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Inquiry Instructional Practice in Middle School Science Classes: Applying Vroom's Valence-Instrumentality-Expectancy Theory of Motivation

Since the late 1950's, science education in the United States has undergone many educational reform movements—most achieving less than ideal results on student performance (Atkin & Black, 2007). Currently, the National Research Council (NRC) is leading science education's newest reform effort, with *A Framework for K-12 Science Education* (NRC, 2012) and the *Next Generation Science Standards (NGSS)* (Achieve, 2013). These documents outline a radical shift in what students are expected to achieve and thus how teachers will have to teach. Inquiry-based instruction now becomes an essential strategy to help students model, design, plan, and analyze scientific experiences as outlined by the performance expectations detailed in *NGSS*. However, there seems to be a disconnect between the performance expectations from *NGSS* (i.e., student-centered instruction which encourages higher-order thinking) and the teacher-centered instructional strategies currently utilized by many science teachers (Marshall, Horton, Igo, & Switzer 2009; Capps & Crawford, 2013). It is no longer appropriate for teachers to solely use lecture or direct instruction where students are only asked to memorize information to be recalled for a quiz or test at a later date. This approach lacks engaging students in the scientific practices—the doing of science. Further, strategies such as demonstrations can be beneficial if students are engaged in the learning process throughout by approaches such as predict, observe, and explain**,** as opposed to sit and observe, which places students in a more passive role not supported by *NGSS*. The expectations stated in the *NGSS* encourage teachers to redesign educational experiences so students deeply and meaningfully think about the science concepts they are learning (Achieve, 2013). Further, these educational experiences should encourage students to apply, analyze, and create—all actions aligned with *NGSS* expectations. It is important, therefore, that educational stakeholders design professional development (PD) that assists teachers in using instructional strategies that will enable all students to succeed relative to the goals set forth by the *NGSS* (Cooper, 2013).

Keywords: Inquiry-based instruction, Motivation, Teacher beliefs

Success of PD that is designed to develop science teachers' inquiry practices can be affected by teachers' attitudes (Glassman & Albarracin, 2006), knowledge and beliefs (Gess-Newsome, 1999), and differing definitions and perceptions of inquiry instruction (Barrow, 2006). Each of these factors' relationships with inquiry-based instruction helps provide a lens to better understand what causes teachers to engage in certain teaching practices. Motivation is a term used to describe "the forces acting on or within an organism to initiate or direct behavior" (Petri & Govern, 2004, p. 16). Therefore one could argue that attitudes, knowledge, beliefs, and differing definitions and perceptions can all affect science teachers' motivation to engage in inquiry practices. Better understanding what motivates science teachers' instructional behaviors can result in improved efforts by researchers to align their instruction with quality inquiry-based instruction. By improving the effectiveness of PD programs, we can begin to decrease the disconnect between current teaching practice and the expectations stated in the *NGSS*.

This study seeks to determine whether Vroom's Valence-Instrumentality-Expectancy (VIE) Theory of Motivation can help explain science teachers' enactment of newly learned inquiry-based teaching practices. Specifically, the purpose of this study is to determine if Vroom's theory provides insight into teacher practice of inquiry instruction by examining teachers' ability beliefs, value of inquiry instruction, and instrumentality beliefs. Additionally, we were also interested to see if teachers' knowledge of inquiry instruction could be an important factor. The research questions for this study include: (a) which constructs within Vroom's VIE Theory of Motivation are related to teachers enacting quality inquiry-based instruction, and (b) how and to what extent can teachers' knowledge of inquiry instruction help explain teachers' enactment of inquiry?

Theoretical Framework and Literature Review

Inquiry-based instruction has a long history in science reform documents (Anderson, 2007). During this history, inquiry instruction has suffered from differing conceptions of what it means to engage in inquiry teaching and learning. Authors of contemporary reform

documents have attempted to clarify the meaning of inquiry instruction so that stakeholders in science education have a common view of inquiry and thus become better able to collectively influence science teaching (Achieve, 2013; NRC, 2012; Osborne, 2014).

Though *The Framework* and the *NGSS* do not explicitly use the term inquiry, it is clearly present within the new scientific practices (Achieve, 2013; NRC, 2012). These scientific practices closely resemble the components of inquiry laid out in the *National Science Education Standards* (*NSES*) (NRC, 1996); however, the authors stress that these practices are geared towards getting students to deeply understand and engage in the work that scientists do to make sense of and validate scientific knowledge (NRC, 2012; Osborne, 2014). Furthermore, an advancement of *NGSS* is that it embeds the scientific practices within the core ideas and crosscutting concepts, instead of the implied integration found in the *NSES*. So, *NGSS* reinforces that scientific knowledge cannot be separated from the process of science.

