take a chance. If you’re wrong, you’re wrong because you didn’t learn it yet” (Diane, I1, Lines 165-170). Here, Diane left the task open to student ideas and to multiple interpretations of evidence. However, she later talked about giving in to the pressure of her students wanting to know the answer. She explained:

> T: And even in the end they’re still like, “So we’re right. Right?” You just told me that all the evidence points to that, but they still need you sometimes to say, “Yes, you got it.” I think some of it is for personal satisfaction, and some of it is because they still feel like even though we’re trying to change their attitude, they keep questioning, “Why does it work this way?” or, “How do I know it works this way?” They still like it when a teacher says, “Yes, it works this way.” (Diane, I1, Lines 280-283)

Here, Diane responded to the pressure by telling students the correct answer, a potentially autonomy-inhibitive practice.

Students' misconceptions as positive factor. Teachers recognized scientific misconceptions as an important influence when describing their enactment decisions. Ben considered misconceptions a huge influence on his enactment decision-making. He explained, "Students have misconceptions, it’s huge. It’s something that- like you can’t ignore that. Whether you want to ignore it or not, you have no choice. Students are coming into your classroom with ideas and you have to honor them and discuss them.

(Ben, I1, Lines 111-114). Ben felt that students would invest more in the unit if he acknowledged all student ideas.

Claire (I2, Lines 544-545) and Diane discussed misconceptions when asked about the introductory candy activity and acknowledged that students have a common misconception about Lamarckian inheritance. Diane explained more about the Lamarckian inheritance misconception:

> T: You could get rid of that misconception so easily here by asking them, "If you came into class every day and the person sitting next to you stretched out your arm, would you eventually be able to reach the candy? And even if you could, could you pass it on to your children?" I definitely like this one a lot, because it's definitely something good to reference later on. (Diane, I2, Lines 597-601)

Viewed as a positive factor, the teachers respond by enacting more autonomy-supportive practices using student misconceptions as a starting point of discussion. Ben, Claire, and Diane all felt that inquiry lessons could set up opportunities to challenge student misconceptions and really change them.

Students' interest as positive factor. Ben mentioned interest as an important way to motivate students, especially in the beginning of a lesson. He felt that a real-life scenario would be a great way to motivate their students. First, Ben talked about a lesson he does with speed and described the student's level of interest and excitement, "you could just feel them coming to class every day wanting to get into it. Like alright, let's do it. Like let's get into it. Like what're we going to get done today? How're we going to move forward? That’s always exciting" (Ben, I1, Lines 358-361). Second, Ben described a lesson about cancer that gained a high level of student interest. He explained:

> T: In order for them to understand what is happening with cancer, it requires them to fully understand the mechanism from mitosis, and if that mechanism goes wrong, what can happen to cells, how it can affect the human body. And what we do, is we create a situation where we have them start to think about this molecular bio-this process on the cellular level (Ben, I1, Lines 84-91).

In both of these examples, Ben student interest as a positive factor for enactment decisions caused Ben to enact more autonomy-supportive (i.e. relevance) practices.

Students' effort as pressure. Mentioned by only one teacher, student effort was a significant influence on Darcy's enactment practices. Darcy previously worked at a different school teaching an honors-level biology class. She struggled with her current student population's effort when she implemented inquiry tasks. She felt their effort was "significantly lower than what I had with the honors class." (Darcy, I1, Line 316). She frequently had students give up when the tasks got too hard and simply put their heads down on the desk. Even when students did participate, she explained, "I’ll frequently get a student to write two things and then they don’t want to do anymore." (Darcy, I2, Lines 633-634).

When asked if making a hypothesis would be motivating to her students, Darcy felt that students would be bored with the "making a hypothesis" task:

> T: they’re so used to making hypotheses and knowing that they’re going to get some kind of data that they’re almost kind of bored with the idea of

> making their own hypothesis. They're just like, "Oh, we gotta do it again. Are we doing it in the normal format? Should it be in the form of "if/then"? Or is it what we think is going to happen? What format do you want in it this time?" They make a lot of hypotheses, so I think they're very used to that idea. (Darcy, I2, Lines 695-701)

Viewing student effort as a pressure, Darcy believed that her students could do inquiry, but got nervous at the thought of enacting inquiry activities in the classroom. When asked if she would use the jigsaw method, she expressed concern, "I get nervous about jigsaws because I have seen kids go into their first jigsaw groups and then go to their next one and be like, 'I don't know we did. I don't know what we did in the first one. I don't remember anything'" (Darcy, I2, Lines 722-725). She felt that the anticipated lack of effort wouldn't deter her from a jigsaw activity, but as the groups get ready to examine the first set of evidences in the IQWST lesson, she might say, "people are going to be relying on you for knowing it, so do a good job and be engaged with it. Don't be passive. Be engaged in that first group so you really understand it" (Darcy, I2, Lines 728-730).

In sum, the perceived lack of effort Darcy felt in her classroom heavily influenced her enactment practices. She often chose autonomy-inhibitive practices in response to this pressure.

Key points. Positive factors from below that influenced teachers to enact more autonomy-supportive practices were the mixed abilities of their students, student frustration, student misconceptions, and student interest. Teachers resolved these potential pressures from below with enhanced student autonomy. Pressures from below that influenced teachers to enact more autonomy-inhibitive practices were a mix of high achievers and special education students, student frustration for teachers to confirm correct answers, and students' lack of effort.

Factors from within. Teachers discussed factors from within as important reasons for enactment decisions in 51 out of 200 (25%) coded instances. Forty-six of the instances were coded as *positive factor* from within and five as *pressures* from within. The four inquiry teachers expressed their views on mastery beliefs [positive factor], the allowance of student agency in the classroom [positive factor], inquiry practice [support], and teachers' need for structure [pressure] as influences from within.

Mastery beliefs as positive factor. Teachers' own beliefs about student mastery were positive influences on enactment decisions. Here, teachers viewed student mastery as allowing students to develop a deeper understanding of a topic before moving on to the next concept or idea. Ben, Claire, and Diane's enactment practices deemphasized grades and focused on mastering concepts. For instance, Claire believed that one teacher concern with inquiry is that students want to know the right answer and are upset when you (the teacher) do not tell them the correct answer. However, Claire believed that as soon as students trust you, and you have proven to them that it is okay to fail, it shows students that science is about figuring things out, not solely about the correct answer. Claire further explained:

> T: When you do inquiry lessons, I feel like ... motivation isn't based on their grade...Grades still exist, but it becomes deeper than that, so it really becomes about the learning and not about so much the grade. And so the kids trust you to guide them and they know that you trust them to an

> extent to figure out the answer. And I think that they appreciate that independence. And they know that at the end of the unit, I don't care if they get an A on the test per say, but ... more importantly, I need you to explain why. And I think it ends up... going deeper than it did when I ... was doing more traditional teaching and more traditional assessing. (Claire, I1, Lines 269-279)

Here, her mastery beliefs served as a support from within influencing her to deemphasize grades and made it more about the learning. Claire felt this resulted in the students being more engaged in learning. Similarly, Ben felt that students benefited from a mastery-oriented classroom where " Instead of worrying so much about their grade or their performance, [students] start to think about the topic that we're discussing and that's what they start to learn more" (Ben, I1, Lines 162-167). Ben believed that the students benefitted when they realized that they that do not always have to get the right answer all the time.

Diane also supported students' content mastery by deemphasizing grades and encouraging students to voice their ideas, telling them, "Just take a chance. I don't expect you to know the answer. You're just learning it. You haven't gotten any evidence. You haven't figured it out yet" (Diane, I1, Lines 165-172). Diane believed that it encouraged student engagement by letting them know that the expectation is not completely reliant on grades.

Teachers' allowance for student agency as positive factor. Ben, Claire, and Darcy talked about the allowance of student control in the inquiry classroom. They viewed student control in the classroom as critical to the learning process and this *support* from within influenced their enactment decisions toward more autonomy-supportive practices. They tried to find balance in their classroom between the delivery of science content and "making sure they [the students] have a voice even from the first day" (Ben, I2, Lines 549-550). The teachers believed that if the science classroom was student-directed where they "work together to figure it out" (Darcy, I1, Lines 224-227) then learning would be "more meaningful than [teachers] just getting up in front of the class" (Ben, I2, Lines 1140-1142).

The teachers referred to themselves as the facilitator or the coach allowing students to move through the lesson content with guidance from a teacher that was supportive of their learning. Claire explained that she felt her role as coach was to "simply to pull things out of their brains." (Claire, I2, Line 637). Claire spoke about allowing students to voice their ideas; she believed that "it helps their learning progression. It helps things kind of stick when you address what they're already thinking directly" (Claire, I2, Lines 585-587).