While the current PD program began during the time of the *NSES*, our concept of inquiry continues to closely align with views expressed in the *NGSS*. Specifically, our PD was designed to encouraged teachers to get their students asking questions, planning and carrying out investigations, analyzing and interpreting data, constructing explanations, engaging in argument from evidence, and gathering, critiquing, and presenting information. The goal of encouraging teachers to get their students engaging in these activities was to encourage students to construct their own knowledge of science concepts and come to a deeper understanding regarding "what scientists have to do to establish reliable knowledge" (Osborne, 2014, p. 180).

Since teachers frequently struggle to implement inquiry instruction, PD programs are often developed to assist teachers in improving their inquiry-based instructional strategies. PD characterisitcs that effectively change teacher practice include: actively engaging participants, having highly qualified PD facilitators, and having access to long-term support (Loucks-Horsley, Stiles, Mundry, Love, & Hewson, 2010). Research also indicates that the combination of multiday workshops and continuous monitoring can significantly impact teacher instructional practices (Sunal, et al., 2001).

Despite the goal of science education reforms and PD programs to encourage inquiry-based teaching (Achieve, 2013; American Association for Advancement of Science [AAAS], 2003; NRC, 1996), teachers continue to struggle with its implementation (Capps & Crawford, 2013). One reason for this struggle is that teachers find it difficult to enact (Sunal & Wright, 2006). Researchers have also found that teachers' insufficient belief, values, and knowledge regarding inquriy instruction dissaude implementation of inquiry-based teaching (Crawford, 2007; Lotter, Harwood, & Bonner, 2006). Further, Grigg, Kelly, Gamoran, and Borman (2013) found that teachers mainly enacted inquiry if the behavior was explicitly modeled during the PD. This indicates that experience with inquiry teaching (i.e., knowledge of what inquiry instruction looks like) can play a role in teachers enacting inquiry-based teaching strategies. Given the barriers that can impede science teachers from engaging in inquiry-based instruction, it is important that we seek to understand factors that influence teacher behavior. While there are many factors which impact teacher behavior, researchers have illustrated the importance of motivation on teacher instructional practice.

Motivational Factors and Teacher Practice

Motivation is a complex process focused on any specified behavior (Ciani, Summers, & Easter, 2008; Czubaj, 1996; Pop, Dixon, & Grove, 2010). Motivation can be affected by many factors such as; a person's context (Ciani et al., 2008), beliefs (Czubaj, 1996), feelings, and values (Thoonen, Sleegers, Oort, Peetsma, & Geijsel, 2011).

It has long been accepted that self-efficacy beliefs are critical in predicting teacher behavior (Bandura, 1997). Self-efficacy is an individual's confidence in achieving a certain task regardless of the barriers that stand in the way (Bandura, 1997). In a study designed to research the impact of four leadership tenants, including the motivation of teachers, Thoonen et al. (2011) found self-efficacy to be a crucial motivational factor regarding teacher learning and teaching practices. Furthermore, Czerniak (1990) found that highly efficacious teachers were more likely to engage in inquiry instruction and instruction that was student-centered.

Outcome expectancy is the belief that "a teacher can make a difference to a child's academic performance" (Desouza, Boone, & Yilmaz, 2004, p. 840). Another term for this is instrumentality belief. Instrumentality belief is the belief that one's performance can have a positive impact (Vroom, 1964). In their study designed to identify the motivating factors which led teachers to engage in the Ohio Competency Based Science Model, Haney, Czerniak, and Lumpe (1996) found that attitude toward the behaivor (i.e., instrumentality beliefs) was found to be the most signigicant contributor toward behavioral intention. Moreover, Bandura (1977) argues that it is a combination of high efficacy and outcome expectancy beliefs that enable individuals to engage and persist in certain behaviors.

Values also play a role in impacting teachers' motivation to enact a given instructional practice. Anderson (1996) details three dimensions that are involved in teachers being able to change their practice: (a) technical (e.g., teacher pedagogical and content knowledge), (b) political (e.g., lack of support), and (c) cultural (e.g., teacher beliefs and values regarding teaching practices) of which he attributes the most important to be the cultural dimension. Further, in their study designed to analyze high school teacher motivation, Ciani et al. (2008) found that the value that a teacher places on certain practices is crucial in determining if he or she persists in continuing to try that specified practice.

Since self-efficacy, instrumentality beliefs, and values are important factors in how teachers teach, it is crucial that

we determine the relationship between these factors and teacher enactment of inquiry-based instruction. Vroom's VIE Theory of Motivation provides a framework with which to investigate the relationship between these three motivational factors and behavior.

Vroom's VIE Theory of Motivation

The theoretical framework we will be using in this study is Vroom's VIE Theory of Motivation. Vroom's VIE Theory focuses on explaining individuals' motivation towards engaging in certain behaviors using three interactive components: (a) value, (b) instrumentality beliefs, and (c) expectancy beliefs (Vroom, 1964). He proposed that a high degree of each regarding a certain behavior would lead to an increase in that specified behavior.