Ben described his role in the classroom as a boat captain and felt that it created a dialogue situation where, as the teacher, student ideas could emerge that "he had never even thought of before" (Ben, I1, Lines 100-101). In the following excerpt, Ben explained his role and the challenges of navigating and directing the classroom lesson,

> T: It's funny the idea of giving up control sounds chaotic almost. It sounds like, almost like you let the kids run the show and they kind of come up with everything. And that's not really the way, your job is to really kind of like captain the boat in the sense that you have all these minds working towards a common goal and your job is to make sure that they get the right type of

> evidence in the right manner, so that they can really engage in those discussions. And I have to be able to identify when they need a little bit more information, when they need a little bit of clarification. Or when they do hit that frustrated roadblock, how do I steer the boat and make sure we get back onto the right track. They're kind of driving the boat, and I'm just steering it, tweaking it a little bit here and there and just providing them with enough support and enough encouragement and just things that keeps them moving, keep them moving, keep them into it. (Ben, I1, Lines 264-283)

Here, Ben really emphasized the allowance of student agency. This role as boat captain reflected his belief that students needed to direct the lesson and engage in discussing their own ideas. Thus, this belief influenced Ben's enactment decisions toward lessons that forefronted student ideas as the driving force behind his inquiry lessons.

Inquiry-specific practice as support. Ben and Claire believed that several features of inquiry instruction were positive influences on their enactment decisions. Their beliefs about the effectiveness of inquiry components such as model-making, evidence use, class discussions, and group work influenced teachers to enact lessons that included these features.

For example, Ben would integrate the development of models to access students' initial ideas as explained here, "I would probably ask that they do is model what they're thinking and give them different opportunities to explain what they're really thinking not just in words but also in drawings or figures or diagrams" (Ben, I2, Lines 487-490).

Claire used evidence in her classrooms as a method of investigating questions. Claire described how she would set up the opportunity to look at evidence by framing it as an authentic scientific process, "I ask them, 'Okay, you're scientists you have a bunch of ideas. What do scientists do next?' Just to reiterate the point that when scientists have questions and they have ideas and they know the answers the next step is to look at the evidence" (Claire, I2, Lines 682-684).

Together with model making and evidence use, teachers viewed class discussions and group work as motivating to students. Claire felt that the IQWST curriculum combined all these features well. She commented, "I think that working in groups is motivating and I think authentic questions and evidence motivate kids. And I also think that jigsaw accountability - that the jigsaw requires them to be accountable - is motivating for them" (Claire, I2, Lines 809-810).

For both Ben and Claire, this support from within influenced their enactment decisions toward the inclusion of more inquiry components this augmenting autonomy-supportive practices.

Teacher's need for structure as pressure. Some teachers (Claire, Darcy) struggled with wanting students to explore their own ideas, but also control how content was presented. In the following example, Claire managed her classroom lesson by allowing for open ideas and then takes those generated ideas home with her to reduce the number of ideas in an effort to keep the lesson moving forward the next day. She explained why she does this,

> T: It allows me to synthesize their ideas and kind of pull out commonalities then come back with a reorganized model. Because sometimes when they're

> seeing different models, you can't really, in the course of a unit, investigate all eight of them. And some of them are kind of off, and so there is logistics in planning. (Claire, I2, Lines 693-697)

Moreover, teachers mentioned practices where they had challenges giving up control of the discussion altogether. Darcy thought that some science topics were not suitable for open discussion and had correct information she was compelled to tell her students. For example, she had a difficult time letting go of the idea that students could have wrong ideas about climate change. In the following example, Darcy describes how she felt obligated to present information to students without any freedom to express their own ideas,

> T: Some lessons where I really want them to get a very precise explanation, I find that I want to take control back for that. I will want to say that very precise explanation. Let me think of a good example. I mean, coming up we're talking about climate change, so I want to be in charge of how I present that because then I'm clear. That's what I'm saying. I'm not giving freedom to some incorrect ideas (Darcy, I1, Lines 245-247; 252-253)

In both exemplars, Claire and Darcy grapple with the openness of the inquiry curriculum tasks and this influenced their enactment practices by taking back control.

In regards to their classroom management, teachers discussed how they control the managing of group work. They maintained control by facilitating the movement of students within the classroom "so it doesn't get too crazy" (Claire, I2, Lines 756-757)" and expressed a need to add structure to group activities that "keeps the students focused"

(Claire, I2, Lines 762-763). This pressure influenced their enactment decisions toward autonomy-inhibitive practices.

Key points. Positive factors from within that influenced teachers to enact more autonomy-supportive practices were teachers' own mastery beliefs, the allowance of student agency, and components of inquiry-specific practice. A pressure from within that influenced teachers to enact more autonomy-inhibitive practices was teachers' own need to maintain structure.

Factors from above. Teachers discussed factors from above as important reasons for enactment decisions in 20 out of 200 (10%) coded instances. Eleven instances were coded as *positive factors* from above and nine as *pressures* from above. The four inquiry teachers identified university colleagues and school district [support], national standards and content coverage [pressure and positive factor], and time constraints [pressure] as important influences on their enactment decisions.

University colleagues and school district as support. Diane, Claire, and Ben viewed colleagues from a local university and their school districts as positive influences on their enactment decisions. They felt that they received the support and professional development needed to enact inquiry curriculum successfully. Diane explained that her work with the university developing science units provided the support she needed to successfully implement inquiry curriculum into her own classroom (Diane, I1, Lines 357-364). Similarly, Claire described her university experience:

> T: I was very lucky because I went through the Master's program at the same time that I worked as a teacher with (colleagues' names) and so I not only had the exposure during my Master classes, but I basically had, I don't

> know if you want to call it consultants, tutors, whatever, but I had professionals who were helping me drive lessons and enact lessons and teaching me about it. (Claire, I1, Lines 214-219).

Here, Claire highlighted the importance of feeling supported by her university while developing her curricula and implementing the challenging inquiry lessons. Combined with support he felt from his school district, Ben also believed that his master's in education program molded him into a successful inquiry teacher. He explained:

> T: I feel like I'm in a pretty lucky situation where pretty much my entire seven year career has been completely inquiry...after going through the program that I went through at (University name) that was kind of the only way I was taught how to teach and luckily I work in a district that allows us the freedom to develop a lot of our own units and pretty much everything is an attempt at inquiry-based teaching. We have the freedom in our district where... based on what we hear from the students we can start to get into some questions or real life applications that they have a lot of interest in" (Ben, I1, Lines 38-43; 82-86).

Importantly, Diane, Claire, and Ben considered the combined support of strong university education training in inquiry instruction and a school district that supported inquiry teaching was key to their successful classroom implementation.

National standards and content coverage as positive factor and pressure. Diane was the only teacher to discuss the national science standards and felt they were simply a necessary part of her teaching responsibilities. Diane thought these new standards aligned well with her inquiry curricula and explained that the recent implementation of the Next Generation Science Standards (NGSS) encouraged her to make enactment decisions that were "hitting inquiry-based ideas" (Diane, I1, Lines 389-391). Here, it may be important that teachers feel that the science standards are not a hindrance to the curriculum, but a call for better practices toward inquiry.

Despite the potential supports that science standards may provide, some teachers felt pressure to prepare students for standardized assessments (Claire) and their own professional assessments (Darcy). Claire explained, "you have to remember that even though we're teaching inquiry, there is content that we need to cover and assess, and the students need to prepare for assessments and they need those terms and they need the notes kind of spelled out in clear way" (Claire, I1, Lines 311-314). Here, Claire felt that she needed to include more traditional methods such as note taking and lecturing to ensure students were getting all of the content she was responsible for covering.

Darcy felt pressure about her own professional assessment and explained:

> T: It seems that there's more of an emphasis on <u>what</u> they're learning instead of <u>how to show</u> what they've learned and <u>some of the skills</u> that they've learned. There is a change in that. I see a change in that coming, but as of right now, in terms of how we [as classroom teachers] are evaluated and how our students are evaluated, it's focused more on content, which makes us a bit more focused on content. (Darcy, I2, Lines 440-445)

Here, Darcy felt that the way an evaluator would view her classroom during an inquiry lesson might not be positive and felt that she needed to show her competence as a teacher by having students quiet and listening to her deliver science content to them.

Furthermore, regardless of the potential support of new science standards, when prompted, the teachers could think of certain topics or subjects in the science standards where they struggled to do inquiry. There was a pressure to cover these content areas and the teachers found themselves using more traditional (non-inquiry) practices. For instance, both Diane and Darcy struggled with biology topics such as DNA base pairing (Diane) and the structure of lipids, carbohydrates, proteins, and nucleic acids (Darcy). Here, both teachers felt that these topics were just facts and could not be taught with inquiry methods. They simply lectured on them and had student take notes.

Ben struggled with his chemistry unit:

> T: As much we'd love to teach inquiry 100% of the time to 100% of the kids, there are- it's not a perfect world and we have situations like that- there's some concepts that, such as some of the chemistry concepts, we find it a little more difficult in order to try and get them to work in inquiry units is hard. It's sometimes hard to find like a big overarching need-to-know question for our chemistry unit. (Ben, I1, Lines 368-373).