Valence (i.e., value), according to Van Eerde and Thierry (1996), is "the importance, attractiveness, desirability, or anticipated satisfaction with outcomes" (p. 576). Instrumentality can be defined as "the perceived probability that good performance will lead to desired outcomes" (Chiang & Jang, 2008, p. 314**).** Said another way, instrumentality is the belief that a person will be rewarded if an expected behavior is shown. In this context, the expected behavior is inquiry-based instruction. Therefore, teachers should believe that they will see increased achievement and student engagement in their classroom due to using inquiry-based instruction. Vroom (1964) defined expectancy beliefs as the probability that effort will lead to certain performance. Ability beliefs are different from expectancy beliefs in that they measure how competent an individual feels about performing a behavior. Since the current study assesses an individual's ability beliefs rather than their expectancy beliefs, the expectancy referred to in this study aligns with Bandura's (1997) ability beliefs.

Methods

This study utilizes an embedded mixed method design (Figure 1) for data collection and a convergent mixed method design (Figure 2) for the analysis (Creswell & Plano Clark, 2011). The embedded design allows for more efficient data collection as well as the ability to examine changes in teachers before and after the intervention. The convergent design allows for the analysis to: (a) examine relationships among VIE variables and teacher practice (quantitative) and (b) explore whether teachers' knowledge of inquiry can help to explain the relationships found between the VIE components and teachers' inquiry-based practices (qualitative). The context of this study, instrumentation, data collection, and analysis of data are described in more detail in the following sections.

Context and Participants

This study tracks five years of a PD program that sought to increase the quality and quantity of middle school science teachers' inquiry-based instruction. The PD was designed based on the 4Ex2 Instructional Model (see Marshall, Horton, Smart, 2009 for a detailed explanation of the 4Ex2 Instructional Model). Utilizing this model, the PD purposed to develop teachers' ability to enact quality inquiry-based instruction in their classrooms by allowing them to: (a) engage and explore in inquiry as a student and teacher, (b) explain inquiry instruction with facilitation from the developers, and (c) extend on their knowledge of inquiry instruction by collectively creating lessons which utilized the 4Ex2 framework.

The program provided teachers with two weeks of summer training, four group follow-up sessions during the academic year, four or more full class observations with debriefing afterwards, and numerous individual support sessions. The summer PD involved modeling examples of inquiry-based instruction, debriefing modeled examples, and developing new inquiry-based lessons in teams. Support during the academic year included co-planning, co-teaching, observations, and debriefing observed classroom instruction.

Each year participating teachers came from one of the 2-3 partnering schools. This study only analyzes data for first year participants, and of the 57 first year science teacher participants, only 36 are included in this analysis because data was incomplete for the others. Teaching experience of participants spanned from 0 to 35 years (M=12.9, SD=10.4) with 67% having

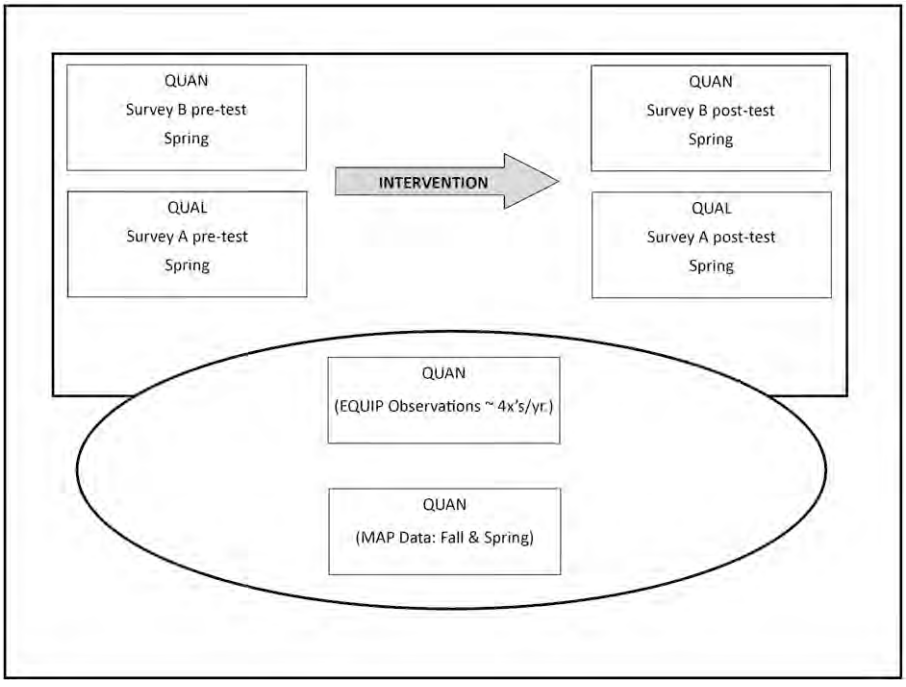

Figure 1. Embedded design data collection method.