Here, Ben struggled to find that driving question that could set up inquiry experiences and he tended toward more lectures and note taking during that unit.

Diane felt that the combination of mathematics with science in her Physics unit caused her to choose non-inquiry instruction. She explained:

> T: When we do the physics unit, when do force and motion, we definitely do inquiry except during that time, because it's like a lot of science and math together. There's times when we simply just have to make sure that they got it. Like when you're teaching a force diagram, there's no real

> way- you could let them kind of figure it out, but then if they do it wrong, there isn't really another way to do a force diagram. (Diane, I1, Lines 222-227)

Here, Diane felt stuck teaching the "right way" to do force diagrams and struggled to incorporate inquiry methods into the Physics unit.

Time constraints as pressure. Darcy expressed time as a pressure in her enactment decisions. She struggled with wanting to allow students the freedom to engage in meaningful scientific discussions and the time constraint of a class period,

> T: I think there's a little bit of a concern where we have time-limited inquiry, which is essentially what I have coming up. I worry about the students coming away with the wrong idea, so I'd rather have a clear sense, like a clear- facts that I'm presenting and then just leaving it at that. If I had the longer time, then I would be able to let it play itself out,...sometimes the actual discussion takes longer than the 40 minute class period. (Darcy, I1, Lines 249-252; 265-269)

Here, Darcy, felt that given more time, she could do more inquiry. Instead, the time constraint of one class period often caused her to end discussions early and take back teacher control potentially diminishing student autonomy.

Key points. University partnerships and support from their school districts were key supports for these inquiry teachers. They felt freedom in creating lessons that were challenging and inquiry-based. Even though Diane was the only teacher to discuss the newly adopted science standards positively, this provided evidence that the standards could have the potential to be a support to teachers' enactment decisions. Still, teachers struggled with certain topics and Claire, Ben, Diane, and Darcy all expressed frustration in trying to make these lessons more inquiry-based choosing autonomy-inhibitive practices. A final pressure from above was limited class time.

Summary of Reasons for Teachers' Enactment Decisions: Supports, Resolved Pressures, and Pressures. By studying these experienced inquiry teachers' reasons for motivational practices, we can begin to understand how teachers satisfy students' need for autonomy, competence, and relatedness. Overwhelmingly, the four inquiry teachers cited a variety of positive influences from below, within, and above for their enactment decisions. These supports from below, within, and above influenced teachers to enact motivational practices that augmented student autonomy, whereas pressures influenced teachers to adopt autonomy-inhibitive practices.

Factors from below accounted for most reasons given by the four inquiry teachers. Teachers viewed students' ability level [positive factor and pressure], students' response to challenge [positive factor and pressure], students' misconceptions [positive factor], students' interest [positive factor], and students' effort [pressure] as the most significant factors. The four inquiry teachers expressed their views on mastery beliefs [support], the allowance of student agency in the classroom [positive factor], inquiry practice [support], and teachers' need for structure [pressure] as factors from within. Lastly, the four inquiry teachers identified university colleagues and school district [support], national standards and content coverage [positive factor and support], and time constraints [pressure] as important factors from above.

Chapter 5: Discussion

Declines in students' motivation, interest, and attitudes toward science learning has been well-documented (for a review, see Osborne, Simon, & Collins, 2003). Researchers find that students want more opportunities for extended scientific investigations, relevant real-world content, and classroom discussions (Osborne & Collins, 2000; Osborne et al., 2003). In response, rigorous science education standards have been developed. The most recent of these standards, the newly adopted NGSS, once again call for students to be engaged with science instruction within inquiry contexts (NRC, 2013).

Inquiry-based science instruction affords students the opportunity to participate in the investigation process and scientific discussion, which increase their conceptual understanding (for a review, see Minner et al., 2009). Further, inquiry units expand opportunities to build upon students' real-world experiences through exploration of science ideas (NRC, 2013). Inquiry units shift away from a focus on science procedures and hands-on experimentation toward cognitive processes that deeply engage learners. Students become the initiators of ideas and moves instruction away from simple recall of scientific terminology and comprehension of readings. Inquiry-based instruction is beneficial to student learning (for a review, see Chinn et al., 2013), but we have limited understanding of the motivational benefits of inquiry-based instruction. Curriculum features of inquiry-based units with autonomy-enhancing features (Blumenfeld et al., 2006) have the potential to provide the necessary conditions for high quality motivational enactment.

Motivational researchers need to explore beyond teachers' motivational practices as supplemental to curriculum and evidence the influence *of curriculum* to enactment practices (Blumenfeld et al., 1992). It is essential to understand how inquiry teachers work with, optimize, supplement, and modify autonomy-supportive curriculum features within inquiry materials. The current research questions focus on autonomy-supportive motivational enactment. Through interviews and classroom observations, this study investigated inquiry teachers' own interpretations and reflections of inquiry curricula, provided detail about the motivational features they noticed, their interpretation of the motivational features of the IQWST inquiry curriculum, and their described modifications to curricular tasks. The findings provide insight into how teachers' enactment practices combine with inquiry curriculum to afford autonomy support to students. The combination of curriculum and instructional supports in inquiry-based curricula provided optimal conditions for high quality enactment in support of students' basic need for autonomy and teachers augmented the motivational affordances of curriculum features through autonomy-supportive enactment practices.

Findings show that, with their extensive experience in inquiry-based classroom instruction, the four inquiry teachers not only notice autonomy-relevant features in inquiry, but they also enact autonomy-supportive practices in their classrooms. However, as seen in previous research, there are tensions and enactment challenges regarding time and content coverage with granting student autonomy (Rogat et al., 2014). Teachers described ways to balance these tensions with important curriculum modifications augmenting autonomy-supportive opportunities for their students above and beyond the designed lessons.

Finally, by identifying and describing antecedents to teachers' motivational practices in a broadened framework encompassing *supports* for autonomy practices, the study provides an elaborated range of influences on teacher practices. The findings indicate a wide range of antecedents for autonomy-supportive practices reporting a variety of teacher supports and strategies that teachers use to teachers resolve pressures.

Two Main Themes as Teachers Notice and Interpret Inquiry-based Curricula

The results support two main themes as science teachers noticed and interpreted the motivational features of inquiry-based science curricula: (1) teachers' motivational practices were frequent and high quality, and (2) teachers augmented motivational affordances afforded by inquiry curricula in autonomy-supportive ways. The first major finding, from the interviews and observations, is the prevalence of high-quality autonomy-relevant teacher practices across all measures from all four inquiry teachers. As seen in previous research (Rogat et al., 2014), these inquiry teachers are using a wide range of academically significant autonomy practices. The second major finding was *how much* teachers think about motivation during the planning stages of their lessons. As evidenced by their first interviews and the pre-and post-observation interviews, the four inquiry teachers give significant thought to how to motivate their students. Their everyday lessons have a wide range of strategies that involve autonomy relevant practices. The four inquiry teachers provided even more evidence of this range of motivational practices as they read through the IQWST curricular materials. Time after time the teachers not only notice the autonomy relevant practice contained within the curriculum materials but also discuss extensions to the curriculum. They take a critical look at the curriculum features and often suggest "better" ways to carry out the activities. Often these modified practices beyond the as-written curriculum serves to enhance student autonomy. These teachers are deliberately modifying intended instruction to be more motivating for their students. A discussion of each theme follows.

Theme 1: Teachers' motivational practices were frequent and high quality. Autonomy support was frequent and aligned with previous research documenting high quality autonomy-supportive classroom practices (e.g. Rogat, et al., 2014). As in this previous study, the inquiry teachers report instances of high quality autonomy-supportive practices related to procedural autonomy, relevance, responsiveness, feedback, cognitive autonomy, and competence support.

Given its history of infrequent and limited supports for autonomy within traditional classrooms (Assor et al., 2002; Bozack, 2008), it is noteworthy that autonomy supports were frequently noticed and enacted by this study's teachers who taught in inquiry classrooms. In much of the SDT literature on autonomy, there is limited detail and descriptive information about a curriculum's instructional tasks and context (Blumenfeld et al., 1991; Blumenfeld et al., 2006). Therefore, this study articulates the four inquiry teachers' motivational practices, through the narratives teachers provided detailing accounts of their enactment practices in an inquiry classroom. Since it is essential that teachers have access to autonomy-supportive curriculum (Rogat et al., 2014), this study also provides rich narratives of their hypothetical enactment of the IQWST lessons. This was necessary since past observational studies have limited evidence of autonomy-relevant practices (Assor et al., 2002; Bozack et al., 2008). The current study extends on a previous observational study results showing frequent autonomy support in inquiry classrooms (Rogat et al., 2014). The findings document that these four inquiry teachers, who said they were autonomy-supportive, *actually taught* in ways that supported student autonomy. During the classroom observations, the four inquiry teachers demonstrated several autonomy-supportive practices while enacting an inquiry lesson aligned with their own curriculum.

In order for teachers to enact motivational features as intended by curriculum designers, teachers must recognize them, interpret them in ways that aligned with the curriculum's intent, and then endorse them. Enacted as a whole, a teacher's practice provides students the motivational benefits of inquiry-based instruction as intended by curriculum designers. It is essential that teachers not only enact it (see Rogat et al., 2014), but also notice it in the inquiry-based materials and are *aware* in the planning of these practices. The encouraging point here is that findings indicate strong evidence that teachers *are* recognizing, enacting and augmenting the autonomy-supportive features in inquiry curricula. Notably, these inquiry teachers described a variety of supports that influenced their enactment decisions. This may account for the high number of instances that augmented instruction affording more student autonomy.

Overall, the teacher practices embedded within inquiry curriculum provide a wide variety of high quality autonomy support, most significantly a high frequency of cognitive autonomy support. These findings are similar to previous studies (e.g. Rogat et al., 2014) in which observations of frequent, multifaceted, and academically-significant conceptualizations of autonomy-relevant practices were found in teacher enactment of inquiry-based curricula. Curricula with autonomy-supportive features may drive teachers to enhance the range and quality of means for motivating their students.

Inhibitive practices. Despite evidence of high-quality enactment, there were also instances of autonomy-inhibitive practices. Similar to previous research (Roget et al., 2014; Turner et al., 2011), teachers grapple with maintaining a balance between giving up teacher control (i.e. cognitive autonomy support) and providing structure (i.e. low cognitive autonomy). Often, in response to student frustration, teachers faced the challenge of trying to facilitate both student autonomy and a need to ultimately provide answers in their science classrooms. These inhibitive practices are aimed at maintaining structure as the teacher retains ownership of the correct answers. Though infrequent, inhibitive practices have the potential to decrease student autonomy. Ultimately, this raises interesting questions about how teachers grapple with enactment and the curricular modifications they make.

Theme 2: Teachers augmented motivational affordances. The four inquiry teachers not only elaborate on their own enactment practices during the interviews, but also propose several modifications, both prompted and unprompted, to the IQWST materials. This is particularly important as teachers respond by either facilitating or inhibiting autonomy-relevant curriculum features. Moreover, these modifications were frequently cognitive autonomy supportive practices (56% of coded instances), which is significant given the benefits already in place to provide cognitive autonomy support. By studying these experienced inquiry teachers' own motivational practices and interpretations of inquiry curricula, we can begin to understand how teachers work in science classrooms to provide autonomy support to students above and beyond the intended instruction. The teachers often elaborated on their own autonomy-supportive practices suggesting modifications that further enhanced the lessons' autonomy-supportive features.

Facilitating student mastery. Examples of modifications include the addition of a student debate and the modification of complex scientific terminology. These modifications serve to enhance student autonomy by maintaining a continued focus on the main content points, enhancing students' feeling of competence with a goal of student mastery, and facilitating teamwork among students as they engaged in the science lessons. Modifications provide opportunity for students to engage with the data and retain responsibility for their own understanding of evidence while students share ideas, listen to each other, and build arguments.

Connecting to the work scientists. Another suggested modification, offered by the inquiry teachers, was to tie the use of authentic data and evidence sets to the work of the scientific community. This modification expands on prior conceptualizations of relevance which present students with authentic data connecting to students' interests and values. This autonomy-supportive curricular modification of connecting to the disciplinary practices of science may be viewed as motivating because it could increase students' interest in scientific topics and career intentions. For instance, by tying to a real case study within the scientific community (i.e. IQWST peppered moth population), students may view the relevance of their tasks as going beyond a simple classroom task and relating it to a scientific profession. This may affect students' willingness to invest more effort and be more engaged. With the recent adoption of the NGSS, there is a move toward emphasizing the disciplinary practice of science and meaningfulness of content. These inquiry teachers recognize how to modify the curriculum to connect to the norms of scientific practice as a means of motivating student learning.

Inhibitive modifications. In addition to providing modifications that enhance the lessons' autonomy-supportive features, the four inquiry teachers also suggested modifications that may diminish student autonomy. For instance, the modification of a group activity into a brief demonstration has the potential to diminish relevance of the activity for those students who do not have the chance to participate. When limited instructional time is afforded to the activity, students may not see it as an integral part of the larger lesson to follow. Furthermore, when teachers maintain structure, this diminishes opportunities for students' cognitive autonomy. In this type of modification, the teacher removed ownership from the students as the teacher is viewed as responsible for the answers.

Challenges felt by second year teacher. In particular, the second year teacher (Darcy) struggled with several of these challenges of enacting student autonomy. First, Darcy grappled with how to maintain structure in the classroom during inquiry- based instruction. She wanted to keep students invested in the inquiry unit, but faced the challenges of student boredom and students' lack of effort during group activities. She was nervous that lack of student effort during group activities (i.e. IQWST jigsaw) would jeopardize the inquiry lesson since students would not be sharing accurate data between groups. These struggles would cause her to modify lessons in which she would remove group activity and replace it with a teacher demonstration (i.e. IQWST candy activity) or replace it with a teacher lecture (i.e. scientifically precise explanation on global warming). These instructional moves diminish student autonomy since the teacher is taking back control of the lesson and its delivery of content. Lastly, Darcy was concerned about her own teacher evaluations. Darcy felt pressure to be seen as a competent science teacher. She felt that her evaluator would be looking to observe a classroom in which students are listening quietly to her delivering science content. These findings need to be considered when expecting novice teachers to enact inquiry-based curriculum. Novice teachers may need support though professional development to enact motivational practices that enhance student autonomy.

Three Main Themes for Teachers' Motivational Practices and Enactment Decisions

The results support three main themes when analyzing the antecedents which proved influential for teachers' motivational practices and enactment decisions during inquiry-based instruction. The current study identifies the influences on teacher behaviors as (1) supports resulting in enhanced autonomy-supportive practices, (2) pressures that they resolved with autonomy-supportive practices, and (3) pressures resulting in practice that diminished student autonomy (see Table 6). The themes suggest a new differentiation of influences is needed when studying antecedents of teachers' motivational practices within an inquiry-based science context or similarly autonomy-supportive context. The conceptualization of antecedents as pressures, used to explain controlling practices in classrooms, limits our understanding of influences as merely negative or inhibitive. This constrained conceptualization may have stemmed from a primary focus on explaining why teachers adopt controlling practices, with limited research considering antecedents of autonomy supportive practices (Reeve, 2009). Further, this research has also largely used self-report surveys to ask teachers about a specified list of pressures or has manipulated pressures experimentally (Deci et al., 1982; Flink et al., 1990), limiting what we know about teachers' perceptions in authentic settings.

Very little is known about the positive factors that may allow for the affordance of more student autonomy. To fully understand teachers' enactment decisions in an inquiry context requires extending this conceptualization beyond simply identifying antecedents as pressures. Recently, studies have been finding some evidence of teachers resolving pressure by responding *with autonomy support*. For example, Fulmer and Turner's (2014) work used observational data and found that teachers addressed pressures from students (i.e. lack of effort during group work and lack of interest in subject area) through offering autonomy (see also Taylor et al., 2009; Hornstra et al., 2015). This work is similar to previous work (Rogat et al., 2014) and underlies the importance to expanding our understanding of all motivational practices, not just controlling practices.

Though how teachers resolve pressures is a step in the right direction to extending our understandings of antecedents, the *supports* that drive teachers to enact *autonomy-supportive* practices have yet to be studied or recognized in the extant literature. An important contribution of the current research is extending the investigation of antecedents to include the many *supports* that influence teachers' motivational practices.

Table 6

Enactment Decisions

	Below	Within	Above
Pressures resulting in **diminished student autonomy**	-Mix of high achievers and special education students -Student frustration for teachers to confirm correct answers -Students' lack of effort	-Teachers' own need to maintain structure	-Class time limitations -Specific science topics

Pressures **resolved** with **enhanced student autonomy**	-Mixed abilities of their students -Student frustration -Student misconceptions -Student interest	-Teachers' own mastery beliefs -Allowance of student agency	
*Supports resulting in **enhanced student autonomy**		-Components of inquiry-specific practice	-University partnerships -School district support -Science standards

*new theoretical extension

Theme 3: Teachers described supports resulting in autonomy-supportive practices. The first major finding was the range of supports that these four inquiry teachers experienced in their classrooms, school districts, and teacher training, which they now take into their classrooms. Support through university partnerships, in their teaching degree programs, and from their school districts were key for these inquiry teachers. The four inquiry teachers credit these supports for their enactment decision-making. These supports afford teachers freedom in creating challenging, inquiry-based lessons. Viewed as a support, the teachers tend to enact more autonomy support resulting in enhanced student autonomy practices.

Another key support is the teachers' own perception of the benefits of inquiry-specific practice. The teachers believe that inquiry is the best way for their students to learn science and their endorsement of inquiry plays a critical role in their enactment decision-making. Given the high amount of augmented autonomy supportive motivational practice in the current findings, these supports might be the key to expanding on the current understandings about the rationales and reasons behind enactment decisions. This study begins to identify teacher supports.