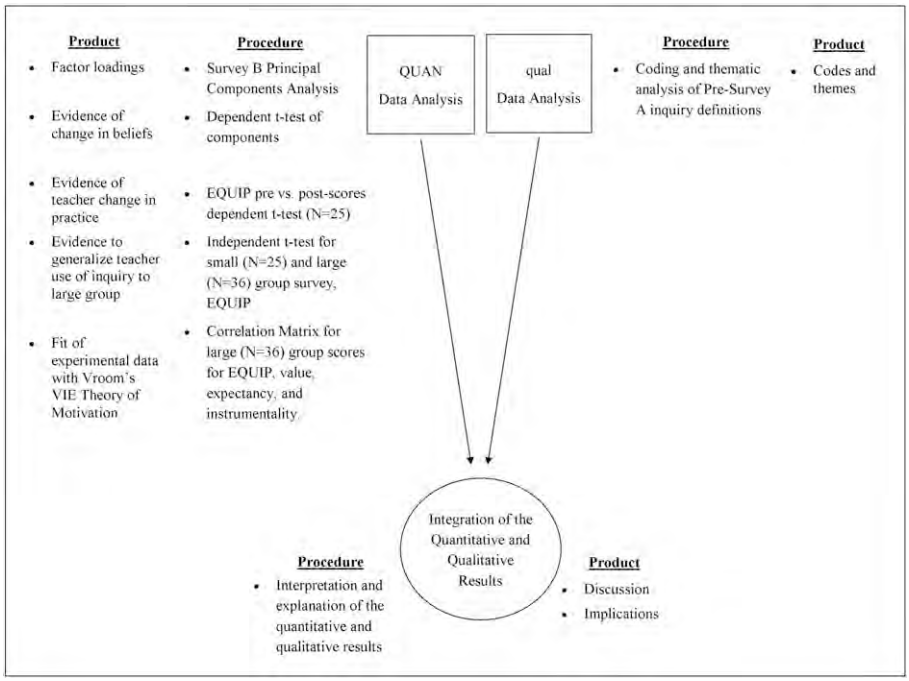

Figure 2. Convergent design data analysis method.

earned a master's degree or higher. Fifty percent taught sixth grade, 30% taught seventh grade, and 20% taught eighth grade.

Instrumentation

The following data sources were included to address the research questions: (a) Electronic Quality of Inquiry Protocol (EQUIP), (b) Survey A: Knowledge and Perceptions of Inquiry Survey, and (c) Survey B: Beliefs and Values Survey. Each of these data sources are detailed in this section.

EQUIP. This observation protocol was designed to measure four constructs of inquiry instruction: assessment, instruction, discourse, and curriculum (see https://tinyurl.com/y7ud5h2l for a detailed description of the EQUIP instrument). Each teacher was formally observed using the EQUIP at least four times (typically once each nine weeks) during the year they were involved in the program. After each observation, teachers were scored on each of the four aspects of inquiry measured, as well as given an overall lesson score. The EQUIP has been found to be highly valid and reliable (Marshall, Smart, Horton, 2010) with a Chronbach's Alpha of 0.912 (N = 102).

Survey A: Knowledge and perceptions of inquiry. This open response survey allows teachers to define and describe inquiry-based instruction, as well as, provide feedback about what they perceive to be the advantages and disadvantages of inquiry instruction.

Survey B: Beliefs and values. This survey uses a Likert-scale (one being "Disagree Completely" and six being "Agree Completely") to assess teacher beliefs and values toward inquiry-based instruction. This survey also collected the general teacher demographic data. The internal consistency value (Cronbach's Alpha) was .75 for this survey.

Data Collection and Analysis

Quantitative data. Data for participants were gathered over a 12 month period. EQUIP data were collected by trained reviewers who met a high inter-rater reliability threshold before starting. Survey data were all collected via online methods during face-to-face meetings.

Figure 2 provides a flowchart illustrating the analysis process. Using the Statistical Package for the Social Sciences (SPSS), a principal components analysis of the 25 survey questions from Survey B was completed in an effort to group the questions into separate components (expectancy, valence, and instrumentality) for analysis. Then, a dependent t-test was conducted to make statistical inferences based on the transformation of teacher beliefs and values. Following the analysis of Survey B, a dependent t-test was performed on the EQUIP data (n = 25 teachers) to determine if the intervention resulted in teachers changing their quality of inquiry instruction. While 36 teachers were included in this study, only 25 of them had pre-intervention EQUIP scores. Specifically, some of the teachers were new hires or not available during the spring prior to the intervention. To ensure that this sub-set of teachers is representative of the whole group, a dependent t-test was performed to determine if a significant difference existed for the beliefs and values scores for the two groups. Finally, a bivariate correlation analysis was performed to determine if there were relationships between the belief and value components found in Survey B and the inquiry-based instruction being enacted by the teachers.