Theme 4: Teachers resolved pressures with autonomy support. The second major finding of this study extends our understandings of antecedents within an extant literature which focuses on the *pressures* teachers experience compelling them to adopt less autonomy-supportive, more controlling strategies (e.g., Reeve, 2009). However, in this study, the four inquiry teachers adopt and modify instructional practices to become *more* autonomy-supportive. The four inquiry teachers often detail how they *resolved* pressures by modifying the curriculum with enhanced student autonomy. This is similar to other findings showing how teachers deal with challenge as teachers address pressures from students in autonomy-supportive ways (Fulmer & Turner, 2014).

The current study elaborates on how teachers use the mixed abilities of their students, student frustration, and student misconceptions as positive influences on their enactment practices. Inquiry-based curricula seem to have the resources (see Table 4) teachers need to respond to the various pressures in the classroom. Inquiry-based curricula have activities that optimize challenge and elicit student ideas as the basis for content development throughout the unit. There is group decision making opportunities, lesson relevance, and the allowance of responsiveness (both teacher and peer) to ideas generated during class discussions.

Theme 5: Teacher pressures resulted in practice that diminished student autonomy. Finally, though infrequent, the teachers did discuss pressures. The pressures are consistent with prior research (e.g., Reeve, 2009). One pressure that influences teachers to enact more autonomy-inhibitive practices teachers' own need to maintain structure as inquiry-based instruction shifts to a more student-centered classroom. A mix of student abilities and students' frustrations with inquiry-based instructions open tasks are pressures faced by teachers sometimes leading to autonomy-inhibitive practices. It is important to note here that the same teachers who offered these inhibitive practice also offered promotive ones. There is more work to be done knowing these pressures in combination with the ways teachers resolve pressures. When are the pressures resolved versus not resolved? This can inform curriculum designers to develop activities that give teachers the opportunity to offer more student autonomy.

Implications for Practice

First, it was imperative to gain an understanding of teachers' practices as embedded in the contextualized inquiry setting. Second, it was important to access the various influences on enactment decisions by studying teachers' interpretations of motivating features and beliefs about students' motivation. This has practical implications for providing more targeted professional development especially given tensions that stem from coordinating these multiple antecedents along with tensions and challenges we know about (e.g. content coverage; time management). When we know *how* teachers respond to the motivational features of an inquiry curriculum, we can (1) revise and develop educative curricular materials that support autonomy and (2) develop better professional development targeted at autonomy-supportive teaching (e.g., Turner, et al., 2011). Curriculum developers interested in understanding teachers' decision-making benefit from knowing what guides teacher practices, how teachers perceive motivation, and make decisions related to motivation. This facilitates the creation of materials that help to optimize opportunities for affording student autonomy in the science classroom. It is critical that curriculum features help teachers resolve pressures in autonomy-supportive ways as suggested in the curricular materials.

Limitations

One limitation of the current study is that this was not a case study. The sample of inquiry teachers was analyzed together as they discussed motivational practices, thus elaborating on the range of autonomy-relevant teacher practices. Hence, there was no teacher comparison, which could have provided more detailed analysis connecting autonomy constructs to specific antecedents. This analytic decision meant that we did not study any one teacher in depth. In future work, it might be interesting to track Darcy, the second-year teacher, as she navigates the pressures she experiences in her classroom. Darcy often discusses controlled responses to pressures and curriculum modifications that diminished student autonomy.

Since the goal of the current study was to compile an elaborated set of autonomy-supportive practices and reasons influencing enactment decision-making, a second limitation was that no student data was collected. Student self-report data would ensure the examination that students ultimately perceive enhanced autonomy support with these frequent and high-quality supports offered. Future work should consider the inclusion of student reports of autonomy support, because it is important to understand how students respond to the motivational affordances of inquiry-based curricula.

Despite having rich inquiry practices, a final limitation of this study was that teachers did not have any motivational intervention or professional development that focused explicitly on autonomy-supportive practices or the notion of autonomy. Future research should consider exploring how teachers respond to professional development in combination with a curriculum that affords autonomy support.

Conclusions and Future Directions

In conclusion, as teachers notice, interpret, and enact inquiry-based curricula two main themes emerged. First, high quality autonomy-supportive practices were frequent across all measures from all four inquiry teachers. Second, the inquiry teachers not only noticed the autonomy-relevant curriculum features, but also suggested modifications to the inquiry-based curricula. These findings showcase the deliberate and often autonomy-enhancing modifications inquiry teachers make since practice was situated in an inquiry-based curriculum that expanded opportunities for student autonomy (Rogat et al., 2014). The extant research is only in the beginning stages of recognizing inquiry contexts as significant contributors to the study of autonomy support in classrooms.

These findings articulate enactment decision-making across a broad range of influences on teachers' motivational practices. The current study furthers this discussion highlighting the importance of accounting for curricular features alongside teachers' motivational beliefs concerning the effectiveness of curricular tasks in their resulting motivational enactment. The results support three main themes describing the range of influences on inquiry teachers' motivational practices and enactment decisions. Teachers are influenced by pressures resulting in enactment practices that diminished autonomy support or by pressures that they resolved with enhanced autonomy-supportive enactment practices. Future research would benefit from studying not only the pressures that influence teachers' motivational practices in classroom, but also any positive factors or supports that may lead to more autonomous teaching behaviors.

Thirdly, teachers are influenced by supports resulting in enhanced student autonomy. Importantly, this finding introduces key instructional supports as a new theoretical extension in the extant literature identifying antecedents to teachers' motivational practices. It seems inquiry teachers have a toolbox or repertoire of motivational strategies. One possible expansion of this work to further understand the antecedents for autonomy support is to perform an analysis of teachers' motivational practices mapped out together with reasons for enactment decisions, which could tie specific pressures or supports to specific autonomy constructs. This may provide a more precise set of suggestions for curriculum developers as they incorporate motivational features into the written curricula. It is essential that curriculum developers ensure that motivational features continue to provide teachers with autonomy supportive tasks.

Given that inquiry is embedded within scientific contexts, future work could explore different subjects taught (e.g. beyond biology as in this study) and investigate whether autonomy-support is subject-specific. Findings indicate that while the four inquiry teachers felt supported enacting their inquiry instruction, there were other sciences that were hard to envision teaching through inquiry instruction. For example, the teachers thought chemistry would be difficult to teach with inquiry methods due to safety concerns.

Finally, as the Next Generation Science Standards are implemented, future work will be critical to investigate the possible effects the new standards will have on inquiry instruction. For example, with the new call for classroom teachers to connect to the practices of scientists, there is a need to study if students are really motivated by this. We still don't know if students find the work of scientists motivating and relevant. Hence, there is a need to conduct studies that talk to students about this and investigate what their perceptions are. As students participate in classroom instruction, future studies could investigate whether students notice the motivational relevance, which may enhance student autonomy.

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Appendices

Appendix A

Interview One Protocol

To gather *general information* about the sample population of teachers. "To begin, I would like ask you some general questions about your teaching."

1. What grade level do you teach?
2. How many years have you been teaching?
3. What subjects are you teaching in the 2014/2015 academic year?
    a. Follow Up: Are these the subjects you have always taught? What subjects have you taught?
4. What textbook or curriculum series do you use?
    a. Follow up: Your school purchases this? Does your entire district use this? How many years have you used this?
    b. Follow up if using a textbook: What types of supplemental resources do you use in combination with the textbook?
    c. Follow up if using an online curriculum: What types of supplemental resources do you use in combination with the online curriculum?
    d. Follow up if using no textbook: What resources do you use as you plan your lessons?
5. How many years of experience do you have with teaching inquiry?
    a. Note: try not to define inquiry for the teachers
    b. Follow up: Could you elaborate on how you teach inquiry?

To examine the teachers' typical instructional practices *related to scientific inquiry and motivation*. (adapted from Pickens, 2007; Taylor et al., 2009) "Now, I'm interested in talking more specifically about your class activities."

6. Can you describe to me a really good example in your class of an activity where students were engaged in scientific inquiry?
    a. Follow Up: How do your students respond to this type of activity? (i.e. are they motivated, frustrated, overwhelmed, excited; access students' resistance)
    b. Follow up: Do you ever feel that your students are frustrated by inquiry? How do you deal with their frustrations?
    c. Follow Up: What is your role during this inquiry lesson?
    d. Follow Up: How are students involved during this type of activity?