Qualitative data. In order to answer our second research question, we assessed our participants' knowledge of inquiry with pre-Survey A which asked them to define inquiry instruction. This allowed us to find out if and how the knowledge of inquiry held by teachers helped explain the relationships found between the VIE components and teacher practice. In doing this, we sought to determine whether Vroom's VIE theory should be modified to include aspects of knowledge regarding the choice behavior.

Participants' pre-definition of inquiry was analyzed using a process of open and emergent coding (Strauss & Corbin, 1998). To begin this process, the participants' responses were de-identified and assigned a pseudonym. Two of the authors independently coded and discussed a subset of the participants' definitions of inquiry and established an initial classification system of codes. Each definition was first separated into individual units, each of which was independently assigned a code. These initial codes were informed by our own conceptions

of inquiry as well as the definition of inquiry presented by *NGSS* (Achieve, 2013) and *NSES* (NRC, 1996). Through a discussion of the author's individual coding schemes, a shared set of codes and meanings was developed. Using this set of codes, the same authors then independently coded the definitions for all 36 participants. Upon compiling the codes, we identified which codes could be grouped in order to decrease redundancy (Glaser & Strauss 1967). This process was repeated until we were able to come up with a set of themes. Furthermore, since we were looking at the quantitative data as a whole, we purposefully grouped the qualitative data accordingly. We felt this would provide qualitative and quantitative data that would better enable us to understand this group of teachers.

Findings

Components in Survey B

Principal Components Analysis (PCA) with a varimax rotation was performed to determine the number and nature of the components present in Survey B. The PCA was run without setting a specific number of components and resulted in eight components being retained due to interpretability and these components having eigenvalues greater than one (Tabachnick & Fidell, 2012). Eight components were identified from the survey (See Table 1), but only the four pertaining to teacher valence, expectancy, and instrumentality were included.

Instruction Beliefs focused on whether teachers believed they were effective at leading an inquiry-based classroom (e.g., During inquiry, I can manage student behavior; I can effectively lead students in inquiry). The category of Support Beliefs was comprised of items related to teachers' beliefs about the support they had to incorporate inquiry instruction at their school (e.g., My school's administration is supportive of inquiry instruction). Collectively, these two components were combined to represent expectancy. Teachers were found to have significantly increased in their instruction beliefs after a year of PD ($p<.05$) but not their support beliefs.

Table 1. Principal Component Analysis and Amount of Error Variance

Components	Factor Labels	Percentage of Variance
1	STEM Education Emphasis	15.091
2*	Instruction Beliefs	27.131
3*	Motivation	35.191
4*	Support Beliefs	42.495
5	Knowledge about Content Standards	49.205
6	Knowledge about Process Standards	55.501
7	Searching for Different Resources	61.609
8*	The Importance of Inquiry	67.035

Note. * Denote components used in the current study.

The Motivation component represents instrumentality since more engaging and motivating instruction can lead to higher student achievement (Fredricks, Blumenfeld, & Paris, 2004; Klem & Connell, 2004; Reyes, Brackett, Rivers, White, & Salovey, 2012). The items in this component involve teachers' beliefs that inquiry instruction increased students' engagement and excitement (e.g., Using inquiry teaching methods increases most students' enjoyment of science; Inquiry teaching methods motivate students who would otherwise be disengaged). Finally, Importance of Inquiry represents teachers' value of inquiry instruction or the valence (e.g., Teaching content is more important than teaching inquiry). Teachers had significant increases in their motivation beliefs after a year of PD ($p<.05$) but not their valence scores.

Teacher Practice

Teachers' growth in implementing inquiry instruction was measured with a dependent t-test comparing teachers pre- and post- EQUIP scores. After one year of the intervention, teachers significantly grew in their ability to implement better quality inquiry instruction in all constructs of the EQUIP, as well as the lesson total (see Table 2).

Significant differences were not found in relevant characteristics (i.e., belief and value scores) between the group of 25 teachers and the group of 36 teachers. Thus, we felt confident in generalizing to the larger group that similar growth in inquiry instruction from pre- to post-intervention would have been expected.

Relationship of VIE Constructs and Teacher Practice

Pre-belief had a significant positive correlation with pre-instrumentality, $r(36)=.435$, $p<.01$ as did belief change and instrumentality change, $r(36)=.372$, $p<.05$. No significant relationship was found between expectancy and valence, but the relationship between pre-instrumentality and pre-valence was significant, $r(36)=.422$, $p<.05$. The instruction construct of teacher inquiry practice was positively correlated with science teachers' pre-instruction ability beliefs (sub-component of expectancy), $r(36)=.363$, $p<.05$. It was also found that the assessment construct of teacher inquiry practice was positively correlated with teachers' pre-instruction ability beliefs, $r(36)=.365$, $p<.05$. There were no other motivational factors found to be significantly related to teachers' inquiry instruction.

Table 2. Pre vs. Post EQUIP Scores (N=25)

	Pre		Post		
Construct	M	SD	M	SD	*p*
Instruction	2.10	0.75	2.58	0.46	.010
Discourse	1.70	0.68	2.31	0.43	<.001
Curriculum	1.84	0.70	2.31	0.31	.004
Assessment	1.76	0.60	2.38	0.49	<.001
Lesson Total	1.70	0.61	2.39	0.46	<.001

Qualitative Results

The authors' independent coding of the 36 pre-responses revealed 190 units within the definitions, 87.9% of which were agreed upon in the initial coding. All cases of disagreement were discussed until consensus was reached. Codes were then collapsed further and verified between authors (Glaser & Strauss, 1967). This resulted in 26 codes being retained. From these 26 codes, five themes emerged (Saldana, 2009). Utilizing these themes, we were able to look at pre definitions of inquiry provided by the teachers to determine if and how their conception (i.e., knowledge) of inquiry instruction could help explain the relationship between their practice and beliefs regarding inquiry instruction.

Theme 1: Student exploration. Thirty-seven percent of teachers' definitions contained this theme. Teachers described student exploration in terms of having students take part in labs and hands-on activities designed to get students to think like scientists. Teachers also used descriptors that had the underlying idea that students were provided an opportunity to look into concepts before they learned about them from the teacher. An example of this is seen in the following definition provided by one of the teachers:

> Inquiry-based instruction involves student centered learning. The students are investigating, observing, and doing more hands-on lessons as well as recording what they are seeing, doing, and predicting. The students are driven to think like real scientists think as opposed to just reading a textbook and taking notes (Claire, survey response, July 16, 2012).

Theme 2: Teacher acts as a facilitator. Seventeen percent of teachers' definitions included this theme. This theme embodied the aspects of inquiry instruction that see learning as being student centered. Teachers considered a class to be student-centered if the teacher acted as a facilitator who clarified explanations through questioning and discussion instead of a direct instructor who was simply providing explanations. A representative definition that described inquiry instruction as being teacher facilitated is, "Students learn by investigating a concept on their own with guidance and questioning from a teacher, rather than having a teacher tell the students what they should be learning from the beginning through lecture (Belinda, survey response, July 16, 2012)."

Theme 3: Students are responsible for their learning. This theme had some overlap with the previous theme and was seen in 26% of teachers' definitions. It embodied teachers' definitions of inquiry which used phrases such as, students explain; students construct their understanding; and students are responsible for their learning. Included in this theme were also the scientific practices that students utilized to take ownership of their learning (e.g., observing, analyzing). The following quote from one of the teachers provides an example of a typical definition which includes this theme.

> Inquiry based instruction is allowing the students to explore and come up with their own understanding of how things work in the world around them. It is student driven and the teacher is more of a facilitator that guides them (Leslie, survey response, July 20, 2009).

Theme 4: Students engaged in learning. This theme included the idea that students should somehow be engaged in learning during inquiry instruction. Eleven percent of teachers' definitions included this theme. Definitions referred to this engagement in learning as purposefully designed by the teacher. An example of this is shown in the following definition: "Inquiry-based instruction involves drawing the students in when you allow them to engage in a thought process or activity that creates an interest, a desire, and a need for understanding a concept (Amanda, survey response, July 16, 2012)."

Theme 5: Students' prior knowledge is utilized. This theme contains the aspects of inquiry concerning the assessment of student knowledge in order to utilize it in the instruction. This theme contained the phrases of teacher questions, prior knowledge, and ongoing assessment and only occurred in 9% of teachers' definitions. The following definition provides a representative example of the teachers' definitions of inquiry instruction that includes the current theme: "Students are asked to solve and identify problems based on previous knowledge and experiences, inferences, observations, and evidence they have collected. The teacher acts as a facilitator to guide the students as they are solving the problem (Cristy, survey response, July 19, 2010)."

Relationship between knowledge and teacher practice. It is illustrated through the emergent themes that teachers explicitly defined inquiry in terms of the student and teacher roles, order of instruction, and instructional strategies designed to engage students. Teachers also explicitly cited the importance of assessment in their definition of inquiry instruction. Specifically, the teachers mentioned the need to assess and use students' prior knowledge, as well as teacher questions to facilitate in-class instruction. Figure 3 illustrates how the emergent themes correspond to the instruction and assessment constructs from EQUIP (see https://tinyurl.com/y7ud5h2l). These were the two EQUIP constructs found to be significantly correlated to pre-instructional beliefs (i.e., expectancy beliefs). While the ideas of discourse and curriculum (the other two EQUIP constructs) are seen in teachers' pre-definitions of inquiry instruction, teachers did not mention these aspects as often in their definitions. Interestingly, teachers' pre-instructional beliefs were not found to be significantly correlated with practices related to discourse or curriculum.