7. Can you recall times when you chose not to use scientific inquiry in your science class- Can you describe to me what happened and why? (Did you decide on a different instructional strategy?)
    e. Follow Up: Were there motivational reasons for not using inquiry? (i.e students are disengaged, disinterested, overly challenged during inquiry)
8. Could you describe for me a lesson when you felt that you students were really motivated? Can you describe what happened and why?
    f. Follow up: What about this lesson was motivating for students?
    g. Follow Up: Do you find [these strategies you just talked about] are an effective way to motivate students?
9. Can you recall a lesson when students didn't seem motivated to you? Can you describe to me what happened and why students weren't motivated in that situation?
10. What are some of your strategies when you notice students are not motivated? Can you think of a time when you did something or said something specific to increase your students' motivation during a lesson? (Describe it to me.)
    h. Follow Up if they don't modify: Why don't you modify lessons to increase student motivation? What are the reasons?
11. If teacher uses a textbook or curriculum: Do you often pick lessons from the textbook or curriculum series directly?
    i. Follow up: Can you describe a lesson that came directly from the textbook/ curricular materials and describe to me what types of modifications you made to the science lesson? (How do you make the science lessons "your own"?)
    j. Why do you make these changes? (What limitations or weaknesses are you trying to address? What are your reasons for modifications?)?
12. If teacher does not use a textbook or curriculum: Can you describe to me what types of modifications you make to a science lesson [from the sources you have discussed i.e. the Internet]? (How do you make the science lessons "your own"?)
    k. Why do you make these changes? (What limitations or weaknesses are you trying to address? What are your reasons for modifications?)?
13. If teachers have not mentioned group work, ask: Do you have students work in groups? How do you enact group work in your classroom (what does it look like?)?

"Before ending the interview, are there any final comments you would like to add?"

To conclude Part One of the interview. "Thank you for your time."

(Confirm the email address to send the inquiry lesson to. Set a tentative date to follow up with Part Two of the interview.)

Appendix B

Interview Two Protocol

To examine the *teachers' interpretations* of the motivational features of a specific inquiry lesson, modifications they would make if they were to hypothetically enact the inquiry lesson, and any reasons for modifications. "Last time we talked, I asked you about your thoughts on scientific inquiry, student motivation in the classroom and factors that influence you in your teaching. Today, I want to talk specifically about the IQWST lesson I emailed to you."

2. Do you have any questions about the IQWST materials (the front matter or the lesson)?
3. Could you summarize for me what you see as the learning goals for this lesson?
4. Can you discuss how these inquiry goals, objectives, and materials differ from your resources and inquiry materials?
5. If you enacted this lesson, do you think your students would be motivated or not motivated? (to do the lesson, to learn science concepts, to work in groups, to do jigsaw activity, to construct a class consensus evidence-based model)
    a. Follow Up: What parts of this lessons would student find motivating?
    b. Follow Up: What parts of this lesson would students find challenging?
    c. Follow Up: Is there anything else about the unit that would enhance or diminish motivation?

Prompting for curriculum modifications: Autonomy/motivation relevant: "Now I am interested in talking more specifically about particular segments of the lesson."

"Looking at "**Introducing the Activity**" on pages 130-131, students participate in an introductory activity that demonstrates how height can be an advantage in obtaining food. This part of the lesson (1) links the content to prior lessons and prior knowledge and (2) engages students in an introductory candy activity."

6. Could you describe how you would enact the candy activity? (If teacher can not use candy: How would you enact this activity without candy?)
    a. Listen for teachers to talk about: How they would you introduce the lesson and the candy activity? (What specifically might you say?)
    b. Listen for teachers to talk about: Would they enact this introductory segment of the lesson- as is or with modifications? What would you do differently? What are the reasons for your modifications?
7. How do you feel your students would respond to this activity? What aspects of this candy activity might motivate or demotivate your students?

a. Do you think that an introductory activity like this one make the content more relevant for students?

8. Do you feel that connections to prior lessons and prior knowledge in lessons motivates student learning in any way?
    a. Follow up: How do these types of connections (to prior lessons/ prior knowledge) make the content more relevant for students?
9. Specific to student motivation, would you make any modifications (not already mentioned)?

"Looking at "**Activity 9.1- The Case of the Peppered Moth**" on pages 131-132, students work in groups with their peers to examine a real case where a variation in a trait proved to be advantageous: the peppered moth. This part of the lesson (1) has students answer making sense questions focused on eliciting students' hypotheses concerning the reasons for this population decline."

10. What would you say to begin this brainstorm discussion (to get out hypotheses for why the dark form of the moth is becoming more frequent and why the light form is less frequent)?
    a. Listen for teachers to talk about: Would they enact this introductory segment of the lesson- as is or with modifications? What would you do differently? What are the reasons for your modifications?
11. While the teacher outlines how she would run this brainstorm discussion, ask: What would you say to the students to get them engaged and keep them involved in the discussion?
    a. Follow Up: Describe your role during these types of discussions?
    b. Follow Up: Describe the students' role and responsibilities during these types of discussions? What do you expect them to be doing?
12. Would you organize/ or have students organize the responses in any way? How and why?
    a. Would you invite students to respond to/ give feedback about any of the initial hypotheses? How and why?
13. Would you modify suggested prompts for the brainstorm discussion (on page 132; to elicit student ideas)?
14. What would you say to students at the close of the discussion?
15. What about this lesson might be motivating to your students? (or not?)
16. Specific to student motivation, would you make any modifications (not already mentioned)?

"Looking at "**Activity 9.2- How Does Variation Matter**" on pages 133-134, students look at several sets of evidence and data in order to gather information to figure out what caused the change in the peppered moth population. This part of the lesson has students (1) participate in groups to examine evidence for the change in frequencies of the two types of moths and (2) then proceed to jigsaw with other groups to share and examine all of the evidence in its totality."

17. What would you say to the student groups as they get ready to examine their set of evidence?
18. What would you say to initiate the collaborative group work and get groups ready?
19. What is your role during these types of discussions?
20. What are the students' role and responsibilities during these types of discussions?
    a. Follow Up: What do you expect them to be doing?
21. What would you say to students to shift to jigsaw groups (where they share the evidence from their initial group discussion)?
22. What would you check for when monitoring group activity across these two group tasks?
23. What would you respond if you saw a group show misunderstanding of the evidence (as they fill in their evidence sheet)?
24. What would you do if you saw a student group writing an evidence-based explanation that was scientifically inaccurate?
25. What challenges or problems might you expect from group work?
    a. Would you check for groups to work well together? What do you emphasize? How would you encourage students to listen carefully to others and respond to others' ideas?
26. Are there aspects of this section of the lesson that might motivate or demotivate your students?
27. Overall, would you enact this segment of the lesson- as is or with modifications? What would you do differently? What are the reasons for your modifications?
28. Specific to student motivation, would you make any modifications (not already mentioned)?

"Looking at "**Activity 9.3- How Does Variation Matter**" on pages 134-135, students construct an evidence- based explanation to account for the change in frequencies of the two types of moths. This final part of the lesson has students (1) construct a class consensus evidence-based explanation about what happened to the moth population."

29. What would you say to students as they get ready to do come together as a class to put together a consensus explanation? What directions would you provide to get this started?
30. Outline how you would run the construction of the class consensus explanation.

a. Prompt: What types of questions would you ask? What would you expect the students to be doing? What are you doing?

b. How would you encourage students to ultimately reach consensus?

31. What would you do/say if the class consensus explanation was incomplete, for example it didn't use or account for all the evidence?

32. What would you do/say if the class consensus explanation was scientifically inaccurate?

33. Are there aspects of this last segment of the lesson that might motivate or demotivate your students?

34. What kind of challenges might you expect while creating a class consensus explanation?

35. Do you or would you take steps to encourage the class to work well together? How would you encourage students in listening carefully to others and responding to others' ideas?

36. Overall, would you enact this segment of the lesson- as is or with modifications? What would you do differently? What are the reasons for your modifications?

    a. Follow up: Would you organize the class discussion so that two explanations were available on the board for the class to examine and debate?

    b. Follow up: Would you organize the discussion so that group explanations were the ones on the board available for the class to examine and - leading to a debate about which group's explanation is most productive? Accounts for the most evidence?- narrowing it down to the strongest explanation? What do you think about using debate to lead a discussion?

    c. Follow Up: How might you support and foster this type of discussion? What might you say?

37. Can you describe other *modifications* you would make related to student motivation that we have not previously discussed?

    a. Follow Up: Why would you make those modifications?

38. Reflecting once more on the lesson as a whole: Brainstorming, jisawing, hypothesizing, coming to a class consensus, [and other motivational strategies discussed], can you summarize what you see as most motivating to students?

39. Finally, reflecting on the lesson as a whole: How does student motivation play a role in your lesson planning?

"Before ending the interview, are there any final comments you would like to add?"

To conclude Part Two of the interview. "Thank you for your time."

(Set a tentative date to follow up with to observe an inquiry lesson.)