Discussion and Implications

This study considered whether Vroom's VIE Theory of Motivation could explain science teachers' implementation of inquiry-based instruction and how teachers' knowledge about inquiry instruction could help explain their teaching practice. Vroom's theory states that an individual's choice to implement certain behaviors is dependent on three motivational components: valence, instrumentality, and expectancy (Vroom, 1964). Additionally,

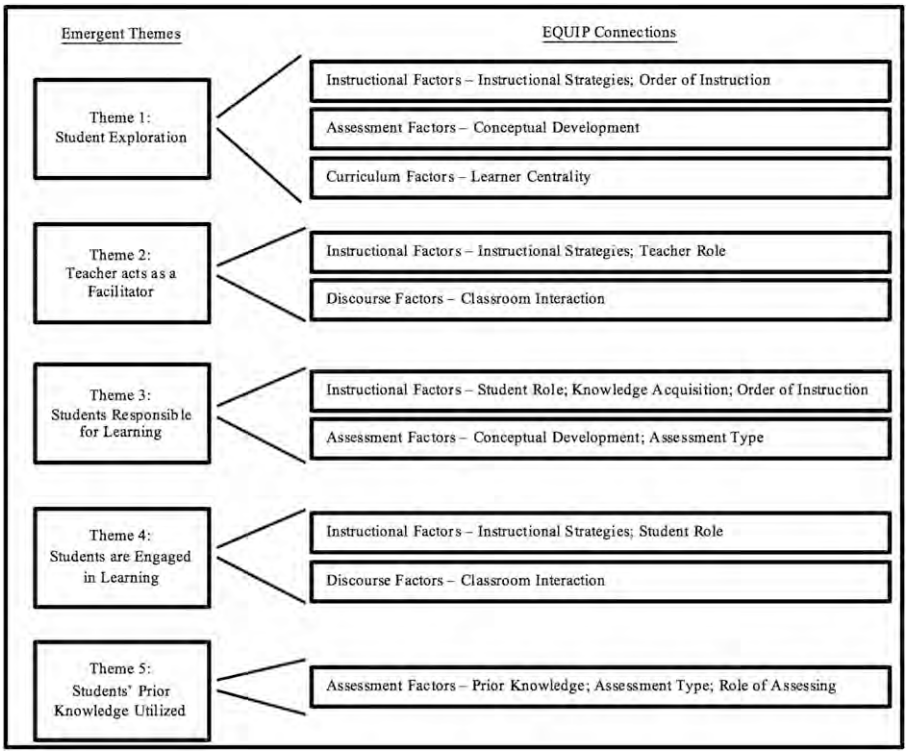

Figure 3. Explicit connections emergent themes and EQUIP constructs.

other research has shown the importance of teacher knowledge in changing teaching practice (Newton, Evans, Leonard, & Eastburn, 2012). Our results show that teachers who were involved in our program for one year significantly improved in their ability to engage in higher quality inquiry-based instruction. However, not all teachers showed this significant increase. Due to these differences, we wanted to determine whether the components of Vroom's theory, as well as, teacher knowledge of inquiry-based instruction could help resolve this quandary.

Our quantitative data found a significant positive relationship between the motivational factor of pre-instructional beliefs (expectancy) and teacher inquiry practices (specifically instruction and assessment). These results are in line with other research regarding the relationship between expectancy beliefs and teacher practice (Haney, Lumpe, Czerniak, & Egan, 2002). Researchers have found that teachers with higher efficacy beliefs are more likely to try new teaching practices, provide students with more control in the classroom, and engage in instruction which includes aspects of constructivist-style teaching (Allinder, 1994; Czerniak & Schriver, 1994; Woolfolk, Rosoff, & Hoy, 1990).

While these results affirm previous research, the qualitative results offer additional information as to why these significant relationships were found. Our qualitative results indicate that the middle school science teachers in our study explicitly defined inquiry-based instruction by focusing mostly on the instructional aspects (e.g., getting students to explore concepts, engaging students in learning, teachers facilitating the learning) and assessment aspects (e.g., assessing prior knowledge, ongoing assessment, utilizing assessment in instructional decisions) of inquiry. This suggests that teacher knowledge of inquiry instruction is involved in the choice to implement inquiry-based teaching practices. Jones and Carter (2007) state that science teacher knowledge can impact teacher ability beliefs, and Haney et al. (1996) found that teacher beliefs are critical factors in determining teacher practice. Our results indicate that our teachers' knowledge of inquiry instruction and inquiry assessment increased their ability beliefs regarding these two factors in inquiry and therefore enabled them to exhibit these inquiry behaviors. An alternative way to interpret this is that the teachers' knowledge of the instruction and assessment factors enabled them to implement these specific inquiry practices which in turn increased their ability beliefs for inquiry instruction and assessment. The dilemma of whether beliefs proceeds practice is still under debate (Mansour, 2009), and more research is needed in this area. However, these data suggest that knowledge may be a precursor of beliefs and practice.