Appendix C

Pre-Observation Interview Protocol

1. What has this class been doing recently?
    a. *[Follow up: What unit are you working on? What instructional materials are you using?]*
2. Where does the lesson you're presenting today fit within the unit?
3. What will be happening in class today [or on the day I will be observing]?
    a. *[Follow Up: What do you hope students will learn as a result of the lesson you have planned?]*
4. What inquiry practices will students be using during the lesson?
5. What can I expect <u>you</u> to be doing in class?
    a. *[Follow Up: What role will you take? What teaching methods will you use?]*
6. How will you engage the students in the lesson?
    a. *[Follow Up: What will the students do? What tasks will students be assigned/involved in?]*
7. Did you make any modifications to the tasks or instructional recommendations as described in the lesson materials?
    a. Why? What informed your modifications when you were planning?
8. How do you expect your students to be motivated during this lesson?
    a. *[Follow Up: What features, practices, or tasks will motivate your students? Do you expect any challenges?]*
9. Did you make any modifications to this lesson as described in the curriculum/lesson materials to ensure students stay motivated?
    a. *[Probe: Why? What were you thinking as you were planning? (the students would be bored, it's too difficult, too easy, confusing)?]*
10. In your previous interviews you mentioned [motivation strategies], are you using these in this lesson? Why?
11. Is there anything in particular that you would like me to focus on during the class?

*End: Thank you so much. See you on [observation date].

Appendix D

Post-Observation Interview Protocol

1. How do you think the lesson went today [or on the day I observed you]? What do you think worked well in this class?
2. You said in the pre-observation interview that the learning outcomes for this lesson as [insert answer], did your students meet all of these learning goals?
3. Remember when you said, "X" during the lesson? Can you talk about the motivational reasons why you said this?
4. Remember when your students were involved in "Task A"? Can you talk about the motivational features of this task?
5. How did your students respond motivationally during the lesson? Were they engaged?
    a. *[Follow Up: Did the students respond as expected?]*
6. Did you face any motivational challenges during this lesson?
    a. *[Follow Up: Was it challenging to incorporate motivation strategies into the lesson?]*
7. Did you alter any instructional plans in response to students' motivation or engagement?
    a. *[Follow Up: Did you notice motivation and enhance it? Did you notice lack of motivation and try to change it? Did you notice students facing difficulty and respond?]*
    b. *[Follow Up: Were there any ways in which the lesson was different from what you had planned? Why? What were you thinking about in that moment?]*
8. If you were to teach this lesson again, what might you do differently?
    a. *[Follow Up: Would you do anything differently to enhance student motivation?]*
9. What will the class being doing next as you continue the unit?

*End: Thank you so much.

Appendix E

IQWST Lesson Summary: Do Variations between Individuals Matter?

Lesson Placement: Lesson 9 of 10 in the larger unit

Lesson Timeframe: 2 class periods

Lesson Background Knowledge: The peppered moth exist as a polymorph consisting to different phenotypes (dark and light forms) within the same population of a species. The numbers of each kind of morph may be influenced by natural selection.

Performance Expectations: Students will analyze data about the consequences of variation in a trait for survival. Students will construct an evidence-based explanation to account for the change of variation in a population.

Introducing the Activity: The brief introductory activity has students participate in an activity that demonstrates how height can be an advantage in obtaining food. A bag of small, wrapped candy is required. The activity uses candy placed at a high place in the classroom to demonstrate that some students are tall enough to reach the candy, while other students are not. This lesson links to the previous lessons' content on biological traits learned in Lesson 1 of the larger unit and of the homework given the night before this lesson.

Lesson 9.1: After the brief candy activity, students work in groups with their peers to examine a real case where a variation in a trait proved to be advantageous: the peppered moth. Projected images of the different morphs of the peppered moth are required. The images will show a dark form and light form of the peppered moth taken in the same location form the same population. Next, students read information about the moth population. The dark form of the moth is becoming more frequent and the light form is becoming less frequent. This part of the lesson has students answer questions focused on eliciting students' hypotheses concerning the reasons for the light colored moth population's decline. This was facilitated by the instructor guiding a student brainstorming session. Prompts for this discussion would include inquiries about the factors that affect moth populations. The students determine which of these factors would be important to investigate next.

Lesson 9.2: In the next segment of the lesson, students look at several sets of evidence and data in order to gather information to figure out what caused the change in the peppered moth population. Each group of students should be assigned one of four evidences: a pollution study, a predation study, a pollution reduction study, and a study about inheritance. The series of studies provide clues as to what happened to the population of peppered moths. The first explores the type of environmental pollution and its effects on the moths' ecosystem. The second explores how the predators of the moths interact with the two variations of the moth. The third explores changes in the last fifty years as the pollution situation has changed. The fourth looks at whether the variation is inherited. After the groups finish, they will jigsaw and form new groups made up of one person from each of the four studies. The jigsaw groups should share and examine all four of the evidences in its totality.

Lesson 9.3: During the concluding lesson, students construct an evidence-based explanation to account for the change in frequencies of the two types of moths. Teachers facilitate the discussion by walking students through the evidences allowing them to construct a chain of reasoning to explain the change in frequency distribution of the moth. This part of the lesson ends with the entire class coming together to form a final class consensus evidence-based explanation.

Appendix F

Identified Autonomy-Relevant Affordances of the IQWST Lesson and Rationales

Introducing the activity. Students participate in an introductory candy activity that demonstrates how height can be an advantage in obtaining food.

- **Procedural Autonomy**- students handle the materials
- **Rationale** - introduces lesson purpose with activity
- **Relevance** - connects to previous lessons, lesson coherence; Contextualizing unit content through introducing to driving question or other context
- **Relevance** - connections between candy activity and height; Connecting concepts to everyday experiences
- **Relevance** – using candy, evokes curiosity; Highlight interestingness and relevance of examples during content representation

Lesson 9.1. Students examine data about a real case where a variation in a trait proved to be advantageous: the peppered moth.

- **Organizational Autonomy** - students choose groups when developing hypotheses
- **Relevance** - authentic data sets are provided
- **Relevance** - connects to previous lessons, lesson coherence
- **Responsiveness** - draws on students' ideas to generate the list on the board during brainstorm discussion
- **Cognitive Autonomy** - Eliciting students' evidence-based explanations using authentic data sets, so their ideas are central to further debate and discussion
- **Relatedness** - work in groups to formulate hypotheses

Lesson 9.2. Students form jigsaw groups and are involved in data analysis while constructing an evidence-based explanation to account for the change in frequencies of the two types of moths.

- **Organizational Autonomy** - students choose groups during jigsaw
- **Organizational Autonomy** - running and directing the decision making within the group
- **Relevance** - authentic data sets are provided
- **Relevance** - connects to previous lessons, lesson coherence
- **Cognitive Autonomy** – students responsible for interpretation of data in jigsaw groups
- **Cognitive Autonomy** - Eliciting students' evidence-based explanations using authentic data sets, so their ideas are central to further debate and discussion
- **Cognitive Autonomy** - encouraging peer responsiveness in jigsaw, students responding to each other

- **Cognitive Autonomy** – students developing explanations; students being held responsible for drawing conclusions about the peppered moth
- **Cognitive Autonomy** - share ideas with classmates
- **Competence support** - organize students ideas in worksheet

Lesson 9.3. Students construct a class consensus explanation about what happened to the moth population.

- **Relevance** - connects to previous lessons, lesson coherence
- **Cognitive Autonomy** - call for consensus evidence-based explanation based on students' developed explanations/ideas
- **Cognitive Autonomy** - Eliciting students' evidence-based explanations using authentic data sets, so their ideas are central to further debate and discussion
- **Responsiveness** - uses these student ideas to construct a class consensus explanation
- **Relatedness** – working in groups to construct class consensus

Appendix G

Summary of Autonomy-supportive Practices and Comparison with Prior Research

Dimension	Conceptualization	Practices from Past Research	Practices from Prior Research (Rogat et al., 2014)	Practices from Current Research
Organizational & Procedural Autonomy	Involving students in decision making related to procedures & task format	Seating arrangements relative to materials Participate in classroom rules; due dates for assignments; choose group members Display work in an individual manner (format; color); discussing Ss wants; handling materials; choose materials for class projects	Informing decision of which group leads discussion Selecting partners Decision whether/how to use color to represent model revision Choice of activity after completing assigned work	Format choice: how to read, interpret, and integrate evidence into their explanations. Selection of group members Choice of how to design their own experiment (i.e. build your own circuit)
Rationale & Relevance	Introducing lesson or task purpose and connecting to students' personal interests, values, and goals.	Rationale accompanied by acknowledging boring, uninteresting nature of the task "How about we try the cube, because it is the easiest one."	Contextualizing unit content through introducing to driving question or other context Connecting concepts to everyday experiences	Connecting the content to disciplinary practices of science Studying real case studies compiled by the scientific community

		Ex: “Doing this activity has been shown to be useful because…”	Revisiting connections to relevant context Highlight interestingness and relevance of examples during content representation Building toward key lesson points using students’ examples Introducing lesson coherence to prior lessons	Connecting to a larger unit question while using meaningful and real-world examples Evoking curiosity around an authentic problem
Responsiveness	Listening to students and responding to questions.	Ex: “Yes, you have a good point” and “Yes, right, that was the second one.” Seconds the teacher carefully and fully attended to the student’s speech, as evidenced by verbal or nonverbal signals	Restating students’ point prior to T elaboration. Eliciting clarification and extension from students to ensure T understanding Using students’ own phrases and ideas in responses and when elaborating on students’ ideas.	Return to students' models, ideas, questions, and brainstorming ideas Use student ideas to make key lesson points Encouraging peer responsiveness