Our results did not entirely confirm Vroom's Motivational Model. Teacher values were not found to be related to teacher practice and neither were instrumentality beliefs. Furthermore, there were no significant relationships found between values, instrumentality, and expectancy. It may be that the survey used to measure the VIE components was not sensitive enough to capture these constructs. It might also be that one year in our PD program was not sufficient to establish these relationships. Research indicates that it takes extended PD experiences to impact teachers' beliefs (Supovitz & Turner, 2000).

What do these findings mean for teacher educators and the development of future PD programs geared at increasing teachers' ability to engage in quality inquiry-based teaching? Based on our results, the goals of PD designers should include increasing science teachers' efficacy beliefs for the teaching practices being encouraged. This focus on increasing efficacy beliefs should also be a goal of teacher education programs since most pre-service teachers' experience in science classrooms do not include inquiry-based learning (Loucks-Horsley et al., 2010). Pre-service and in-service teacher inexperience with inquiry-based teaching can predispose them to having low ability beliefs regarding inquiry instruction, as well as a lack of pedagogical knowledge regarding how to engage

in inquiry-based teaching. Because of this, pre- and in-service teachers should be provided with ample opportunities to learn, practice, and reflect upon what it takes to engage in proficient inquiry-based instruction.

Our qualitative results highlight that teacher knowledge of specific inquiry-based strategies is a key component to teachers engaging in inquiry-based instruction. Therefore PD programs and teacher education programs should ensure that teachers' knowledge of inquiry practices is bolstered. In order to increase teacher knowledge of inquiry instruction, teacher educators and PD facilitators should seek to answer questions such as: what should I be doing as a teacher?; what should I expect my students to be doing?; how do I encourage discourse between students and myself?; how do I modify pre-existing activities into rigorous inquiry-based learning experiences?; etc… Our findings indicate that our teachers had pre-existing (albeit incomplete) knowledge of how instruction and assessment looked during inquiry-based instruction. In keeping with the constructivist framework that inquiry instruction is built upon, it seems that this prior knowledge assisted the teachers in developing new knowledge regarding these aspects of inquiry instruction. This then perhaps led to them enacting these specific aspects of inquiry-based teaching.

While we and others (Adams, Schmidt, Weaver, Witzig, & Zhao, 2012) advocate for PD to be designed in the same constructivist style in which inquiry teaching was developed, we admit that doing this could lead to incomplete conceptions of how to engage in inquiry-based instruction. In our case, we may have focused heavily on modeling and reflecting on the instructional and assessment aspects of inquiry instruction while giving less attention to discourse and curriculum, which may be more difficult to model. Further, our results suggest the need to be explicit and clear in defining and modeling the apsects of inquiry instruction being developed. Grigg et al. (2013) found that the aspects of inquiry instruction that teachers were more likely to engage in when teaching corresponded to the inquiry strategies that were clearly and explitly modeled during the PD program. They argued that the clear and explicit modeling of certain inquiry teaching strategies provided the teachers with more experience (i.e., knowledge) regarding how inquiry-based teaching should look.

Admittedly, the task ahead of PD facilitators and teacher educators is a challenging one, especially given the expectations of the *NGSS* (Achieve, 2013). While it may be tempting to try and focus only on knowledge or beliefs, research indicates that attempting to impact both results in greater change (Mundry & Loucks-Horsley, 1999). This change does not happen quickly (Supovitz & Turner, 2000) and therefore pre- and in-service teachers should be provided with extended experiences that seek to increase both knowledge and efficacy beliefs regarding inquiry instruction.

Our qualitative findings also imply that Vroom's VIE Theory of Motivation may benefit from adding the construct of knowledge into the equation regarding individuals' choice to engage in certain behaviors. However, a more valid and reliable VIE instrument geared toward inquiry-based instruction would better enable researchers to investigate this relationship.

Presently, several questions still remain unanswered. Does a second year of PD on inquiry instruction bring about the relationship hypothesized by Vroom's Theory? What is the predicative effect of the VIE components if the second year provides support for Vroom's Theory? Would having better measures for the components have provided different results? Are these components important in teachers sustaining inquiry instruction years after the PD has been completed? Our sample size for this research study is relatively small and therefore some caution should be taken in generalizing our results to other populations. Regardless, the results and implications provide insights for PD facilitators and teacher educators to consider.

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