			Drawing on students' ideas in content representation and to make key lesson points Reintegrating Ss ideas & explanations in discussion *Encouraging peer responsiveness	
Feedback	Offering encouragement when students show effort & persistence; Recognizing/praising mastery and progress;	Ex: "Good job" and "That's great." "Almost," "You're close," and "You can do it."	Recognizing new contributions and evolving ideas; Ss comments that advance the class discussion Coupling informational feedback with a task focus, and potential for improving Conveying high expectations prior to challenging work Whole class feedback reflecting skill and conceptual development during the unit.	Creating checkpoints to respond to students during key parts of a lesson Recognizing students' evolving ideas

Cognitive Autonomy	Encouraging students' ownership related to ideas, strategies, thinking and learning.	Ex: Multiple approaches, strategies on problems; time for decision making/pacing; justify solutions; be independent problem solvers; debate; Re-evaluate errors and evaluate their own or others solution ideas; Formulate personal goals and re-align to correspond with interests; Informational feedback; T listening time; Ask questions	Making explicit how curriculum tasks foster students developing & revising explanatory models Maintaining open curriculum tasks (1) with more than a single right answer, (2) opportunities for self-direction, choice and decision making, (3) grounded in student-initiated ideas and theories, and (4) requiring explanation, justification and synthesis Facilitating student-student discussion by asking students' to respond to one another Eliciting students' initial models and model evaluation, so their ideas are central to further debate,	Using scaffolding practices to break down tasks Maintaining open curriculum tasks (1) by withholding the correct answer, (2) opportunities for self-direction, choice, and decision making, (3) grounded in evidence data sets, and (4) requiring explanation and synthesis of evidence Curriculum tasks require reading and interpreting scientific evidence with the goal of integration into students' individual and class explanations Eliciting students' evidence-based explanations using authentic data sets, so their ideas are central to

		discussion and alternative solutions	further debate and discussion
		Guiding questions to support students in thinking about, elaborating, clarifying their ideas	Central driving question coupled with lesson-specific guiding questions as central to drawing conclusions and creating class consensus explanations based on students' developed understanding of evidence
		Encouraging self-regulated learning by (1) involving Ss in the development of criteria for model development & evaluation, (2) making reminders to use co-developed criteria for evaluating models and arguments, and (3) transforming criteria into rubrics for Ss self-evaluation	Encouraging self-regulated learning by (1) involving students in the development of explanations through the critical evaluation of evidence data sets
		Encouraging peers to hold each other accountable for use of criteria	Encouraging peers to hold each other accountable for the use of authentic data sets in the jigsaw groups; student are accountable for sharing the

				cognitive work with peers
Competence	Supporting students' mastery	Providing students with optimal challenge High expectations in students' confidence	-	Providing students with optimal challenge High expectations in students' confidence
Relatedness	Fostering a sense of shared experience and belongingness	Teacher caring Trusting relationships Encouraging equal participation from all students	-	Teacher caring Trusting relationships Encouraging equal participation from all students Knowing your students Having students engage in group work to persist with challenging inquiry tasks

Appendix H

Coding Categories

Autonomy Supportive Practices

1. **Rationale and Relevance** refers to practices that explicitly address the purpose of the lesson; connections to prior and future lessons, or explicitly to students' interests, experiences, and lives so students feel like their point of view is accounted for.
2. **Responsive** teachers actively listen and respond to student ideas to engage students' participation and interest in the curriculum materials
3. **Organizational and Procedural Autonomy** practices convey a range of choice making opportunities; students involvement in decision making about task content; teachers do not give directives or answers
4. **Cognitive Autonomy Support** practices explicitly use student ideas as a starting point for building new connections and constructing meaning; clear intentions to transfer the responsibility of learning to students; teachers encourage self-regulation; students are responsible for cognitive work
5. **Positive Feedback** refers to practices that provide positive praise and supporting of students' ideas
6. **Relatedness and Competence-Support** refers to practices that foster a sense of shared experience and belongingness and encourage and support students' mastery

Controlling Practices

1. **Low Relevance and Low Purpose** refers to practices that discount the relevance of the curriculum materials to everyday experiences and student interest
2. **Nonresponsive** practices are dismissive of student ideas or there is deliberate ignoring of student ideas
3. **Low Cognitive Support** refers to practice that withdraw opportunities for students' responsibility for thinking where teachers direct and dominate the talk asking low level questions and telling answers
4. **Negative Feedback** refers to practices that provide highly critical feedback and criticism

Reasons for Autonomy-relevant Practices

1. **Factors from Below** include teachers’ perceptions student characteristics; students' ability level; students' interest; students' response to challenge; students' content misconceptions; students' effort
2. **Factors from Within** include teacher beliefs and teacher characteristics; inquiry-specific beliefs; mastery beliefs.
3. **Factors from Above** include national standards, university partnerships, and time constraints.

Appendix I

Summary of Reasons for Teachers' Enactment Decisions and Comparison with Prior Research

Dimension	**Conceptualization**	***Pressures* from Past Research**	***Pressures* from Current Research**	****Resolved Pressures & Supports* from Current Research**
Factors from Below	Accounts for student characteristics	Students' characteristics of being bored or off-task Students' lack of motivation Students' negative attitude about school or the domain	Students' ability level Students' response to challenge Students' effort	Students' ability level Students' response to challenge Students' misconceptions Students' interest
Factors from Within	Accounts for teacher style and personality	Teachers' beliefs Teachers' personality disposition	Teachers' need for structure	Teachers' mastery beliefs Teachers' belief about inquiry practice Teachers' belief about student agency

Factors from Above	Accounts for teaching responsibilities	Student assessments Accountability Time constraints School administration	National standards and content coverage Time constraints	National standards and content coverage University colleagues and school district

Note: * denotes a new construct of each dimension

Appendix J

Summary of Teacher Practices Across Three Measures

Dimension and Conceptualization	**Exemplars from Teachers' Own Autonomy-Supportive Practices**	**Exemplars from Teachers' IQWST Analysis of Autonomy-Supportive Practices**	**Practices from Teacher Observations**
Organizational & Procedural Autonomy Involving students in decision making related to procedures & task format	"We did a reaction time unit, and I let them pick any variable they thought affected reaction time, and they got the test it. They designed an experiment and they got to decide what they wanted to do"	"when they do regular group work, I try and leave it a little more up to them in terms of how they work together in their groups"	"[They get] to figure it out on their own or without any step by step or cookie cutter directions"
Rationale & Relevance Introducing lesson or task purpose and connecting to students' personal interests, values, and goals.	"it's about picking things that they are interested in, which are all around them and then kind of building the relationships in those lessons and assessments"	"I think anytime that we have an opportunity to link what we're getting into or new information; if you can link it to something that they've spent time investigating, they've spent time learning about and trying to understand it, it just makes that connection deeper."	"I want it to feel like a scientific community where we talk about things"
Responsiveness Listening to students and responding to questions.	"You have to give up control in the classroom, in the sense that like you have to be listening a lot to the kids,	"I'll listen to different students and I'll try and extend their understanding and try and lead them to	"what I'm going to be doing is listening. I'm going to be listening to their questions, listening to their perspective"

	and the kids have to drive units and have to tell you when they're frustrated. You can't just plow through it."	something that deals with pollution or something that deals with predators, just enough that it gets it into their heads and they start to think about it"	
Feedback Offering encouragement when students show effort & persistence; recognizing/ praising mastery and progress	"Sometimes I'll bring the group together when I feel like a lot of students are struggling with the same thing"	"This is great. Can you think of something else? Even if you think you have one good hypothesis, try and think of some other explanations"	"Good. I like the way you are thinking. That's a really interesting way of thinking."
Cognitive Autonomy Encouraging students' ownership related to ideas, strategies, thinking and learning.	"You don't want to give them the answer; you don't want to tell them how this is supposed to work. What you really want to do is you want to put them in a situation where they feel ownership and they feel like .. this is something that [they] really want to think about."	"The hardest part for me during this kind of lesson is trying not to give anything away. I want the experience to be authentic, and so I want the students to have their own ideas and bring them all to the table"	"it's not something that I, the teacher, kind of put together for them and prescribed ... It's something that one of them, maybe even themselves, generated the day before"
Competence Encouraging and supporting students' mastery	"they're excited to be able to show each other what they're doing, because they feel confident in their roles."	"I think that this [IQWST lesson] was the right amount of challenging and motivating, but not so challenging that most students would quit. "	"you should have confidence in your ability. You can do this. You've done it before. I believe in you, and I'm here to help you. We're doing this together"
Relatedness	-	"students like to work in groups and things like the	"a good rapport with students, noting that this was

Fostering a sense of shared experience and belongingness		jigsaw model, so it allows students to work together"	key to getting students motivated to persist with difficult inquiry tasks."